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Mapping of Indian Diabetes Research during 1999-2008: A Scientometric Analysis of Publications Output

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ABSTRACT

This study analyses the India research output in diabetes during 1999-2008 on several parameters including its growth, rank and global publications share, citation impact, overall share of international collaborative papers, and share of major collaborative partners. It also analyses the characteristics of most productive institutions, authors, and highly-cited papers. The publications output, impact and collaborative publication share of India is also compared with China, South Korea and Brazil.

Keywords: Scientometric analysis, diabetes research, publications output

1. INTRODUCTION AND LITERATURE REVIEW

Diabetes mellitus is a group of chronic metabolic conditions, all of which are characterised by elevated blood glucose levels resulting from the body's inability to produce insulin or resistence to insulin action or both. This group of conditions can be sub-divided into four clinically distinct types. Type 1 diabetes (previously known as insulin-dependent, juvenile or childhood-onset) is characterised by lack of insulin production and requires daily administration of insulin. It accounts for 5 per cent to 10 per cent cases of all cases of diabetes. Symptoms include excessive excretion of urine (polyuria), thirst (polydipsia), constant hunger, weight loss, vision changes, and fatigue, which may occur suddenly, Type 2 diabetes (formerly called non-insulin-dependent or adult-onset) results from the body's ineffective use of insulin. Type 2 diabetes accounts for 90 per cent of people around the world, and is largely the result of excess body weight and physical inactivity. Symptoms may be similar to those of Type 1 diabetes, but are often less marked. As a result, the disease may be diagnosed several years after onset, once complications have already arisen. Until recently, this type of diabetes was seen only in adults but it is now also occurring Gestational diabetes is hyperglycaemia, which is first recognized during pregnancy. Symptoms of gestational diabetes are similar to Type 2 diabetes. Gestational diabetes is most often diagnosed through prenatal screening, rather than reported symptoms. Fourth group is composed of other types of diabetes caused by specific genetic defects of beta-cell function or insulin action, diseases of the pancreas or drugs or chemicals[1-3]. There are many complications due to diabetes. Cardiovascular disease is responsible for between 50 per cent and 80 per cent of deaths in people with diabetes. Diabetic neuropathy can lead to sensory loss and damage to the limbs. Diabetic retinopathy is a leading cause of blindness and visual disability. Diabetes is among the leading causes of kidney failure, but its frequency varies between populations and is also related to the severity and duration of the disease. Diabetic foot disease, due to changes in blood vessels and nerves, often leads to ulceration and subsequent limb amputation[4].

According to recent estimates of the International Diabetes Federation (IDF), the number of diabetic patients worldwide have risen sharply from 30 million in 1985 to 150 billion in 2000 and 285 million by 2010, and comprises 6.6 per cent of the world population in age group 20-79. However, by 2039, 435 million people (7.8 per cent of the adult population) are expected to suffer from diabetes. Globally by 2010, four million deaths were expected due to diabetes in 20-79 age group (6.8 per cent of globally all-cause mortality in this age group). Diabetes along with cardiovascular diseases, cancer and chronic

respiratory diseases accounts for 60 per cent of all deaths worldwide. In many countries in Asia, the Middle East, Oceania and the Caribbean, diabetes affects 12-20 per cent of the adult population. Almost 80 per cent of diabetes deaths occur in low- and middle-income countries. Each year around 6 million people develop diabetes and 4 million dies every year. It is a leading cause of blindness, kidney failure, heart attack, stroke, and amputation. The countries with the largest number of diabetic people today are India (50.8 million), China (43.2 million), USA (26.8 million), Russia (9.6 million), Brazil (7.5 million), Germany (7.5 million), Pakistan (7.1 million), Japan (7.1 million), and Indonesia (7.1 million). In 2010, India was expected to have 58.7 million diabetes patients (almost 7 per cent of its adult population), which is likely to increase to 87 million (8.45 per cent of the adult population) by 2030. China is expected to increase its diabetic patients from 43.2 million at present to 62.6 million by 2030. In India, by 2010 diabetes-related deaths were expected around 10.07 lakh people in adult age group of 20-79 years every year, the majority of whom being women (5.81 lakh)[5]. The alarming figure of diabetes prevalence in India made the government to start a National Diabetes Control Programme in 1987. It started on a pilot basis in some districts of Tamil Nadu, Jammu and Kasmir, and Karnataka IT. In 1998, India launched Rs 5000 crore pilot projects for prevention and control of diabetes, cardio-vascular diseases and stroke in seven states across one district each.

