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Abstract

This study was to analyze bibliometric data from the number of publication of IMS and SUM Hospital, Bhubaneswar during 2009 to 2013 to assess research productivity and impact and gathered and synthesized the number of publications of 34 departments for almost all department of the institute (N=207): (1) total number of published articles per department, (2) total number of citations to published articles per department, (3) average number of citations per article, (4) institutional impact indices, (5) institutional percentages of articles with zero citations, (6) annual average number of faculty per department, (7) average number of citations per faculty member. Using *t* test and λ^2 and ANOVA analysis, the authors calculate the relationships between measures, if they existed with reference to the Bradford's law of scattering and degree of collaboration.

Key word: Bibliometric study, ANOVA, Degree of Collaboration, MCI, Bradford Law

Introduction

Bibliometric statistics are used by institutions of higher education to evaluate the research quality and productivity of their faculty. With bibliometric indicators, such as gross totals of publications and citations and journal impact factors gives the consideration of tenure, promotion and reappointment decision at an individual level (Borgman & Furner 2002, Garfield 1983 part-1, 2, Cronin & Atkins 2000, Epstein 2004, Maunder 2007). At the departmental, institutional, or national level, bibliometrics inform funding decisions (Borgman & Furner 2002, Murphy 1998, Lewison 1999), develop benchmarks (Borgman & Furner 2002, Noyons et al. 1999), and identify institutional strengths (Borgman & Furner 2002, Huang et al 2006, Schummer 2007), collaborative research (Borgman & Furner 2002, Garfield 1993), and emerging areas of research (Borgman & Furner 2002, Hinze 1994, Leydesdorff et al. 1994). Due to the important organizational and personnel decisions made from these analyses, these statistics and the concomitant rankings elicit controversy. Many scholars denounce the use of ISI's impact factor and immediacy index as well as citation counts in assessing a study's quality and influence. Major criticisms of reliance on bibliometric indicators include manipulation of impact factors by publishers, individual self-citations (Seglen 1997), uniqueness of disciplinary citation patterns (Seglen 1997, Coleman 1999), context of a citation (Shadish et al. 1995), and deficient bibliometric analysis (Weingart 2005). Many researchers condemn ISI for promoting and promulgating flawed and biased bibliometric data that rely on unsophisticated or limited methodologies (Seglen 1997, Walter et al. 2003, Loonen et al.2007), exclude the vast majority of the world's journals (Seglen 1997, Walter et al. 2003), and contain errors and inconsistency (Seglen 1997, Moed 2003). Conversely, other researchers point out the utility of bibliometric measures, even in light of valid criticisms, and posit that they accurately depict scholarly

communication patterns (Raan 1996, Aksnes 2006, Hirsch 2005), correlate with peer-review ratings (Oppenheim 1997), predict emerging fields of research (Raan 1996), show disciplinary influences (Schoonbaert & Roelants 1996), and map various types of collaboration (Raan 1996). Assessment of medical colleges and their research output has demonstrated no methodological uniformity. Arguably the most famous ranking of US medical schools is America's Best Graduate Schools, published by the magazine, U.S. News & World Report, which takes two research measures into account: total dollar amounts from National Institutes of Health (NIH) research grants and the average dollar amounts from NIH research grants per faculty member (U.S. News & World Report 2007). Several methodological shortcomings have been identified with the U.S. News & World Report's rankings, including the predominance of reputational measures, omission of over half of the accredited medical schools, inadequate use of standard statistical methods, and absence of any bibliometric measure (McGaghie & Thompson 2001, National Opinion Research Center 2003, Webster 2001). Although their methodologies differed, more rigorous studies addressed the issue of evaluating biomedical research. Over twenty-five years ago, McAllister and Narin appraised research at medical schools in the United States by comparing NIH funding and basic citation information (McAllister & Narin 1983). More recently, McGaghie and Thompson argued that research output should be evaluated by grants and peer-reviewed publications as well (McGaghie & Thompson 2001). Combining quantitative and qualitative methodologies, Wallin recommended sound bibliometric analysis paired with a peer review of the research's influence to evaluate research (Wallin 2005). More sophisticated analyses have formulated novel bibliometric indicators from collected data. In assessing medical schools in Europe, Lewison used bibliographic and bibliometric data that tracked the amount of international collaboration, volume and increases of research output, ''journal esteem factors,''

