

# Collaboration Pattern amongst Health Care Professionals in India

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## Abstract

Earlier studies on author productivity and collaboration have established that productive, active and prolific authors, especially in the field of Health Science, are also highly collaborative. The purpose of this study is to determine whether the most productive authors in the literature of Health Science, for the eight year period 2000–2007, are also the most collaborative.

This study intends to determine the degree of collaboration and to examine the co-relation between productivity and collaboration pattern of the health care professionals in Christian Medical College (CMC), Vellore, India. Christian Medical College is a premier and century old institution of education and research in Medical Sciences in India. To this end, the research productivity data of the faculty of CMC included in the global Online Database PubMed by the NLM has been taken for analysis of the collaboration pattern. Of these, this study includes only those primary journals indexed in Pub Med and subscribed in the CMC library. This was decided to ensure accessibility to the full text data articles to obtain the full bibliographic data of the authors and their affiliation. The study period is spread from 2000 to 2007.

This study found that while the degree of collaboration in the literature of Health Science was very high, the correlation amongst the productivity and collaboration is low. Intra-collaboration of health

care professionals is higher than the inter-collaboration across the discipline and institutions. Inferences and interpretations drawn of this study are given in detail in the full text of the paper.

## 1 Introduction

All health science scientists are members of a world-wide scientific community they work jointly to further understand the technology and advances of Health Sciences and to provide the theoretical basis upon which the superstructure of technology and advancement can be built. Depending on this study, scientific collaboration can be defined as “*a process of functional interdependence between authors in their attempt to coordinate skills, tools, and rewards*” (Patel, 1972). In addition, it is a key element in the advancement of knowledge and the productivity of research in a field. Multiple authorship, as much is an indication of collaborative work. Over forty years ago, Smith (1958) observed that authorship patterns in psychology were changing. He reported an increase of two and three-author papers, whereas single-author papers had decreased, and then he concluded that there was indeed a trend towards multiple authorship and that it was likely to continue.

This study tries to examine the nature of authorship pattern, collaboration pattern- spacial, institutional and subject, and the most prolific author of the literary productivity by CMC Faculty in the field of Health Science during the study period 2000 to 2007.

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## 2 Data Source

The journals indexed in the PubMed Database published by National Library of Medicine are taken for the analysis. The web URL <http://pubmed.gov> with the string “(Vellore[ad] AND Christian Medical College[ad]) AND 2000:2007[dp] AND free full text[sb] AND “lo-proviincmclib”[filter]” for the period of eight years was searched. The other publication of Christian Medical College but indexed in PubMed are excluded for the analysis of this study.

## 3 Methods

A working database was designed and developed using *Microsoft Access* with the downloaded items from the above said database source and searches. This database was manipulated using a statistical software package *Minitab* to observe the pattern and degree of collaboration amongst the CMC Health Science Faculty. Lastly, to calculate the international collaboration of CMC faculty, the formula suggested by Davidson Frame<sup>3</sup> and Carpenter was adopted. To this end, the papers having more than one country in the address field were identified and based on the number of international linkages; Internationalization Index as suggested by Davidson Frame<sup>3</sup> and Carpenter was calculated.

$$II = \frac{100 \times \text{Number of International Links}}{\text{Total No. of papers from the country}}$$

To examine the co-relation between authors and subjects, Health Science was classified as per the National Library of Medicine (NLM) Classification Code and then using MS-Access ranking was made to infer the author productivity in the sub-disciplines of health Sciences.

## 4 Inferences

Analysis reveals that the total quantum of literary output by the CMC Health Science Faculty is 428 from 2000 – 2007 (Table 1). Based on the above raw data, the distribution of authorship pattern was studied (Table 2). The total occurrences of collaborated papers are found to be more (91.11%) than those papers by solo authors of the collaborated papers. The numbers of papers co-authored by four and five authors are the largest. The total number of authors who have produced 428 papers during

the study period as stated in Table 1 is 1765 and the collaboration pattern of these 1765 authors is as follows.