1.1 Diabetes Education and Research in India

At present, in India the number of doctors who can help to solve diabetic problems (with specialisation in endocrinologists) is staggeringly small and the education in endocrinology is available only at super specialisation level after postgraduate degree. There are hardly few endocrinology seats in government medical colleges and only few offers super specialisation in endocrinology, including All India Institute of Medical Sciences, New Delhi, Post Graduate Institute of Medical Education & Research, Chandigarh;Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, Banaras Hindu University Institute of Medical Sciences, Varanasi; and Andhra Medical College and Osmania Medical College, Hyderabad. Other than medical colleges, one can acquire a Diploma of National Board, from a private hospital. But here too, the seats are limited as few hospitals such as Apollo and Sir Ganga Ram Hospital, New Delhi are authorised by the government to provide this training. In India, a number of research institutions, hospitals and professional bodies are involved in conducting various training and fellowship programmes for doctors and para-medical staff in prevention and cure of diabetes. Some of these are the WHO Collaborating Centre for Research Education & Training in Diabetes in collaboration with M.V. Hospital, Chennai; All India Institute of Diabetes and Research College, Ahmedabad,, S.K. Diabetes Research and Education Centre, Kolkata; Manipal Hospital (Department of Diabetes and Endocrinology), Mumbai University (Faculty of Medicine); All India Institute of Medical Sciences (Department of Endocrinology and Metabolism), New Delhi; Amrita Institute of Medical Sciences, Kochi; Madras Diabetes Research Foundation, Coimbatore; and Diabetes Research Foundation and Research Society for the Study of Diabetes in India.

In addition, a number of research institutes under the Indian Council of Medical Research (ICMR), Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Department of Science and Technology (DST), etc., are engaged in diabetes research. In addition, several international and foreign government funding agencies, such as WHO, USAID, UNAIDS, the National Institutes of Health (USA), the UK Medical Research Council, the UK Department for International Development, International AIDS Vaccine Initiative, Gates Foundation and the Clinton Foundation, etc. provide financial support to diabetes research in India from time to time. Several global pharmaceutical companies are entering India for research and development activities, given the large patient pool available here.

1.2 Literature Review

A few studies have been conducted in measuring the progress of the research in diabetes worldwide and in Indian context in the past. Lewin[6] studied world diabetes mellitus publications during 1984-2005, using MEDLINE database and indicated that the publication growth of articles parallels the increase in diagnosed cases of diabetes mellitus (both Type 1 and Type 2 together) and the literature relating to Type 1 diabetes mellitus has saturated, while that of Type 2 showed the increase over time. Apoor[7], *et al* studied author self-citation in the diabetes literature. Krishnamoorthy et al[8] studied world diabetes literature during 1995-2004, using MEDLINE database. Arunachalam and Gunasekaran[9] analysed 837 Indian and 427 China research papers during 1990-99 and identified major institutions, journals used, sub-fields, international collaboration, etc. Ratnakar and Satynarayana[10] analysed 3068 Indian diabetes research papers during 1976-2006 on the same lines. Somogyl and Schubert[11] made an interesting correlation between national bibliometric and health indicators in diabetes.

2. AIMS AND OBJECTIVES

The main objective of this study was to analyse the research performance of India in diabetes research in national and global context, as reflected in its publication output during 1999-2008. In particular, the study focuses on the following objectives:

- To study the Indian research output, its growth, rank and global publication share and impact.
- To study the patterns of international collaboration.
- To study the publication productivity and impact of leading Indian institutions and authors.
- To study the characteristics of Indian highly cited-papers.