systematic review percentages, and citations by patents (Lewison 1998). Integrating several measures derived from a variety of sound methodological approaches might provide a nuanced and more accurate interpretation of a medical school's research output. The objective of this study was to collect and examine bibliometric data, NIH-funding statistics, and faculty size information from Association of American Medical Colleges (AAMC) medical schools in the United States to identify some basic measures of research productivity and impact. In addition to presenting a general picture of a medical school's research, conducting a macro-level institutional analysis was intended to provide medical schools with potential benchmarks for future comparisons. Additionally, the author sought to analyze the multivariate relationships between the collected research publications to describe the relative association of individual measures with each other.

In this study, the number of research publication on individual department and faculty of IMS and SUM Hospital, Bhubaneswar were analyzed for last five years and compare with other private and government college of India.

Materials and method

The number of research publications are collected from an Indian Medical College i.e. Institute of Medical Sciences and SUM hospital, Bhubaneswar from 2009 to 2013. In this college clinical, preclinical and nonclinical departments are there. Each department gives new research paper in each year. For this connection a web site meeting is conducted in the year 2014 and with the help of this website we collect the research publications for each department. All the research publications are maintained in the Central Research department, IMS and SUM Hospital,

Bhubaneswar. These records are verified simultaneously by the professional library staff of this institution.

We have maintained each publication with author wise i.e. single, double or multi author separating in individual year. As there are varieties of research work, we classified the research publications in two parts i.e. clinical research and pre clinical research. The publications of this institute are indexed in different database like Pubmed, medknow, scopus etc. Also certain publications are non indexed. These varieties of papers are maintained separately.

As a teaching medical college attached with the hospital, the concept or the theme of the research come to our faculty as well as the students. In this manner they both have publications independently which are maintained separately in individual year.

Result and discussion

In five year study, a total number of 207 papers were published in our institute. The number of authors was varied from article to article. A comparative study between single author and more than one author was taken and it was found that statistically significant at $p = 0.01$ in t test (Table1).

Table 1 **Distribution of authorship**

	Single Author	Joint Author	Three Authors	Four Authors	More than Four Authors	Total
2009	6	2	5	1	7	21
2010	12	4	7	3	6	32
2011	11	2	15	5	10	43
2012	7	10	7	8	18	50
2013	9	10	11	15	16	61
Grand Total	45	28	45	32	57	207

The research articles were written by all faculties of various departments. For comparison, we classified into two departments broadly i.e. Clinical and Pre – Clinical departments. In statistical point of view, there is no significance difference between articles written by different authors of clinical and preclinical departments. As p = 0.32 in t test (Table2).

Table 2 **Distribution of articles in clinical and pre clinical departments**

	Clinical	Pre Clinical	Total
2009	14	7	21
2010	19	13	32
2011	20	23	43
2012	13	37	50
2013	17	44	61
Grand Total	83	124	207

As a medical teaching institute and recognized by MCI (Medical Council of India), the published articles were found in different databases. But, here we consider three databases as indexed journal and rest articles were taken as non indexed. With t test, we compare indexed and non indexed journals of our published papers, it reveal that indexed journals were found more as compare to non indexed journal and it is statistically significant at p = 0.01. (Table - 3)

Table3 **Distribution of articles in different database**

	PubMed	Medknow	Scopus	NonIndexed	Total
2009	2	8	6	5	21
2010	8	9	8	7	32
2011	12	11	11	9	43
2012	9	9	26	6	50
2013	13	16	31	1	61
Grand Total	44	53	82	28	207

In this five year study of research development in the IMS & SUM Hospital, Bhubaneswar; the authors like professor, associate professor, assistant professor and research scholars have produced many papers in different journals. It is found from ANOVA test that, statistically significant between their designation irrespective to Professor, Associate professor, Assistant professor and research scholars. The number of papers published in different intervals of last five years was highly significant in statistical analysis (Table 4a, b and c).