INTRA-COLLABORATION (**within India**)- 1661  
INTER-COLLABORATION (**foreign**)- 104

Obviously, the foreign collaboration is found to be very low. At the intra level, the degree of collaboration of the CMC Faculty outside the parent institution – CMC - is found to be even lower (18/1661). It is to be noted that the intra-departmental/institutional (within CMC) collaboration seems to be the highest among the CMC Health Science Faculty (1643/1661).

A study of the degree of collaboration of the CMC Faculty with the other countries is as given below (Table 4). The Indo-American collaboration is found to be the top the list, followed by Indo-British collaboration (Table 5).

An attempt was made to observe the author collaboration in relation to the sub-disciplines of Health Science (Table 8 and 9).

Each of these inferences is presented subsequently.

### 4.1 Productivity Pattern

The total number of the literary productivity of the CMC Health Science faculty accounted for 428 papers. On analysis, 91.11% (n=390) were found to be products of collaboration, either joint (2) or multiple authors (more than 2), whereas only 8.88% (n=38) were works of a single author (Table 1).

Table 1 : Quantum of Literature Output

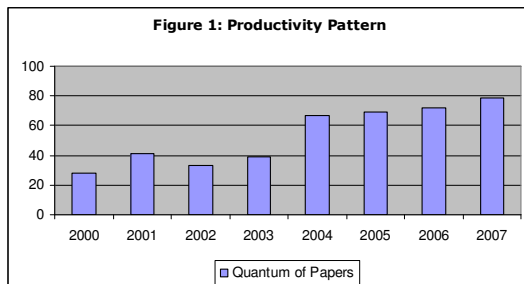
Year	Quantum of Papers	Quantum of Authors	Solo Authored Papers	Multi Authored Papers
2000	28	140	3	25
2001	41	205	4	37
2002	33	165	4	29
2003	39	156	6	33
2004	67	201	3	64
2005	69	345	5	64
2006	72	288	8	64
2007	79	265	5	74
Total	428	1765	38	390

Based on this data, the pattern of productivity was

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drawn which is as presented in the following figure:



The productivity pattern seems to be not on the increasing trend, but fluctuating. However, over the study period from 2000 to 2007, the volume of production has increased – 28/2000 to 79/2007.

#### 4.2. Authorship Pattern

The authorship pattern was as observed in Table 2. A total of 8.87% papers (38/428) were produced by single author, 13.55% of papers produced by joint authors (58/428) and 77.56% of papers produced by three or more authors (332/428). Hence, the team work accounts for about 390.

Table 2 : Authorship Pattern

No of Authors	Occurrences
Single	<b>38 (8.87%)</b>
Joint	<b>58 (13.55%)</b>
Multiple	<b>332 (77.56%)</b>
3	<b>86 (20.09%)</b>
4	<b>89 (20.79%)</b>
5	<b>66 (15.42%)</b>
6	<b>69 (16.12%)</b>
7	<b>22 (5.14%)</b>
<b>Total No. of Papers =</b>	<b>428</b>

Of the total 1765 authors, 839 are the unique authors who have produced literature from CMC Health Science Faculty over the 8 years study period (Table 3).

Table 3 Productivity Pattern

Number of Authors	Frequency of Occurrence	Total No. of Authors
552	1	<b>552 (31.27%)</b>
108	2	<b>216 (12.24%)</b>
59	3	<b>177 (10.03%)</b>
44	4	<b>176 (9.97%)</b>
14	6	<b>84 (4.76%)</b>
15	7	<b>105 (5.95%)</b>

Number of Authors	Frequency of Occurrence	Total No. of Authors
13	5	<b>65 (3.68%)</b>
9	8	<b>72 (4.08%)</b>
3	9	<b>27 (1.53%)</b>
5	10	<b>50 (2.83%)</b>
4	11	<b>44 (2.49%)</b>
4	12	<b>48 (2.72%)</b>
2	13	<b>26 (1.47%)</b>
3	14	<b>42 (2.38%)</b>
2	15	<b>30 (1.70%)</b>
1	17	<b>17 (0.96%)</b>
1	34	<b>34 (1.93%)</b>
<b>839</b>		<b>1765</b>

A single author has a frequency of 34 occurrences, while about 552 authors have contributed once, either as a single author or jointly.