3. METHODOLOGIES AND SOURCE OF DATA

This study is based on the Indian publication data in diabetes research retrieved from the *Scopus* citation database for the 10 years (1999-2008). For citations data, three-years, two-year and one-year citations window was used for computing average citations per paper during 1999-2006, 2007 and 2008. The search strategy on diabetes literature was carried out using the following keywords suggested by Arunachalam and Gunasekaran[9], Ratnakar and Satynarayana[10] and Rosalind A. Maria[12].Title-Abs-Key(diabete* or niddm or iddm or mody or mrdm or fcpd**)** or (Title-Abs-Key (hyperglycem* or hypoglycem* or hyperglcaem***)** or **(**islet transport* or islet encapsulation or islet cryop* or islet neogen* or islet culture***)** or Title-Abs-Key **(**insulin resist* or insulin signaling or insulin senstivity or insulin receptor) or Title-Abs-Key (glucose transport or resistin or pancreatic regeneration)) and (AFFIL**(**India**)** and Pubyear Aft 1998 and Pubyear Bef 2009. For identifying literature on three types of diabetes and for different diabetes complications, different keywords strategies were developed. For calculating the international collaborative papers, a separate search strategy, which combines India's collaboration with 140 major countries was prepared. For analysing institutional and author's output, separate search strategies were developed for generating institutional and author outputs.

4. ANALYSIS

4.1 Publication Rank and Share of Most Productive Countries

In overall, the global publication share (Table 1) of the top 18 countries vary from 1.13 per cent to 29.61 per cent during 1999-2008. United States topped the list with global publication share of 29.61 per cent. The United Kingdom ranked second, followed by Japan, Germany, Italy and France (with global publication share ranging from 4.01per cent to 8.40 per cent). China, Spain, Sweden and the Netherlands ranked at 7th to 10th positions (with global publication share ranging from 2.32 per cent to 2.95 per cent). The countries that ranked between 11th and 18th positions were India, Switzerland, Turkey, Brazil, South Korea, Poland, and Taiwan (with global publication share ranging from 1.13 per cent to 1.92 per cent).

Among developed countries, which showed decline in publication share from 1999 to 2008. United States (3.0 per cent) topped the rank, followed by Japan (1.97 per cent), France (1.48 per cent) , Germany (1.39 per cent), Sweden (0.60 per cent), Belgium (0.28 per cent), U.K. (0.12 per cent) and Switzerland (0.03 per cent). In contrast, developed countries that showed rise in their publication share during the same period were Spain by 0.85 per cent Turkey by 0.85 per cent, Italy by 0.52 per cent, Netherlands by 0.41 per cent and Poland by 0.20 per cent. In contrast, most developing countries showed rise in their publication share from 1999 to 2008: China included 4.24 per cent, Brazil by 1.27 per cent , India by 1.05 per cent, South Korea by 1.04 per cent, and Taiwan by 0.58 per cent (Table 1).

India ranked at 11th among the top 18 countries in diabetes research, with its global publication share of 1.92 per centduring 1999-2008. Compared to India, China, Brazil, South Korea and Taiwan ranked at 7th, 15th, 16th, and 18th, positions with global publication share of 2.95 per cent, 1.28 per cent, 1.22 per cent and 1.13 per cent, respectively. Taiwan's global ranking remained the same, i.e., 15th while for China, Brazil, India, and South Korea global ranking has increased from 14th to 5th, 18th to 12th, 12th to 10th and from 17th to 13th.

4.2 India's Publications Output in Diabetes

India's cumulative publications output comprised of 4824 papers during 1999-2008, with average number of papers per year as 482. The annual average growth rate of Indian publications in diabetics during the period 1999-08 was 13.71 per cent (Table 2)**.** Compared to India, the publications output of China, Brazil, and South Korea during the same period consists of 7413 papers, 3235 papers, and 3069 papers, with average number of papers per year as 741, 323 and 307 papers, respectively. The cumulative publications output of India increased from 1534 to 3290 papers from 1999-2003 to 2004-2008, witnessing a growth rate of 114.47 per cent. Compared to India, the cumulative publications output of China, Brazil, and South Korea increased from 1436 to 5983 papers, 852 to 2383 papers and 799 to 2270 papers, witnessing a growth rate of 316.64 per cent, 179.69 per cent and 184.10 per cent, as against 146.18 per cent of the world cumulative publication output during the same period (Table 3). The average citations per paper registered by India's publications output in diabetes were 4.29 during 1999-2008, compared to 3.38 for China, 6.45 for Brazil and 7.79 for South Korea. The average citations per paper registered for India's cumulative publications increased from 3.99 during 1999-2003 to 4.42 during 2004-2008, similar to increase in China from 3.23 to 3.42. In contrast, there is a decrease in average citations per paper from 7.05 to 6.24 in case of Brazil and from 7.83 to 7.77 in case of South Korea (Table 3).

