How relevant is medical research done in India? – A study based on *Medline*

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Does India perform medical research in areas where it is most needed? According to Government of India sources, India suffers mainly from diarrhoeal diseases, infancy diseases, respiratory diseases, tuberculosis and malaria. An analysis of journal use as seen from seven years of Medline reveals that Indian researchers are active in general and internal medicine, paediatrics, pharmacology, immunology, pathology, oncology, surgery, cardiovascular research, gastroenterology and neurosciences. Apart from analysing the reasons for the mismatch, this study provides inventories of the amount and nature of available expertise and its institutional and geographic distribution.

THIS piece of research is based on the premise that quantitative information on the output of the health research community is a valuable first step in the complex process of improving the contribution health research makes to the solution of a nation's health problems[1], and the belief that scientometric tools, developed and used in the West, can be adapted to study many aspects of scientific activity in India[2]. Apart from trying to quantify medical research in India and evaluating its relevance to the country's needs, I draw attention to the need for exercising caution in using international databases in evaluating indigenous research performance.

Any human endeavour, especially one that involves public funding, should be subjected to assessment and performance review. Research is no exception. For a very long time, scientific research in India was thought to be an inherently good thing deserving public support, and not much attention was paid to assessment and performance review. Those days of idealism are over. Now both the government and the taxpayers, not only in India but around the world, are more pragmatic and they would like to see their investment in research bring in adequate returns.

Indeed the US Congress passed in 1993 the Government Performance and Results Act, and the Clinton Administration initiated in the same year the National Performance Review, which focused on the performance of all government programmes including the assessment of the government's investments in research. In assessing research performance, one is not merely interested in the economic returns and social impact of research but also in the quality of research and its impact on advancement of knowledge.

In the West there has been a tradition of evaluation of research, witness the large number of articles in this area published in journals like *Scientometrics, Science and Public Policy, The Scientist, Science Watch* and *Journal of the American Society of Information Science*. The US National Science Foundation started bringing out its biennial Science Indicators reports (now Science and Engineering Indicators) as early as 1972. A few years ago, the Ciba Foundation organized a symposium on evaluation of research in which the world's leading experts such as Alvin Weinberg, Eugene Garfield, the late Michael Moravcsik and Tibor Braun took part[3]. One aspect, viz relevance of research, I thought, was not given as much attention in that symposium as it deserved.

The question of relevance is especially important in a developing country, where scarce resources have to be used judiciously. The relatively low research expenditure underlines the importance of making appropriate strategic research choices. Also, as pointed out by Hicks *et al.*[1], 'it is important that health research priority setting be developed in tandem with existing research capacity. This underlines the importance of assessing the amount and nature of available expertise and positioning research output, both in the national health needs, and in the international science research contexts[1].'

In early 1995, I looked at the relevance of medical research in India, by looking at the disease pattern as revealed by mortality and morbidity statistics on the one hand and, on the other, the journals used by Indian medical researchers to publish their work as seen from five years of *Science Citation Index* (1981–1985), and came to the tentative conclusion that there was a substantial mismatch between the needs and the areas where work was being done[4]. My findings received considerable attention, perhaps because, while bibliometric analysis has been used for many other purposes, it has rarely been used to evaluate the relevance of a nation's research programme. Besides, few attempts have been made so far to inventory and assess the quantity and

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Table 1. Journals used often by Indian researchers to publish their papers in medical research [Source: *Medline* Nov. 1987– Dec. 1994]

Journal	Country	Subject	Impact factor	No. of papers
Indian Pediatr.	IND	Pediat.	0.000	801
Indian J. Exp. Biol.	IND	Biology	0.000	777
J. Assoc. Physicians India	IND	Med. Gen.	0.000	705
Indian J. Med. Res.	IND	Med. Gen.	0.000	569
J. Indian Med. Assoc.	IND	Med. Gen.	0.000	396
Indian J. Physiol. Pharmacol.	IND	Physiol. //Pharmacol.	0.000	377
Bull. Environ. Contam. Toxicol.	USA	Env. Sci.	0.766	321
Biochem. Int.	AUS	Bioch. Mol.	0.690	314
Indian J. Biochem. Biophys.	IND	Bioch. Mol. //Biophys.	0.000	298
Indian J. Pediatr.	IND	Pediat.	0.000	287
Indian J. Pathol. Microbiol.	IND	Pathology	0.000	279
J. Postgrad. Med.	IND	Med, Gen.	0.000	254
Indian J. Lepr.	IND	Dermatol. //Immunol.	0.000	237
Indian J. Gastroenterol.	IND	Gastro.	0.000	235
Indian Heart. J.	IND	Cardiovasc.	0.000	234
Int. J. Cardiol.	NLD	Cardiovasc.	0.545	186
Indian J. Cancer	IND	Oncology	0.000	167
Mutat. Res.	NLD	Genetics	1.727	159
Indian J. Ophthalmol.	IND	Ophthal.	0.000	152
Biochem. Biophys. Res. Commun.	USA	Bioch. Mol. //Biophys.	3.803	145
Biochem. Biophys. Acta	NLD	Bioch. Mol. //Biophys.	2.460	137
Indian J. Chest Dis. Allied Sci.	IND	Resp. Sys.	0.000	137
J. Commun. Dis.	IND		0.000	135
Indian J. Malariol.	IND		0.000	125
Indian J. Med. Sci.	IND	Med. Gen.	0.000	119
Natl. Med. J. India	IND	Med. Gen.	0.000	108
Mol. Cell Biochem.	NLD	Bioch. Mol.	1.149	103
Indian J. Dermatol.	USA	Dermatol.	0.534	101
Cancer Lett.	NLD	Oncology	1.075	97
Plant Foods Hum. Nutr.	NLD	Nutri. Diet.	0.000	95
Trans. R. Soc. Trop. Med. Hyg.	UKD	Pub. Health	1.175	94
J. Ethnopharmacol.	CHE	Botany //Pharmacol.	0.412	92
J. Laryngol. Otol.	UKD	Otorhino.	0.317	88
Int. J. Lepr. Other Mycobact. Dis.	USA	Pathology	0.000	85
Contraception	USA	Obst. Gyne.	1.038	83
Indian J. Publ. Health	IND	Pub. Health	0.000	83
J. Surg. Oncol.	USA	Oncology //Surgery	0.492	82
Ecotoxicol. Environ. Safety	USA	Env. Sci. //Toxicol.	1.155	78
FEBS Lett.	NLD	Bioch. Mol. //Biophys.	3.479	77
Br. J. Urol.	UKD	Urol. Neph.	0.695	76