#### 4.3 Collaboration Pattern

The joint and multiple authors' contributions (390) were examined for the type of collaboration at the intra and inter level. Adopting the Internationalization index (refer Section 3), the international linkage was calculated and the result yielded is as follows:

<b>Total No. of Collaborative Papers</b>	390
<b>Total No. of Links</b>	104
<b>Internationalization Index</b>	24.30%

The CMC Health Science faculty is found to have only 24% of inter-collaboration at the international level. This has been further studied in detail for its specific cross-country collaboration analysis.

##### 4.3.1 Inter-collaboration Pattern

The cross-country analysis reveals that authors from 14 different countries have collaborated with CMC Faculty. United States of America ranks high amongst the 14 nations, followed by United Kingdom and the rest as found in Table 4 and Figure 3. Most of the collaboration of CMC faculty has been with the Western countries, except for 3 collaborations with the neighboring countries – Bangladesh (twice) and Pakistan (once).

Table 4 Inter-Collaboration Pattern

COUNTRY	NO. OF AUTHORS	PERCENTAGE
<i>USA</i>	40	2.27
<i>UK</i>	28	1.59
<i>Canada</i>	6	0.34
<i>Australia</i>	5	0.28
<i>France</i>	4	0.23
<i>Oman</i>	4	0.23
<i>Switzerland</i>	4	0.23
<i>Germany</i>	3	0.17
<i>Bangladesh</i>	2	0.11
<i>Belgium</i>	2	0.11
<i>Japan</i>	2	0.11
<i>Sweden</i>	2	0.11
<i>New Zealand</i>	1	0.06
<i>Pakistan</i>	1	0.06
<b>Total =</b>	104	5.89

#### 4.3.2 Intra- Collaboration pattern

The intra-collaboration of the CMC Faculty in Health Sciences is viewed from two approaches - collaboration within CMC (81.03%) and the other with the rest of the country (4.62%) (Table -5)

Table 5: Institutional Collaboration Pattern

COLLABORATION PATTERN	NO OF ARTICLES % (390)
Number of Articles collaborated with in institution (CMC)	<b>316 (81.03%)</b>
<b>Number of Articles collaborated with in country</b>	<b>18 (4.62%)</b>

Obviously, collaboration with CMC colleagues seems to be higher than that of the collaboration with the colleagues from the rest of the country.

#### 4.3.3 Subject Collaboration

A ranked Correlation analysis of subject versus authors was attempted (Table 6).