Table 1. Global publication output, publication share and rank of top 18 most productive countries in diabetes research

Country	No. of Papers			% Share of Papers			Rank		
	99-08	1999	2008	1999-08	1999	2008	99-08	1999	2008
USA	74503	4813	9547	29.61	30.48	27.48	1	1	1
UK	21124	1335	2895	8.4	8.45	8.33	2	2	2
Japan	16277	1239	2042	6.47	7.85	5.88	3	3	3
Germany	14178	1033	1793	5.64	6.54	5.16	4	4	4
Italy	11196	660	1633	4.45	4.18	4.70	5	6	6
France	10093	820	1290	4.01	5.19	3.71	6	5	7
China	7413	125	1747	2.95	0.79	5.03	7	14	5
Spain	7202	359	1084	2.86	2.27	3.12	8	8	8
Sweden	6035	467	819	2.86	2.96	2.36	9	7	11
Netherlands	5832	342	895	2.86	2.17	2.58	10	9	9
India	4824	215	838	2.86	1.36	2.41	11	12	10
Switzerland	3624	220	474	2.86	1.39	1.36	12	11	16
Turkey	3436	120	558	2.86	0.76	1.61	13	16	14
Belgium	3287	244	442	2.86	1.55	1.27	14	10	17
Brazil	3231	105	672	2.86	0.66	1.93	15	18	12
South Korea	3061	111	606	2.86	0.70	1.74	16	17	13
Poland	2864	142	383	2.86	0.9	1.10	17	13	18
Taiwan	2831	125	475	2.86	0.79	1.37	18	15	15
Russia	758	61	108	2.86	0.39	0.31	19	19	20
South Africa	697	31	110	2.86	0.2	0.32	20	20	19
World	251590	15790	34744	100	100	100			

Table 2. Publication output and impact of Indian research
I output in diabetes

Period	TP	TC	ICP
1999	215	715	15
2000	227	871	18
2001	276	1027	22
2002	390	1654	39
2003	426	1862	54
2004	469	2883	59
2005	543	3260	70
2006	652	3840	75
2007	788	3295	114
2008	838	1271	120
1999-08	4824	20678	586

TP=Total papers; TC=Total citations; ICP=International collaborative papers

4.3 International Collaboration in India's Publication Output

The cumulative international collaborative papers in diabetes during 1999-2008 comprised 586, which accounts for 12.15 per cent share in the cumulative output of India in diabetes. Compared to India, the international collaborative papers share of China, Brazil and South Korea in their national outputs in diabetes during 1999-08 was 20.50 per cent, 20.83 per cent and 23.98 per cent, respectively. India witnessed a substantial increase in its share of international collaborative papers from 9.65 per cent during 1999-03 to 13.31 per cent during 2004-2008**.** Similarly, China, Brazil and South Korea increased their publications share from 18.45 per cent, 21.20 per cent and 21.40 per cent during 1999-2003 to 20.50 per cent, 20.83 per cent and 23.98 per cent during 2004-2008 (Table 4).

Among the top 13 Indian collaborative partners, publishing 10 and more international collaborative papers with India in diabetes during 1999-2008, United States tops the list by contributing 50.68 per cent publications, followed by United Kingdom (16.72 per cent), Canada, Australia, and Sweden (between 5.29 per

Table 3. Number of cumulative publications and citations of India, China, South Korea and Brazil in diabetes research

Country	Total papers			Total citations			Average citations per paper		
	1999-03	2004-08	1999-08	1999-03	2004-08	1999-08	1999-03	2004-08	1999-08
India	1534	3290	4824	6129	14549	20678	3.99	4.42	4.29
China	1436	5977	7413	4638	20436	25074	3.23	3.42	3.38
Brazil	849	2382	3231	5985	14864	20849	7.05	6.24	6.45
South Korea	799	2262	3061	6256	17576	23832	7.83	7.77	7.79