quality of existing research capacity, especially in the health sector, in developing countries. I knew all along that it would not be advisable to draw conclusions entirely based on my analysis of the *SCI* data of five years, as *SCI* had covered during the period I took for analysis just one Indian medical journal, viz *Indian Journal of Medical Research*. In medical research, unlike in physics or chemistry, a high proportion of papers was likely to be published in local or national journals.

I decided to repeat the study, this time using the CD-ROM version of the standard edition of *Medline* as my source instead of *SCI*.

Methodology

I collected data from *Medline* 1987 November to 1994 December. I chose a fairly long period to avoid possible misleading conclusions that might arise from deviations that could result from short-term fluctuations in emphasis on research in different medical specialities. As *Medline* does not always include complete addresses of authors, making a search by merely giving 'India' in the address field, one would miss many Indian papers. I included the names of all Indian cities and towns where there are higher educational and medical research institutions. For all entries originating in India, I downloaded the necessary bibliographic data and converted them into a database. The analysis of the data for identifying prolific institutions and cities/towns, journals used for publishing papers from Indian institutions, etc. was carried out using Foxpro.

Problems pertaining to data analysis

There were a few issues to be resolved. The first related to the level of aggregation at which India's contribution to medical literature is classified. Should it be at the individual article level? That would be ideal, but next to impossible. I decided to look at India's contribution at the journal and institutional levels. Following the example of CHI Research, Inc.[5] and ISSRU of the Hungarian Academy of Sciences[6], I allotted whole journals to subfields and subfields to major fields, and classified each paper into the field/subfield of the journal in which it was published. The second concerned the classification of diseases and journals. Diseases are usually classified as pertaining to different systems such as respiratory system, circulatory system, and nervous system, whereas journals are classified under fields and subfields such as allergy, andrology, gastroenterology, and surgery. By and large, I used the classification of journals followed by *SCI* and given in the *SCI Guide*[7]. For non-*SCI* journals, I used the classification used by Ulrich, the well-known reference source on serials literature. The world scientometric community is fully aware of the problems in all kinds of classification. These were discussed at a one-day workshop[8] immediately following the Fifth Biennial International Conference of the International Society of Scientometrics and Informetrics at River Forest, IL, USA, in June 1995. The third problem related to the correctness of the mortality and morbidity data. These were collected from a report of the World Health Organization's South East Asia Regional Office[9], New Delhi, and the report clearly states that the data were provided by Indian agencies and they were reliable to only a certain extent.

Results and discussion

Journals used

In the seven years (as seen from *Medline* Nov. 1987–Dec. 1994), Indian researchers had published 19,952 items in 1440 journals. Of these, 19,916 were journal articles (as classified by *Medline*), nine were letters and eight clinical trials.

The 40 journals in which Indian researchers had published at least 75 papers in the seven years are listed in Table 1, along with the number of papers published in each one of them, the journal country and the subject category to which the journal belongs. Some journals belong to more than one medical subfield, e.g. *Indian Journal of Leprosy* is classified under three subfields, viz. dermatology, immunology and pathology. At the time of writing, a few journals were left unclassified, as they are neither indexed in *SCI* nor are they listed in the print version of Ulrich. Table 1 also gives the impact factors of the journals taken from *Journal Citation Reports* 1991. An impact factor of 0.0 means that the journal is not indexed in *SCI*.

Of these 40 journals, 21 are published in India. The top six in this list as well as 13 out of the top 15 are Indian journals. There were nine other Indian journals (not included in Table 1) from which *Medline* had indexed at least one paper during the period studied. These are: *Trop. Gastroenterology* (69 papers), *Hindustan Antibiotics Bulletin* (33), *Journal of the Indian Society of Pedod. Prev. Dent.* (28), *Indian Journal of Dental Research* (27), *Journal of the Pierre Fauchard Academy* (14), *Fed. Oper. Dent.* (12), *Journal of the Indian Dental Association* (11), *Indian Journal of Dermatology* (9), and *Acta Anthropogenetica* (6). Thus *Medline* had covered thirty Indian journals during the period under study. Not all 30 were, however, covered in each one of the seven years. For instance, in 1992, it covered only 22 of them. Three of the 30 Indian journals indexed in *Medline* (viz. *Indian Journal of Biochemistry and Biophysics, Indian Journal of Experimental Biology* and *Acta Anthropogenetica*) are not mainstream medical journals.