Table 4 –A Designations of authors

	Professor	Associate Prof.	Asst. Prof.	MD / Research Scholar	Total
2009	18	8	27	13	66
2010	17	14	34	11	76
2011	25	22	57	13	117
2012	55	24	73	16	168
2013	48	29	53	32	162
Grand total	**163**	**97**	**244**	**85**	**589**

Table 4-B

Anova: Two-Factor Without Replication		
SUMMARY	*Average*	*Variance*
2009	16.5	65.66667
2010	19	106
2011	29.25	368.25
2012	42	710
2013	40.5	139
Prof.	32.6	313.3
Asso. Prof	19.4	69.8
Asst. Prof.	48.8	341.2
MD/Res Sch.	17	73.5

Table 4-C

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2226.2	4	556.55	6.920829	0.003965	3.259167
Columns	3201.75	3	1067.25	13.2715	0.000405	3.490295
Error	965	12	80.41667			
Total	6392.95	19				

In last five year study, to know the research activity in our institute we found 207 articles. It was found that the published articles were in different varieties of areas. The highest numbers of publication were published in the area of Medicine, i.e. 89, where as two number of publication were found in each area of health professions and computer science respectively. (Table - 5)

Table 5 Bibliometric publication, Analysis of publications according to different subject area

Subject Area	**Publications**
Medicine	89
Biochemistry, Genetics and Molecular Biology	48
Pharmacology, Toxicology and Pharmaceutics	29
Surgery	25
Immunology and Microbiology	5
Social Sciences	4
Neuroscience	3
Health Professions	2
Computer Science	2
Total	207

As compare to single institute, multi institutes research products are always good and effective. In our documentation it was revealed that with our institute there were several collaborative institutes in India and also abroad countries were found (Table - 6). As a health sector the investigators collaborate with 55 (fifty five) different institutes/organizations for their standard and effective output. Similarly the authors were published in 61 (sixty one) different journals (Table 7 and 8).

It is found from this study that medicine wing is the top subject in publication followed by the other departments.

Table 6 Analysis of the publications to different geographical areas

COUNTRY	Publications
India	197
Qatar	3
Saudi Arabia	3
Spain	2
United States	2
Total	207

It is understood from this study that the publication of this institutions is associated with other parts of the world.

Table 7 Association of the authors with different organizations

Name of the Institutions	Publications
Institute of Medical Sciences & SUM Hospital	117
B. J. B. Autonomous College	11
S.C.B. Medical College and Hospital	9
S O A University	7
All India Institute of Medical Sciences, New Delhi	3
Regional Medical Research Centre, Bhubaneswar	3
Kalinga Institute of Medical Sciences, Bhubaneswar	3

Sharda University	3
Navodaya Medical College	2
Postgraduate Institute of Medical Education and Research	2
Maharaja Krishna Chandra Gajapati Medical College and Hospital	2
District Surveillance Unit of Punjab under Integrated Disease Surv.	2
Indira Gandhi Institute of Medical Sciences	1
KJ Somaiya Medical College	1
Municipal Corporation of Delhi	1
Sikkim Manipal Institute of Medical Sciences	1
ASLO	1
Media Lab Asia	1
Govt. Junior College	1
School of Public Health	1
Apollo Hospital	1
Pondicherry Institute of Medical Sciences	1
Indian Association of Leprologist	1
Medwin Hospital	1
Schieffelin Institute of Health-Research and Leprosy Centre	1
Hi-Tech Medical College	1
Government Dental College and Research Institute	1
Narayan Medical College	1
Central Security Hospital	1
Health Division UNDP	1
Kalahandi Institute for Tribology and Ethnobiology	1
Roland Institute of Pharmaceutical Sciences	1
National Institute of Science Education and Research	1
Utkal University	1
CMO Office	1
NIFT	1
CRHP	1
Sri Venkateshwaraa Medical College Hospital	1