Table 4. Number and share of international collaborative papers of India, China, Brazil and South Korea

Country	Number of international collaborative papers			% share of international collaborative papers		
	99-03	04-08	99-08	99-03	04-08	99-08
India	148	438	586	9.65	13.31	12.15
China	180	493	673	21.20	20.70	20.83
Brazil	180	493	673	21.20	20.70	20.83
South Korea	171	563	734	21.40	24.9	23.98

cent to 7.34 per cent), Japan, Germany, Italy, South Korea and Switzerland (between 3.07 per cent to 4.61 per cent), and France, China and Netherlands (between 2.39 per cent to 2.90 per cent). On analysing the shift in international collaborative publications share of these countries from 1999-2003 to 2004-2008, it was found that the share of United States has increased by 2.72 per cent, followed by United Kingdom by 3.39 per cent, Canada by 1.68 per cent, Australia by 1.21 per cent, South Korea by 3.20 per cent, Germany by 2.09 per cent, France by 1.17 per cent, China by 0.71 per cent, the Netherlands by 1.39 per cent and Italy by 0.04 per cent. The share of all other collaborating countries decreased by 5.58 per cent with Sweden, followed by 0.41 per cent with Switzerland (Table 5).

4.4 Subject-wise Research Priorities in Diabetes Research

The diabetic research output was classified under seven broad subject areas falling under health and life sciences as per *Scopus* classification, with maximum research output (2840 papers, 58.87 per cent share) during 1999-2008 coming from medicine, followed by biochemistry, genetics and molecular biology (1382 papers, 28.65 per cent share), pharmacology, toxicology and pharmaceutics (1107 papers, 22.95 per cent share), agricultural and biological sciences (359 papers, 7.44 per cent share), chemistry (293 papers, 6.07 per cent share), neurosciences (141 papers, 2.92 per cent share) and immunology and microbiology (125 papers, 2.59 share). In terms of impact as reflected in average citation per paper using a three-year citation window, the maximum impact (5.63) during 1999-08 was shown by chemistry, followed by biochemistry, genetics and molecular biology (4.90), neurosciences (4.79), immunology and microbiology (4.57), pharmacology, toxicology and pharmaceutics (4.47), medicine (4.12), and agricultural and biological sciences (4.08). Of these seven sub-fields, the publication citation impact increased from 3.57 to 4.38 in case of medicine and from 4.58 to 5.04 in biochemistry, genetics and molecular biology. During the same period, the publication citation impact decreased from 4.81 to 4.34 in pharmacology, toxicology and pharmaceutics, 6.74 to 5.24 in chemistry, 4.64 to 3.86 in agricultural and biological sciences, 6.55 to 3.97 in immunology and microbiology, and 4.85 to 4.77 in neurosciences (Table 6).

4.5 Type of Diabetes and Diabetic Complications

In all 1170 papers have been published on Type 2 diabetes in India during 1999-2008 (rising from 346 to 824 papers from 1999-2003 to 2004-2008), followed by 282 papers on Type 1 (rising from 115 to 167 papers), and 163 papers on gestational diabetes (rising from 61 to 102 papers) during the same period. In terms of growth in different types of diabetes literature, the largest growth (138.15 per cent) took place on diabetes Type 2 literature, followed by gestational diabetes (67.2 per cent) and type 1 diabetes (45.22 per cent) from 1999-2003 to 2004-2008.

Table 5. India's international collaborative papers with different countries in diabetes research

Collaborating Country	No. of ICP			% Share of ICP		
	99-03	04-08	99-08	99-03	04-08	99-08
USA	72	225	297	48.65	51.37	50.68
U.K.	21	77	98	14.19	17.58	16.72
Canada	9	34	43	6.08	7.76	7.34
Australia	8	29	37	5.41	6.62	6.31
Sweden	14	17	31	9.46	3.88	5.29
Japan	9	18	27	6.08	4.11	4.61
Germany	4	21	25	2.70	4.79	4.27
Italy	5	15	20	3.38	3.42	3.41
South Korea	1	17	18	0.68	3.88	3.07
Switzerland	5	13	18	3.38	2.97	3.07
France	3	14	17	2.03	3.20	2.90
China	3	12	15	2.03	2.74	2.56
Netherlands	2	12	14	1.35	2.74	2.39
Total	**148**	**438**	**586**	**100.00**	**100.00**	**100.00**