Most Indian papers indexed in *Medline* had appeared in low-impact journals. Nearly three-fourths (14,822 out of 19,952) were published in journals whose impact factor (*JCR* 1991) was less than 1.0 or in journals which were not indexed in *SCI*. These include 9,525 papers in 530 non-*SCI* journals (impact factor taken to be 0.0) and 5,297 papers in 419 journals with impact factor less than 1.0. Only 58 papers were published in journals whose impact factor was higher than 8.0. Besides, some of these papers in high impact journals, such as the 12 papers in the *Proceedings of the National Academy of Sciences USA*, may not be mainstream medical research papers and are most likely to be in related areas such as new biology/biomedical research.

Analysis by subfield

Medline covers not only the literature of medicine, but also related fields such as biochemistry, biophysics and even chemistry and materials science (biomaterials). In Table 2, I list only papers that are classified under 4 subfields of medicine. In these subfields, authors from Indian institutions have used 1013 journals to publish 13,855 articles. As some journals are included in mor than one subfield, totalling by subfield leads to 1368 journals and 18,244 articles as seen from Table 2. There is a large difference between the two sets of numbers. Take, for example, pharmacology. If we include Indian articles in all journals under the subfield, there are 1367 papers published in 94 journals. But, if we avoid duplicate counting, the number of journals drops to 53 and articles to 398. There is a reason for this large drop: whenever a journal is classified under pharmacology and one or more other categories, pharmacology is the one which gets left out as most of the time the subfields under which a journal falls are arranged alphabetically. In many cases, the additional category is not among the 45 subfields listed in Table 2 (see note 1).

Table 2. Indian research papers covered by *Medline* Nov. 1987–Dec. 1994 classified by subfields

Subject	No. of journals	No of papers	No. of journals	No. of papers
		(No duplicates)		
Med. Gen.	57	2394	52	2374
Pediat.	43	1420	33	1367
Pharmacol.	94	1367	53	398
Immunol.	74	928	61	534
Pathology	48	916	21	465
Oncology	56	821	39	692
Surgery	68	750	35	335
Cardiovasc.	41	663	41	663
Gastro.	26	606	25	537
Neurosci.	101	584	88	513
Pub. Health	46	569	27	405
Toxicol.	42	568	16	207
Microbiol.	52	553	32	365
Dermatol.	25	551	24	516
Physiol.	30	533	16	445
Trop. Med.	13	432	6	152
Obst. Gyne.	37	417	31	386
Radiol.	52	403	34	277
Ophthalmol.	28	362	25	342
Vet. Med.	30	302	22	178
Endocr.	41	300	34	233
Parasitol.	20	292	15	251
Urol. Neph.	25	283	21	258
Resp. Sys.	17	280	12	258
Nutri. Diet.	20	278	15	229
Med. Res.	38	208	25	146
Psychiat.	30	184	22	152
Dentistry	29	169	26	162
Anatomy	20	149	20	149
Otorhino.	16	135	15	131
Orthoped.	20	122	17	101
Virology	10	97	9	91
Allergy	8	92	8	92
Med. Mis.	16	88	14	76
Andrology	4	82	4	82
Hematol.	20	77	17	60
Anesthes.	11	67	9	61
Psychol.	19	46	11	25
Med. Leg.	7	39	7	39
Geriatrics	8	35	7	34
Med. Lab.	7	27	7	27
Rheumatol.	7	27	7	27
Sub. Abuse	9	24	7	16
Epidemiol.	1	2	1	2
Nursing	2	2	2	2
Total	1368	18244	1013	13855

*Whenever a journal is included in more than one subfield, to avoid duplicate counting, it is taken into account under only one category (which is given as the first subfield in Table 1); often, this happens to be the category which has alphabetical precedence.

Indian researchers have used 101 journals to publish 584 papers in neurosciences, and 94 journals to publish 1367 papers in pharmacology. In contrast, at the other end of the spectrum, they have used just one epidemiology journal to publish two papers, and two nursing journals to publish two papers. In terms of number of papers published, general medicine tops the list with 2,394 papers. Research medicine (208 papers) and general medicine (2,394 papers) together account for 2,602 papers. One can take this number as India's contribution in the area of general and internal medicine. Paediatrics comes next with 1,420 papers, followed by pharmacology (1,367), immunology (928), pathology (916), oncology (821), surgery (750), cardiovascular research (663), gastroenterology (606) and neurosciences (584).

The top ten fields in Indian medical research, in terms of number of papers published, do not include tropical medicine and respiratory system diseases, two areas which are very important in India, as seen from mortality and morbidity statistics (Table 3). Cancer/oncology and cardiovascular diseases do not figure in Table 3, and yet relatively considerable amount of research is being carried out in India in these areas. Again, with more than nine million blind, including two million children, India tops the world in the incidence of blindness. India also suffers from a very high incidence of glaucoma and cataract. But, there is hardly any research in ophthalmology.