Foreign Expert	1
Division of Critical Care	1
Dr. Ram Manohar Lohia Hospital	1
UNICEF	1
Banaras Hindu University	1
L.V. Prasad Eye Institute India	1
North Shore-Long Island Jewish Health System	1
Indian Council of Medical Research	1
Universidad de Alcala	1
Department of Atomic Energy Government of India	1
Bombay Leprosy Project	1
RG Kar Medical College	1
Hamad Medical Corporation	1
Kalinga Hospital Ltd.	1
United Nations Population Fund	1
LEPRA Society	1
Maulana Azad Institute of Dental Sciences, New Delhi	1
Total	207

Table 8 Article published in different Journals

Sl No	**Name of the Journals**	No of Publications	Cumulative Publications	Percentage	Cumulative Percent
1	International Journal of Pharma and Bio Sciences	24	24	11.594	11.594
2	Asian Pacific Journal of Tropical Biomedicine	15	39	7.246	18.841
3	Asian Pacific Journal of Tropical Disease	12	51	5.797	24.638
4	Indian Journal of Public Health Research and Development	9	60	4.348	28.986
5	International Journal of Pharmaceutical Sciences Review and Research	9	69	4.348	33.333

6	Indian Journal of Dermatology	8	77	3.865	37.198
7	Journal of Clinical and Diagnostic Research	7	84	3.382	40.580
8	Indian Journal of Clinical Biochemistry	6	90	2.899	43.478
9	Indian Journal of Medical Microbiology	5	95	2.415	45.894
10	Journal of Public Health Germany	5	100	2.415	48.309
11	National Medical Journal of India	4	104	1.932	50.242
12	Indian Journal of Surgery	4	108	1.932	52.174
13	Asian Journal of Pharmaceutical and Clinical Research	4	112	1.932	54.106
14	Indian Pediatrics	4	116	1.932	56.039
15	Journal of Acute Medicine	3	119	1.449	57.488
16	Journal of the Indian Medical Association	3	122	1.449	58.937
17	Osong Public Health and Research Perspectives	3	125	1.449	60.386
18	Indian Journal of Otology	3	128	1.449	61.836
19	Indian Journal of Hematology and Blood Transfusion	3	131	1.449	63.285
20	Indian Journal of Human Genetics	3	134	1.449	64.734
21	Indian Journal of Leprosy	3	137	1.449	66.184
22	Indian Journal of Medical Research	3	140	1.449	67.633
23	Indian Journal of Orthopaedics	2	142	0.966	68.599
24	Indian Journal of Dermatology Venereology and Leprology	2	144	0.966	69.565
25	Indian Journal of Pathology and Microbiology	2	146	0.966	70.531
26	Indian Journal of Pediatrics	2	148	0.966	71.498
27	Indian Journal of Pharmacology	2	150	0.966	72.464
28	Indian Journal of Rheumatology	2	152	0.966	73.430
29	Indian Journal of Traditional Knowledge	2	154	0.966	74.396
30	Indian Journal of Tuberculosis	2	156	0.966	75.362
31	Interdisciplinary Sciences Computational Life Sciences	2	158	0.966	76.329
32	International Journal of Applied Pharmaceutics	2	160	0.966	77.295
33	International Journal of Perioperative Ultrasound and Applied Technologies	2	162	0.966	78.261