Table 6. Distribution of Indian papers in diabetes research by various sub-fields

Subject	Number of publications			Number of citations			Average citations per paper		
	99-03	04-08	99-08	99-03	04-08	99-08	99-03	04-08	99-08
Medicine	932	1908	2840	3328	8363	11691	3.57	4.38	4.12
Biochemistry, Genetics and Molecular Biology	415	967	1382	1901	4871	6772	4.58	5.04	4.90
Pharmacology, Toxicology and Pharmaceutics	306	801	1107	1473	3474	4947	4.81	4.34	4.47
Chemistry	76	217	293	512	1138	1650	6.74	5.24	5.63
Agricultural and Biological Sciences	103	256	359	478	988	1466	4.64	3.86	4.08
Neurosciences	41	100	141	199	477	676	4.85	4.77	4.79
Immunology and Microbiology	29	96	125	190	381	571	6.55	3.97	4.57

In terms of diabetic complication, maximum effect had been on heart-related complications as reflected in 1100 papers (rising from 317 to 783 papers from 1999-2003 to 2004-2008), followed by 649 papers in nephropathy (rising from 207 to 442 papers), 451 papers in neuropathy (rising from 140 to 311 papers), by 377 papers in brain and cerebral circulation diseases (rising from 111 to 276 papers), by 187 papers in retinopathy (rising from 55 to 132 papers), by 113 papers in diabetes affecting feet or foot, etc (rising from 26 papers to 87 papers). The maximum growth (305 per cent) from 1999-2003 to 2004-2008 occurred in diabetes affected foot or feet, followed by diabetes affecting heart (147 per cent), retinopathy (140 per cent), diabetes affecting brain and cerebral circulation (139.64 per cent), nephropathy (113.53 per cent) and neuropathy (100.95 per cent).

4.6 Contributions and impact of 20 most productive Indian institutions

The institutions (Table 7) participating in diabetic research in India (with 38 or more papers) contributed 1824 papers during 1999-2008, which accounted for 37.81 per cent share in India's research output with an average number of papers per institute as 91.2. Only five institutions recorded publications output more than the average output of the all institutions. These are All India Institute of Medical Sciences, New Delhi with 344 publications, followed by Annamalai University, Annamalainagar (208 papers), Madras Diabetes Research Foundation, Chennai (169 papers), Postgraduate Institute of Medical Education & Research, Chandigarh (160 papers), and University of Madras, Chennai (93 papers). The average citation impact recorded by these 20 institutions was 5.66 during 1999-2008. Only eight institutions recorded higher citation impact than the average citation impact of all institutions. These are National Institute of Nutrition, Hyderabad with citation impact of 10.93, followed by National Institute of Pharmaceutical Education & Research, Mohali (9.39), Madras Diabetes Research Foundation, Chennai (8.3), All India Institute of Medical Sciences, New Delhi (7.22), St John's Medical College, Bangalore (7.22), Panjab University, Chandigarh (6.89), Maulana Azad Medical College, Delhi (6.08), and Jawaharlal Nehru University, New Delhi (6.03). The average h-index received by these 20 institutions was 13.45. Eight institutions recorded higher h-index than the average h-index of all 20 institutions. These are All India Institute of Medical Sciences, New Delhi with h-index of 33, followed by Madras Diabetes Research Foundation, Chennai (26), Annamalai University, Annamalainagar (23), National Institute of Pharmaceutical Education & Research, Mohali (17), Panjab University, Chandigarh (14), University of Madras, Chennai (14), Postgraduate Institute of Medical Education & Research, Chandigarh (14), and National Institute of Nutrition, Hyderabad (13).