Analysis by journal country

In Table 4, I have classified Indian papers indexed in *Medline* by journal country. The number of Indian journals covered by *Medline* is only a small fraction of the more than 250 Indian journals received at the National Library of Medicine, National Institutes of Health, Bethesda, MD, USA, the publishers of *Medline*. Thus, while *Medline*'s coverage of Indian journals is better than the coverage in *SCI*, which covers only one medical journal from India, viz. *Indian Journal of Medical Research*, it also leaves out a very large number of Indian journals. The fact is, simply, many Indian journals do not meet the criteria for inclusion in *Medline*. Editors and publishers of Indian journals should examine why Indian journals do not measure up to the expectations of

Table 3. Leading causes of mortality and morbidity in India by rank order

1983–1985	1988–1990	1991–1993
	Leading causes of mortality	
Senility	Infectious and parasitic diseases	Diarrhoeal diseases
Respiratory diseases	Circulatory system diseases	Respiratory diseases
Infancy diseases	Respiratory diseases	Infancy diseases
Circulatory diseases	Injury/poisoning	Pneumonia
Fevers	Diarrhoeal diseases	Infectious and parasitic diseases
	Leading causes of morbidity	
	Diarrhoeal diseases	Respiratory diseases
Data not	Influenza	Diarrhoeal diseases
available	Malaria	Malaria
	Tuberculosis	Whooping cough/Measles
	Whooping cough	Neonatal tetanus

Source: *Health Situation in the South-East Asia Region 1991–1993*, World Health Organization Regional Office for South-East Asia, New Delhi, 1995, pp. 40–41.

international database producers. Samiran Nundy and colleagues at the All India Institute of Medical Sciences have carried out a study on the quality of Indian medical journals and they found that most of them are poor[10,11]. On a request from the Indian Council of Medical Research, Nundy and colleagues examined 113 serious English-language journals published in India covering a wide range of subjects such as anaesthesiology, genetics, parasitology, social and preventive medicine and urology[11]. Most of these journals were sponsored by professional societies and academic bodies and all but a handful were not coming out on time and only a few were indexed in international secondary services (three in *Current Contents*, 22 in cumulated *Index Medicus* and 26 in *Excerpta Medica*). Says Nundy[10]: 'most journals not included in the international indexing services did not deserve to be included.'

Nundy and co-workers have also found from an analysis of the publication output of more than 125 Indian medical institutions, as seen from eight years of *SCI*, that most of these institutions are not active in research[12]. This view is in general agreement with the opinion of M. S. Valiathan, who points out that India has hardly contributed anything to modern surgery[13]. Noting that starting from the late nineteenth century a number of Indian physicians and surgeons had gone to Britain, and lately to the US as well, for training and that many of them had won respect and acceptance all over the world for their competence and universality of outlook, Valiathan wonders why, despite all the achievements, 'India's name did not figure in the honour roll of nations which contributed to the advancement of surgical knowledge despite her wholehearted adoption of European medicine and surgery.' In his view, 'India enjoyed a free ride in surgery from the nineteenth century, borrowing Western theory and practice and contributing nothing.' Valiathan is emphatic in asserting that 'in surgery India lives on borrowed intellectual capital' and that 'no concept, no discovery, no technology or procedure originated in India which shaped or directed the course of global surgery[13].'

Overall, Indian researchers use Indian journals the most, followed by US, UK, Dutch, German and Swiss journals (Table 4). A very large percentage of Indian papers in paediatrics (1,088 out of 1,420), general medicine (2,151 out of 2,394) and physiology (377 out of 533) had appeared in Indian journals. In tropical medicine, an area of considerable importance to India, Indian research publications had appeared mainly in British journals: 69 in Indian journals and 238 in UK journals. In neurosciences, India had published all her papers in foreign journals, mostly in US and UK journals.

Use of British vs American journals

There were six papers in *British Medical Journal* and 22 in *Lancet* in my *Medline* sample, but none at all in the *Journal of American Medical Association* and only one in the *New England Journal of Medicine*. There were two papers in *Nature* and one in *Science*. Two points are evident. One, not all papers published in *Nature* and *Science* are indexed in *Medline*. This is understandable as those not indexed may not pertain to medicine. What is surprising is that not all papers from India in *Lancet* are also being indexed in *Medline*! For example, *SCI* 1992 (CD-ROM version) has indexed 30 papers published in *Lancet*, from India[14], but *Medline* has indexed only 22 in seven years. Two, it appears to be far more difficult for Indian researchers to get their papers published in leading American journals than in British journals. Data from four years of *SCI* (1989-1992) show this fact not only with respect to *Lancet* and *NEJM* but also with respect to *Nature* and *Science*[14]. There could be many reasons, such as page charges levied by American journals, editors' attitudes and India's historical links with the UK. Editors' attitudes do matter. The editor of the *Lancet* Richard Horton, the former editor of *BMJ*, Stephen Lock and the current editor Jane Smith are known to be sympathetic to Third World researchers. The *BMJ* editors have come to India more than once to exchange views with Indian editors and to conduct training programmes on medical writing. Richard Horton, as chair of the World Association of Medical Editors, assembled a global network of researchers to assist editors of Third World journals in establishing peer review processes. Horton believes that often cultural differences are misinterpreted as bad science[15]. In contrast, the editor of *New Engl. J. Med.*, Jerome P Kassirer is on record as having said that 'what developing countries should receive is guidance on nutrition and immunizations before getting advice on medical editing'. He says

Table 4. India's contribution to the journal literature of medicine arranged by country of publication of the journals [Source: *Medline* Nov. 1987–Dec. 1994]