NLM SUBJECT CODE	SUBJECT HEADING	Single Author Papers	Multi-Author Papers	Total No. of Articles	% (390)
WL	Neurology and Neurosurgery	5	54	59	<b>13.85</b>
QW	Microbiology and Virology	1	38	39	<b>9.74</b>
WB	Medicine	1	34	35	<b>8.72</b>
WA	Preventive and Community Medicine	2	28	30	<b>7.18</b>
WS	Pediatrics and Child Health	1	28	29	<b>7.18</b>
WN	Radio diagnosis	0	28	28	<b>7.18</b>
WI	Gastrointestinal Sciences	0	27	27	<b>6.92</b>
WQ	Obstetrics and Gynecology	3	12	15	<b>3.08</b>
WW	Ophthalmology	2	15	17	<b>3.85</b>
WO600	Pediatric Surgery	1	15	16	<b>3.85</b>
WO	Surgery	1	12	13	<b>3.08</b>
WK	Endocrinology	1	10	11	<b>2.56</b>
WG	Cardiology	1	8	9	<b>2.05</b>
WH	Hematology	1	8	9	<b>2.05</b>
WM	Psychiatry	1	8	9	<b>2.05</b>
WJ	Urology	1	7	8	<b>1.79</b>
WO200	Anesthesia	1	6	7	<b>1.54</b>
QU	Biochemistry	1	4	5	<b>1.03</b>
QV	Pharmacology	1	4	5	<b>1.03</b>
WD	Infectious and Communicable Diseases	1	4	5	<b>1.03</b>
QZ	Pathology	0	8	8	<b>2.05</b>
Q	Sciences General	1	3	4	<b>0.77</b>
QY	Clinical Pathology & Laboratory	1	3	4	<b>0.77</b>
WX	Critical Care Medicine	1	3	4	<b>0.77</b>
WF	Respiratory Medicine	1	2	3	<b>0.51</b>
WU	Dentofacial Surgery	1	2	3	<b>0.51</b>
WV	Otolaryngology Head Neck Surgery	1	2	3	<b>0.51</b>
QC	Physics	1	1	2	<b>0.26</b>
QH	Biology	1	1	2	<b>0.26</b>
QS	Anatomy	1	1	2	<b>0.26</b>
WR	Dermatology	1	1	2	<b>0.26</b>
WY	Nursing	1	1	2	<b>0.26</b>
WZ	History of Medicine	1	1	2	<b>0.26</b>
QT	Physiology	0	4	4	<b>1.03</b>
WE	Orthopaedics	0	4	4	<b>1.03</b>
QB	Botany and Plant Sciences	0	1	1	<b>0.26</b>

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NLM SUBJECT CODE	SUBJECT HEADING	Single Author Papers	Multi Author Papers	Total No. of Articles	% (390)
W	Medical Juris-prudence	0	1	1	<b>0.26</b>
WO500	Plastic Surgery	0	1	1	<b>0.26</b>
Total =		38	390	428	100

The most prolific subject is found to be Neurology and Neurosurgery (13.85%), followed by Clinical Virology and Microbiology (9.74%), Medicine (8.72%), Preventive and Community Medicine (7.18%), Child Health (7.18%), Radio diagnosis (7.18%) and Gastrointestinal Sciences (6.92%). Interestingly, all the high ranked subject distribution of the literature by CMC faculty in Health Science is in the core Health Science specialties.

#### 4.4 Prolific Author

With the objective to identify the most productive authors amongst CMC Faculty arrange another ranked list was prepared. Table 7 presents the top ten of these ranked authors. The single author with the frequency of occurrence of 34 times (Refer Table 3) is identified to be Rajshekhar, V of the Neurological Sciences Department. It seems to be more collaborative in literary production. It has been also found the most prolific author Dr. Rajshekhar V produced all the literature with the collaboration (34/34).

Table 7: Prolific Authors

Faculty	No. of Papers	Rank
Rajshekhar V	34	<b>I</b>
Jesudason Mary V	17	<b>II</b>
Thomas N Sridharan G	15	<b>III</b>
Muliyil J Kumar S Abraham O C	14	<b>IV</b>
Thomas R Kannangai R	13	<b>V</b>
Singh S Govil S Chacko J Chacko AG	12	<b>VI</b>

Faculty	No. of Papers	Rank
Srivastava A Ramakrishna B S Kang G Chacko G	11	<b>VII</b>
Raghupathy P John G T Jana A K Chandy M Abraham P	10	<b>VIII</b>
Sridharan G. Sen S Mathai E	9	<b>IX</b>
Scott J X Ramalingam S Jacob KS Gopalakrishnan G Gnanamuthu C George B Chandy MJ Alexander M Abraham S	8	<b>X</b>

Productivity Pattern of the prolific author was analyzed. All his 34 papers are products of collaboration only. His has collaborated with 62 different authors and all are not only within India but also from within CMC itself, but for one with Apollo, Chennai.