34	Annals of Cardiac Anaesthesia	2	164	0.966	79.227
35	Archives of Virology	2	166	0.966	80.193
36	International Journal of Pharmaceutical and Clinical Research	2	168	0.966	81.159
37	International Journal of Pharmacy and Pharmaceutical Sciences	2	170	0.966	82.126
38	International Journal of Pharmtech Research	2	172	0.966	83.092
39	International Journal of Preventive Medicine	2	174	0.966	84.058
40	Child S Nervous System	2	176	0.966	85.024
41	Journal of Clinical Imaging Science	2	178	0.966	85.990
42	Desidoc Journal of Library and Information Technology	2	180	0.966	86.957
43	Journal of Cytology	2	182	0.966	87.923
44	Journal of Forensic and Legal Medicine	2	184	0.966	88.889
45	Journal of Global Infectious Diseases	2	186	0.966	89.855
46	Journal of Herbal Medicine	2	188	0.966	90.821
47	Journal of Obstetrics and Gynecology of India	2	190	0.966	91.787
48	Journal of Pediatric Neurosciences	2	192	0.966	92.754
49	Journal of Pharmaceutical Sciences and Research	2	194	0.966	93.720
50	Diabetes and Metabolic Syndrome Clinical Research and Reviews	2	196	0.966	94.686
51	Journal of the Association of Physicians of India	1	197	0.483	95.169
52	Hemoglobin	1	198	0.483	95.652
53	Indian Journal of Anaesthesia	1	199	0.483	96.135
54	Neurology India	1	200	0.483	96.618
55	North American Journal of Medical Sciences	1	201	0.483	97.101
56	Ophthalmic Plastic and Reconstructive Surgery	1	202	0.483	97.585
57	Indian Journal of Critical Care Medicine	1	203	0.483	98.068
58	Pharmacologyonline	1	204	0.483	98.551
59	Photodermatology Photoimmunology and Photomedicine	1	205	0.483	99.034

60	Research Journal of Pharmaceutical Biological and Chemical Sciences	1	206	0.483	99.517
61	Tropical Biomedicine	1	207	0.483	100.000
	Total				

Discussion

The publishing research results are no more confined to a particular area or region. We can see as many as researchers of this institution have published their research results in their interested journal during the last five year period of investigation. Visibility and accessibility of journals has enhanced the scope of publications. We found that the research output is also growing during the course of investigation. It emerged that some articles have been published by researchers from different countries on collaborative basis. Joint authorship is the most preferred authorship pattern among researchers mostly for two to three authors, as it is observed that only 45 papers have been published by single author and the rest are of the joint authorship pattern of publication. Increase in the publication of research results in the journal over a period of five years unarguably corroborates the growth in research activities undertaken in this institute at global level in general and India in particular.

As discussed in this paper that the published articles are indexed and some are also not indexed, this study reveals that the authors are interested to publish their papers in indexed journals. We found that only 28 articles are published in non-indexed journals where the rest is published in indexed journals; the present investigation again proved that the highest number of publication is in scopus database. During these five years we found the pace with the improvement in its research output. This institute has a remarkable change during the period of investigation. The number of papers published increased substantially, but still further investigation is required for better output of the result. This institute has a short span of 10 years, of which we examined only

five (2009 - 2013). During this short period this institute has tried to place it's name in national and also international level of reputation.

The literature exists no prior study which similarly investigated the changes of the bibliometric visibility of research activity of a particular medical institute. DeShazo et al. showed that over the last 20 years the publication output of MI outperformed the average growth of journals indexed for Medline (Borgman & Furner 2002). Falagas et al. compared the JIF and the SJR in general: according to them, the SJR has a better coverage of the citation database (Scopus) (Moed 2002). This general statement was revisited by our study in the special case of MI journals. Recently, a comprehensive classification of bibliometric measures based on a principal component analysis was published (Raan 1996). The analysis of 39 established and proposed bibliometric measures yielded that (i) scientific impact "cannot be adequately measured by any single indicator, (ii) JIF should no longer be considered "the 'golden standard' of scientific impact". This is confirmed by our study.

Earlier analyses of biomedical and medical research typically focused on specific disciplines (Lewison 1998, Bansard et al. 2007), journals and the influence of journal impact factors (Garcia et al. 2007), and national research performance of countries (Horta & Veloso 2007). Few studies concentrated on medical school research productivity and impact on an institutional level. The methods used by the investigators of these studies differed, so comparisons of data sets were complicated. Nevertheless, discrete correlations found in certain studies offered some points of comparisons with this research. In 1983, McAllister and Narin found a much more significant linear correlation between total number of articles and NIH funding than this study (r50.95 versus r50.69, P,0.001). Changes in publishing behaviors, such as the enormous growth in the volume of scholarship, and grant funding might explain this. They