Journal country	No. of journals	No. of papers
India	30	6684
USA	509	4428
United Kingdom	314	3158
Netherlands	91	1688
Germany	121	891
Switzerland	81	638
Australia	20	603
Denmark	30	312
Japan	45	251
Czechoslovakia	13	235
Italy	45	232
Sweden	16	170
Canada	14	86
Hungary	9	85
France	25	74
Belgium	8	66
Spain	4	51
Austria	4	49
Thailand	2	46
Poland	10	37
Singapore	3	28
Bangladesh	1	25
Norway	5	19
Greece	2	15
Brazil	5	11
Ireland	5	9
Israel	3	7
Chile	1	6
China	2	6
Korea	2	5
Mexico	2	5
Pakistan	1	5
South Africa	3	4
Hong Kong	1	3
Sri Lanka	1	3
New Zealand	1	3
Yugoslavia	2	3
Costa Rica	1	2
Finland	2	2
Venezuela	1	2
Bulgaria	1	1
Egypt	1	1
Kenya	1	1
Malaysia	1	1
Romania	1	1
Total	1440	19,952

Table 5. Contribution made by different types of institutions as seen from *Medline* (Nov. 1987–Dec. 1994)

Academic	13,111
Research	3805
Ministries	1055
Others	1643
State	183
Private	151
International	4
	19,952

Academic			
College		*University*	
Medical	4812	General	4354
General	194	Medical	194
Engineering	129	Agriculture	390
Agriculture	17	Engineering	14
	5152		4952

Research Institutions	
Council of Scientific and Industrial Research	1578
Indian Council of Medical Research	1007
Dept. of Atomic Energy	874
Defence Research and Development Organization	215
Indian Council of Agricultural Research	131
	3805

Ministries			
Health and Family Welfare	642	Home	10
Science and Technology	317	HRD	8
Planning	35	Steel and Mines	2
Industry	27	Env. and Forest	1
Agri. and Rural Develop.	11	Finance	1
		Labour	1
			1055

Others	
Hospitals and Clinics	1650
General	144
	1794
State	
Health and Family Welfare	137
Home	30
Industry	13
Steel and Mines	2
Public Health	1
	183
International (ICRISAT)	4

that 'very poor countries have much more to worry about than doing high quality research', and that 'there is no science there'[15]. Similar is the attitude of Floyd E. Bloom of *Science*. For him, poor language skills also mean poor science! 'If you see people making multiple mistakes in spelling, syntax and semantics, you have to wonder whether when they did their science they weren't also making similar errors of inattention'[15].

The academic links are also equally important. For historical reasons, many Indians go to Britain for higher education in medicine and unlike those who go to the USA most of them return to India to set up practice and pursue research. Indian students use many British textbooks, many of them available as ELBS low-cost editions. The British Council libraries located in major Indian cities have excellent collections of medical books, journals and reference sources, and doctors form a substantial segment of the membership.

Table 6. Indian institutions often publishing papers [Source: *Medline* Nov. 1987–Dec. 1994]

Institution	No. of papers
All-India Institute of Medical Sciences, New Delhi	1630
Post-Graduate Institute of Medical Education and Research, Chandigarh	1383
Banaras Hindu University, Varanasi	635
Tata Memorial Centre and Cancer Research Institute, Bombay	512
Christian Medical College and Hospital, Vellore	493
Industrial Toxicology Research Centre, Lucknow	383
Indian Institute of Science, Bangalore	369
Central Drug Research Institute, Lucknow	357
Indian Institute of Chemical Biology, Calcutta	266
King Edward Memorial Hospital, Bombay	255
Maulana Azad Medical College, New Delhi	254
Kasturba Medical College, Manipal	248
University of Madras, Madras	235
K. G. Medical College, Lucknow	234
Panjab University, Chandigarh	231
National Institute of Mental Health and Neurosciences, Bangalore	229
Jawaharlal Nehru University, New Delhi	227
Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow	226
Bhabha Atomic Research Centre, Bombay	221
Medical College, Rohtak	214
Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry	214
G. B. Pant Hospital, New Delhi	213
Calcutta University, Calcutta	200
Seth G. S. Medical College, Bombay	199
Sree Chitra Tirunal Institute for Medical Sciences, Trivandrum	187
University College of Medical Sciences, Delhi	174
University of Delhi, Delhi	173
Centre for Cellular and Molecular Biology, Hyderabad	170
Calcutta Medical College and Hospital, Calcutta	145
Punjab Agricultural University, Ludhiana	145
National Institute of Immunology, New Delhi	142
Lady Hardinge Medical College, New Delhi	141
St. John's Medical College, Bangalore	135
Lokmanya Tilak Municipal Medical College and General Hospital, Bombay	134
Haryana Agricultural University, Hisar	133
Institute for Research in Reproduction, Bombay	126
Jawaharlal Nehru Medical College, Aligarh	125
Bose Institute, Calcutta	125
Safdarjang Hospital, New Delhi	116
Indian Council of Medical Research, New Delhi	115

Analysis by institution

The distribution of papers by institutional type is given in Table 5. Academic institutions (universities and colleges) are the leading publishers of medical research papers. Central government institutions have published more papers than state government institutions. Interestingly, Council of Scientific and Industrial Research laboratories have published more papers than Indian Council of Medical Research (ICMR) laboratories. But then ICMR receives very little funding. The Department of Atomic Energy (DAE) accounts for more papers than the institutions under the Ministry of Health and Family Welfare. This is not only because DAE is a far more high profile outfit but also because it has two institutions, viz. Tata Memorial Centre and Cancer Research Institute, Bombay, which publishes a large number of papers, and Bhabha Atomic Research Centre, Bombay, the flagship of DAE, which also contributes a good deal in the area of radiology and nuclear medicine.