Table 8: Rajshekhar V (Rank 1) - Pattern of Co-Authorship

Collaborated Authors	Subject/Departments	NLM	Institution	Occurrences	% in Total Publication (428)
Chacko G.	Neurology	WL	CMC	7	<b>1.64</b>
Chacko AG	Neurology	WL	CMC	6	<b>1.40</b>
Arun Kumar MJ	Neurology	WL	CMC	3	<b>0.70</b>
Moorthy RK	Neurosurgery	WL	CMC	3	<b>0.70</b>
Chandy MJ	Neurosurgery	WL	CMC	2	<b>0.47</b>
Daniel RT	Neurology	WL	CMC	2	<b>0.47</b>
Job A	Otolaryngology	WV	CMC	2	<b>0.47</b>
Joseph BV	Neurology	WL	CMC	2	<b>0.47</b>
Kulkarni V	Neurology	WL	CMC	2	<b>0.47</b>
Kumar GS	Neurology	WL	CMC	2	<b>0.47</b>
Muliyil JP.	Community Medicine	WA	CMC	2	<b>0.47</b>
Poonnoose SI	Neurosurgery	WL	CMC	2	<b>0.47</b>
Raghuram L	Radiodiagnosis	WN	CMC	2	<b>0.47</b>
Rupa V	Otolaryngology	WV	CMc	2	<b>0.47</b>

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Collaborated Authors	Subject / Departments	NLM	Institution	Occurrences	% in Total Publication (428)
Shah KC	Neurology	WL	CMC	2	0.47
Sujit Kumar GS	Neurology	WL	CMC	2	0.47
Abraham RG	Radiodiagnosis	WN	CMC	1	0.23
Bannur U	Neurology	WL	CMC	1	0.23
Chandi SM.	Cardiology	WG	CMC	1	0.23
George M	Surgery	WO	CMC	1	0.23
Henry PT	Medicine	WB	CMC	1	0.23
Jacob CK.	Nephrology	WJ	CMC	1	0.23
Jonathan A	Neurology	WL	CMC	1	0.23
Joseph V	Neurology	WL	CMC	1	0.23
Khan D	Anaesthesia	WO200	CMC	1	0.23
Lath R	Neurosurgery	WL	Apollo Hospitals, Chennai	1	0.23
Mathews MS.	Microbiology	QW	CMC	1	0.23
Oommen A.	Neurology	WL	CMC	1	0.23
Ponniah M	Anaesthesia	WO200	CMC	1	0.23
Rao A	Radiodiagnosis	WN	CMC	1	0.23
Singh AD	Radiodiagnosis	WN	CMC	1	0.23
Singh S	Radiodiagnosis	WN	CMC	1	0.23
Thomas N	Pathology	QZ	CMC	1	0.23
Thomas PP	Nephrology	WJ	CMC	1	0.23
Venkatesan T	Anaesthesia	WO200	CMC	1	0.23
Total =				62	14.49

The following table reveals that about 50% of his collaboration is within his own Department/specialty.

Table 9: Prolific Author Collaboration on NLM Classified Subjects

Subject / Departments	NLM	Occurrences	% (62)
Neurology	WL	39	62.90
Radiodiagnosis	WN	6	9.68
Otolaryngology	WV	4	6.45
Surgery	WO	4	6.45
Nephrology	WJ	2	3.23
Community Medicine	WA	2	3.23
Nephrology	WJ	1	1.61
Cardiology	WG	1	1.61
Medicine	WB	1	1.61
Pathology	QZ	1	1.61
Microbiology	QW	1	1.61
		62	100.00

## 5 Summary

CMC, Vellore is leading medical institution of repute in the country and in the world. Its R&D activity and output of the Health professionals of CMC, as per this study, is not very encouraging. The range of collaboration with international colleagues in the discipline is lower. And also the collaborative pattern of literature produced is at inter-departmental level and not inter-institutional level. And amongst the top ten authors, only one female author (Mary V Jesudasan) was identified. Though medical field is dominated by lady professionals, their productivity seem to be very low. Perhaps, inclusion of the full text articles and those items not available in the CMC library may yield a different finding.

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