also discovered interconnectedness between impact metrics, size-dependent productivity metrics, and faculty perceptions of institutional quality (McAllister & Narin 1983). More recently, a study on peritoneal dialysis publications significantly correlated articles and citation counts (r50.63, P50.039) (Chen et al. 2007), though the significance appeared somewhat weaker than this study's findings (r50.98, P0.001). In concordance with this study's findings, British researchers concluded that research impact correlated positively to funding (Lewison & Dawson 1998, Dawson et al.). A recent JAMA study corroborated this causal relationship, discovering that funding over $20,000 generally indicated higher-quality medical education research (Lee et al. 2002). Lewison also arrived at the same conclusion as this study: an assortment of statistical indicators is essential in institutional analyses as each indicator paints a very different picture of research (Lewison 1998). Though not focused exclusively on medical schools, van Raan conducted a comprehensive institutional analysis using statistics from the 100 largest European universities. His research also found a strong correlative relationship between average citations per article (a/c) and percentage of articles that are not cited (z) (r5-0.92), which bolstered the current study's principal components analysis and basic linear correlation (r520.74, P,0.001). Other metrics from the current study exhibited similar associations with van Raan's power law analysis, including strong correlations between total articles (a) and total citations (c) (r50.98, P,0.001; van Raan, r50.89) and a negligible correlation between total articles (a) and percentage of articles that were not cited (z) (r520.255, P50.002; van Raan, r50.35) (Van Raan 2008).

Degree of collaboration

Degree of collaboration is an examination of the prominent area of inquiry in bibliometric studies indicating the trend in patterns of single and joint authorship in the publication of IMS & SUM Hospital during this five year period under study, as shown in Table-9. The degree of

collaboration "C" is 0.78 that means there is the dominance of single authors on the multiple authors.

Table-9 Degree of collaboration

	Single Author Paper (N_S)	Multiple Author Paper (N_M)	$N_M + N_S$	Degree of Collaboration (C)
2009	6	15	21	0.71
2010	12	20	32	0.63
2011	11	32	43	0.74
2012	7	43	50	0.86
2013	9	52	61	0.85
Grand Total	**45**	**162**	**207**	**0.78**

The extent of collaboration in research can be measured with the help of the formula:

$$C = \frac{N_M}{N_M + N_S}$$

Where, C= Degree of Collaboration
NM = Number of multiple authors
NS = Number of single authors

Application of Bradford Law:

Bradford's law of scattering states that:

If we arrange the scientific journals in order of decreasing productivity of articles on a given platform, it may be found some nucleus of periodicals more particularly devoted to the subjects and several other groups or zones containing the same number of articles as the nucleus when the number of periodicals in the nucleus and succeeding zones will be as 1: n: n^2: n^3… (Vickery, 1993).

Applying the law into the present context of the whole sample of 207 publications published in 61 different journals (table 8) can be divided into three equal zones. This study reveals that first zone contains 5 core journals as they come under the nuclear zone. The second quantum of journals forms the second zone which contains the next 16 journals approximately. These 16 journals are called "allied journals" as those come under the first peripheral zone around the nucleus. The third and the final quantum of journals form the third zone and contain the remaining 40 journals which is second peripheral zone. These 40 journals are called "alien journals".

The ratio of number of journals in these three zones is 5: 16: 40. It is almost equivalent to 5: 5×3: 5×3^2 where 5 represent the number of journals in the nucleus and n = 3 is a multiplier. This is well known Bradford's pattern, i.e. m: m*n: m* $(n)^2$. Here 'm' is number of core journals in a discipline and 'n' is known as Bradford multiplier. Therefore, Bradford's law of scattering is confirmed by this collected data.

Conclusion

The publishing interest is purely dependant on the author's output, contribution pattern and the research quality. Our study reveals considerable growth in publications of IMS & SUM Hospital. We found a good number of publications both in clinical and pre clinical departments of this institute during last five years, with minimal contribution to the global research output. Hence, it is an urgent necessity to setup an enabling environment for research, with a proper vision, institutional support, adequate funds and appropriate training. In addition, collaboration across the region needs to be strengthened to efficiently face future regional health care challenges. This

investigation also revealed that the number of publication is gradually increased from year to year.

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