Indian institutions which had contributed more than 115 papers in the period under study are listed in Table 6. Only two institutions, viz. All India Institute of Medical Sciences, New Delhi, and Post Graduate Institute of Medical Education and Research, Chandigarh, had published more than 1000 papers each in the seven years studied, and two more, viz. Banaras Hindu University, Varanasi, and Tata Memorial Centre and Cancer Research Institute, Bombay, had published more than 500 papers. Seven other institutions have published more than 250 papers each.

Analysis by city

The distribution of papers by city is given in Table 7. Only cities which have published more than 100 papers are listed. Delhi (including New Delhi) tops the list with 4021 papers. This is largely due to the concentration of institutions performing research in the capital and their proximity to funding agencies, almost all of which are also located in the same city. Why should there be so much concentration of medical research centres in the nation's capital? Sane voices like that of Nundy advocate decentralization of health care and health research facilities. The major institutions contributing to medical research in Delhi are the All India Institute of Medical Sciences, Maulana Azad Medical College, Jawaharlal Nehru University, G. B. Pant Hospital, University College of Medical Sciences, University of Delhi, and National Institute of Immunology. Note that both Jawaharlal Nehru University and University of Delhi figure in the list largely because of their contribution to biomedical research which are also indexed in *Medline*; in fact, their contribution to medical research proper is rather meagre. The same is the case with the Indian Institute of Science, the seventh leading Indian institution in terms of number of papers indexed in *Medline*. Delhi is followed by Bombay, Chandigarh, Calcutta and Lucknow, all of which had contributed more than 1,250 papers each in the seven years. The other major contributors are Bangalore, Hyderabad, Madras, Varanasi, Vellore and Thiruvananthapuram. Delhi, Maharashtra, Uttar Pradesh and West Bengal are the leading states. Maharashtra and West Bengal owe their positions largely to Bombay and Calcutta respectively, whereas contributions from Uttar Pradesh come from Lucknow, Varanasi and Aligarh.

Table 7. Indian cities' and states' contributions to the world literature of medicine as seen from *Medline* (Nov. 1987–Dec.1994)

City	No. of papers	State	No. of papers
Delhi	4021	Delhi	4021
Bombay	2268	Maharashtra	2823
Chandigarh	1654	Chandigarh	1654
Calcutta	1490	West Bengal	1581
Lucknow	1253	Karnataka	1463
Bangalore	886	Tamil Nadu	1319
Hyderabad	671	Andhra Pradesh	910
Madras	663	Kerala	511
Varanasi	648	Punjab	418
Vellore	494	Haryana	397
Trivandrum	418	Madhya Pradesh	362
Pune	373	Gujarat	360
Pondicherry	324	Pondicherry	324
Manipal	272	Rajasthan	318
Ludhiana	261	Jammu & Kashmir	168
Rohtak	222	Bihar	150
Aligarh	216	Orissa	135
Mysore	169	Himachal Pradesh	110
Ahmedabad	165	Meghalaya	68
Hisar	143	Goa	60
Srinagar	129	Assam	39
Agra	127	Manipur	8
Gwalior	125	Tripura	3
Tirupati	114		
Madurai	109		
Baroda	106		
Jaipur	95		
Amritsar	90		
Nagpur	84		
Patna	77		
Allahabad	72		
Shillong	68		
Jabalpur	67		
Mangalore	65		
Patiala	65		
Kanpur	59		
Shimla	58		
Bambolim	57		
Bhubaneswar	57		
Meerut	57		
Indore	54		
Jammu Tawi	53		
Udaipur	51		
Jodhpur	50		

Comparison of analysis based on *SCI* and *Medline*

While by and large the conclusion drawn from the earlier study based on *SCI* data[4] – that a large part of the medical research carried out in India is not in areas where research is needed the most – is validated by this study, there are a few significant differences. In Table 8, I list different subfields of medicine in which India is active in research. There are three lists in descending order of number of papers from India, the first two based on medical journals (under 45 subfields) indexed in *Science Citation Index* in two different periods, and the third based on *Medline* data discussed in this paper.

1. The *Medline*-based study, unlike the *SCI*-based study, indicates that India performs considerable amount of research in paediatrics, an area where much research is truly warranted by mortality statistics. This is largely because most paediatrics papers from Indian institutions have appeared mainly in two Indian journals, viz. *Indian Pediatrician* and *Indian Journal of Pediatrics,* which are covered by *Medline* but not by *SCI*. Another area of considerable importance to India where research is shown to be done in India by our analysis of *Medline* data is gastroenterology. This area did not figure as an active area in our analysis of *SCI* data[4] (see Table 8).

2. The *SCI* data showed that India was doing relatively well in tropical medicine[4], but in the *Medline* data, tropical medicine is not among the top ten fields, in terms of number of papers published. In the *Medline* ranked list, it has dropped to the 16th place; it holds the sixth rank in *SCI* 1981-1985 list and fifth rank in the *SCI* 1991-1993 list (see Table 8). While general and internal medicine and pharmacology occupy roughly the same ranks, viz. within the top three positions, there is considerable variation in the ranks of some fields, e.g. microbiology, pathology and neurosciences. While some of these differences could be attributed to shifting emphasis over time, one cannot ignore the effect of the

Table 8. The relative position of different subfields in terms of number of papers published in three different periods as seen from *SCI* and *Medline*

SCI 1981–1985		*SCI* 1991–1993		*Medline* 1988–1994	
Subfield	No. of papers	Subfield	No. of papers	Subfield	No. of papers
Medicine, General	1640	Medicine, General	817	Medicine, General	2394
Microbiology	976	Pharmacology	665	Pediatrics	1420
Pharmacology	935	Immunology	419	Pharmacology	1367
Endocrinology	367	Surgery	342	Immunology	928
Radiology	301	Tropical Medicine	341	Pathology	916
Tropical Medicine	290	Oncology	322	Oncology	821
Neurosciences	263	Neurosciences	317	Surgery	750
Hygiene	249	Microbiology	311	Cardiovascular	663
Oncology	240	Toxicology	294	Gastroenterology	606
Surgery	226	Cardiovascular	294	Neurosciences	584
Parasitology	202	Pathology	256	Public Health	569
Physiology	186	Radiology	227	Toxicology	568
Pathology	172	Public Health	212	Microbiology	553
Obstetrics	163			Dermatology	551
Immunology	154			Physiology	533
				Tropical Medicine	432

degree of comprehensiveness with which a database covers Indian research in different fields.

It is important, therefore, to know the limitations of the databases used before we draw conclusions!

The interest in cancer and cardiovascular research has another dimension. Although these are not diseases that affect most people in India, i.e. relative to other diseases such as respiratory, diarrhoeal and infectious and parasitic diseases, there are enough rich patients with these ailments who are willing to pay any amount in selected urban hospitals. Doctors in such hospitals are better endowed to carry out research and publish their findings. Many of them have had overseas training, especially in the UK and the USA, where cancer and cardiovascular diseases are rather important. Also, unlike in less expensive hospitals, doctors in such hospitals are not overworked and they can find time to do research and write up their findings.

Lack of co-ordination

Overall, researchers seem to enjoy a lot of freedom in the matter of choice of research problems. There seems to be no co-ordination by an apex agency on what is being pursued. Analysing data from *Medline* on medical research publications from India's southern state of Kerala, Kartha and Mohandas[16] have come to similar conclusions: 'There is a striking contrast between major health problems and those that attract attention of researchers. While infection, parasitic diseases, perinatal and pregnancy-related problems, skin diseases, respiratory diseases and nutritional disorders are the major health problems in the state, a large number of publications are related to cardiovascular problems and cancer. This may be because there are three institutions completely devoted to these disciplines. Even in these areas it is debatable whether research efforts are matched with the needs of the beneficiaries.' Echoing Valiathan's concern on the lack of original contributions from India, Kartha and Mohandas[16] lament that 'simple diagnostic tests for case detection, new modalities for treatment, strategies for identifying high risk population for a specific disease, or methods for prevention of a disease have not been so far originally reported from Kerala'. In their view, 'emerging health problems related to substance abuse, behavioural, environmental and occupational diseases, and mental health problems have not attracted the attention of investigators. Research efforts to a large measure appear to be along beaten tracks, thus leading to very few facts of strategic value being collected'[16].

Conclusion

What Valiathan[13] has said in the context of surgery may very well apply to all of medicine, and what Kartha and Mohandas[16] have stated out of their experience in Kerala may very well apply to all of India. As Samiran Nundy points out succinctly, Indian health care is not good and we should try and improve it; we want our medical profession to have higher standards; and we should not copy Western countries, but do research into our own problems and spend a little more money on health[17]. Laments Sunil Pandya[18], a Bombay-based neurosurgeon: 'Clinical research in India is woefully deficient and inadequate in spite of the availability of an almost unmatched reservoir of patients and illnesses, i.e. clinical and pathological material.' The most important reason for this, says Pandya, is the absence of a culture of research[18]. It would be useful to investigate the role played by professional bodies such as the Indian Medical Association, the Indian Medical Council, and the government's apex agency for medical research, the Indian Council of Medical Research, in orienting research in the country.

Fifty years after Independence is an opportune time to look back and take stock of things. What has been the role of indigenous scientific research in the creation of new and useful knowledge and in finding solutions to problems? It will be instructive to compare research performance in different sectors, especially with agriculture – which like medicine draws heavily on the life sciences. Agriculture research in India has certainly played a key role in transforming a food-deficient country into a food-surplus country. In contrast, medical research in India, but for a few exceptions such as Sambhu De's work on cholera[19] and the development of synthetic heart valves and bloodbags at the Sree Chitra Tirunal Institute[20] – both of these being examples of outstanding work relevant to the needs of India – has not covered itself with glory. This despite the fact that medicine enjoys a better status and image than agriculture in the Indian society. How can one explain this vast difference?

The lack of leadership and the lack of clarity of the goals may be important reasons. Nundy has drawn attention to another facet of this problem, viz. the nexus formed between self-seeking doctors and 'powerful' politicians, seriously harming academic standards in medical education and research[21]. In contrast, ICAR had the benefit of some excellent political, administrative and scientific leaders who had both the vision and the commitment to achieve the goals and the capacity to work together. They could articulate their ideas well and motivate the rank and file. Besides, the country's goals on the food and agriculture front were well defined and well understood, and the Indian farmer, with his abundant common sense, contributed a great deal to the success on the food front. In India, problem solving is not done in medicine as well as it is done in agriculture, and what is achieved in research – say, for example, in immunology – has very little influence on health care delivery. Matching ICMR's research programmes and what is being published by Indian medical researchers in Indian journals on the one hand with their relevance to the health care delivery objectives of the Department of Health and Family Welfare on the other would be revealing. Things might take a while to change. Delivering the Dr Y. Nayudamma memorial lecture in December 1996, J. S. Bajaj, member of India's Planning Commission looking after health-related issues, said that AIDS, cancer, tuberculosis, hepatitis and malaria in that order would be the thrust areas for research, while admitting that communicable diseases, disorders due to nutritional deficiencies and pregnancy-related illnesses would continue to be major causes of morbidity and mortality in the first decade of the 21st century.

One may also refer to ICMR's attitude to research on medical research in India. Arora *et al.*[22] reported in their paper on the best medical colleges in India that ICMR was unwilling to give them information on grants given to medical colleges (on the grounds that it would serve no purpose). My own limited experience in trying to get data on library and information budgets for a study on their impact on research performance was no better: ICAR sent the data within a few weeks for most of its laboratories and ICMR has not sent it yet.

One other problem deserves attention. The peer review process, the very linchpin of the scientific and scholarly enterprise, does not function all that well in India. But the situation in medicine seems to be worse than in other fields. How else can one explain a Nobel-class researcher like Sambhu Nath De, who made, according to P. Balaram, Editor of *Current Science*, not one but at least three major discoveries in cholera and diarrhoeal research which forever altered the fields, going unsung and being little known in the Indian scientific community in his lifetime?

1. Hicks, E. K., Cabo, P. G. and Rikken, F., *Knowledge and Policy: The International Journal of Knowledge Transfer and Utilization*, 1995, **6** (3 and 4), 79–98.
2. Arunachalam, S. and Manorama, K., *Scientometrics*, 1989, **15**, 393–408.
3. *Evaluation of Scientific Research*, a Ciba Foundation Conference, John Wiley & Sons, Chichester, Sussex, UK, 1989.
4. Arunachalam, S., Paper presented at the Fifth International Conference on Scientometrics and Informetrics, River Forest, 1995.
5. National Science Foundation's Science Literature Data Base, Computer Horizons, Inc., Cherry Hill, NJ, USA, 1986.
6. Schubert, A,. Glanzel, W. and Braun, T., *Scientometrics*, 1989, **16**, 3–478.
7. *Science Citation Index 1994 Guide & List of Source Publications*, Institute for Scientific Information, Philadelphia, PA, USA, 1995.
8. Workshop on Scientometric Standardization, immediately following the Fifth Biennial Conference of the International Society for Scientometrics and Informetrics, River Forest, IL, USA, June 1995. *Scientometrics*, 1996.
9. *Health Situation in the South-East Asia Region 1991–1993*, WHO Regional Office for South-East Asia, New Delhi, 1995, pp. 40–41.
10. Nundy, S., in *The Future of Medical Journals* (ed. Lock, S.), British Medical Journal, London, 1991, pp. 74–80.
11. Sahni, P., Reddy, P. P., Ravi Kiran, Reddy, K. S., Pande, G. K., and Nundy, S., *Lancet*, 1992, **339**, 1589–1591.
12. Sudhakar Reddy, K., Sahni, P., Pandey, G. K. and Nundy, S., *Natl. Med. J. India*, 1991, **4**, 90–92.
13. Valiathan, M. S., *Surgery in India*, Sir A. L. Mudaliar Endowment Lectures, Madras University, 1987.
14. Arunachalam, S., Srinivasan, R. and Vidyalakshmi Raman, Science in India – A profile based on India's publications as covered by *Science Citation Index* 1989–1992, Workshop on Science Indicators, Tamil University, Thanjavur, India, 21 December 1995.
15. DeKoker, B., *Sci Am.*, 1995, **273** (2), 80–81.

16. Kartha, C. C. and Mohandas, K., Personal communication (letter from C. C. Kartha dated 15 March 1995).
17. Nundy, S., *Arch. Emergency Med.*, 1986, **3**, 1–3.
18. Pandya, S., *Br. Med. J.*, 1990, **301**, 333.
19. Balaram, P., *Curr. Sci.*, 1990, **59**, 623.
20. Valiathan, M. S., *Curr. Sci.*, 1990, **59**, 14–17.
21. Nundy, S., *Trop. Gastroenterol.*, 1986, **7**, 41–42..
22. Arora, M., Banerjee, J. K., Sahni, P., Pande, G. K. and Nundy, S., *Natl. Med. J. India*, 1996, **9**, 135–140.

Note 1. For example, the Swiss journal *Agents and Actions* is covered under chemistry and pharmacology. The six papers published by Indian authors in this journal are not included in the 13,855. Unincluded, similarly, are the six articles in the German journal *Archives der Pharmazie (Weinheim)* and the 27 papers published in the Belgian journal *Archives Internationales de Pharmacodynamie et de Therapie*, both of which are covered under chemistry, which is not covered in Table 2. Again the 92 papers Indian authors had published in the Swiss journal, *Journal of Ethnopharmacology* do not figure in the 13,855 papers, as this journal is classified under botany, another subject not included in the 45 subfields shown in Table 2. However, these missing articles are captured in lists of journals under appropriate subfields, not minding duplication. For want of space, these lists are not shown here.

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