4.7 Productivity and Impact of Top Indian Scholars in Diabetes Research

The 20 scholars with 25 or more papers, (in diabetic research in India) contributed 963 papers during 1999-2008, which accounted for 19.96 per cent in country's research output with an average number of papers per institute as 48.15. Only 6 authors (Table 8) have recorded publication output more than the average output of the all authors. These are V. Mohan with 157 publications, followed by A. Ramachandran (99 papers), R. Deepa (88 papers), L. Pari (77 papers), C. Snehalatha (68 papers), and A. Misra (52 papers). The average citation impact recorded by these 20 authors was 8.33 during 1999-2008. Only nine authors have recorded higher citation impact than the average impact of all authors. These are C.S. Yajnik with citation impact of 17.34, followed by N.K. Vikram (14.90), A. Misra (12.33), R. Deepa (11.81), V Vijay (10.07), C. Snehalatha (9.94), R. Chakrabarti (9.60), V. Mohan (8.71), and A. Ramachandran (8.37). The average h-index received by these 20 authors was 13.20. Seven authors recorded higher h-index than the average h-index of all authors. These are V. Mohan with h-index of 26, followed by R. Deepa (24), A. Ramachandran (19), A. Misra (19), L. Pari (18), C. Snehalatha (17), and V. Vijay (15) .

4.8 High Cited Papers

The characteristics of highly cited papers were also evaluated. Based on publication output of India in this area, 100 papers were identified as highly cited ones. These papers received citations (since their publications till 1 October 2009) varying from 45 to 266 during 1999-2008. Of these 100 papers, 71 appeared as articles, 26 as reviews, two as conference papers and one as letter. Of the 100 high-cited papers, 27 involve international collaborations (18 bilateral and 9 multilateral) and 25 involve national collaborations.

These 100 papers together received 7657 citations with an average of 765 citations per paper. Of these 100 papers, 5 papers are in citation range of 201-300, 10 in citations range of 101-200, 15 papers in citations range of 76-100, 50 papers in citation range of 51-75, and the 20 in citations range of 26-50. The authors of these were affiliated to 52 Indian institutions including 21 papers from All India Institute of Medical Sciences, New Delhi; 10 from Madras Diabetes Research Foundation, Chennai; 6 papers from KEM Hospital & Research Centre, Pune, 6 papers from M. V. Hospital for Diabetes, Chennai; 5 papers from Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow; 3 papers each from Amla Research Centre, Trissure, Annamalai University, Postgraduate Institute of Medical Education & Research, Chandigarh, and St John Medical College, Bangalore were published. These papers were published in 64 journals, including 11 papers in *Journal of*

Table 7. Contribution and impact of top 20 Indian institutions in diabetes research

Name	TP	TC	ACPP	H-Index
All India Institute of Medical Research, New Delhi	344	2482	7.22	33
Annamalai University, Annamalainagar	208	1122	5.39	23
Madras Diabetes Research Foundation, Chennai	169	1403	8.30	26
Post Graduate Institute of Medical Education & Research, Chandigarh	160	455	2.84	14
University of Madra, Chennai	93	417	4.48	14
Christian Medical College & Hospital, Vellore	91	231	2.54	12
National Institute of Pharmaceutical Education & Research, Mohali	84	789	9.39	17
Sajay Gandhi Post Graduate Institute of Medical Sciences, Lucknow	76	397	5.22	12
Central Drug Research Institute, Lucknow	68	264	3.88	12
BHU Institute of Medical Sciences, Varanasi	65	193	2.97	9
Panjab University, Chandigarh	64	441	6.89	14
National Center of Cell Science, Pune	57	290	5.09	7
Andhra University	54	124	2.30	8
Maulana Azad Medical College, Delhi	51	310	6.08	8
Manipal College pf Pharmacy, Manipal	43	159	3.70	11
St John's Medical College, Bangalore	41	296	7.22	8
National Institute of Nutrition, Hyderabad	40	437	10.93	13
Jawaharlal Nehru University, New Delhi	39	235	6.03	12
Medical College & Hospital, Kolkata	39	107	2.74	6
M.S.University of Baroda	38	176	4.63	10
Country Output	4824			
Publication's Share of 20 institution's Output in Country's Output	37.81			
Total	**1824**	**10328**	**5.66**	**13.45**

Ethnopharmacology, 7 in *Diabetologia*, 5 in *Diabetes Research & Clinical Practice*, 3 each in *Nutrition* and *Molecular & Cellular Biochemistry*, etc.

5. SUMMARY AND CONCLUSION

India's total publications output was 4824 in diabetes research compared to China's (7413 papers), Brazil's (3235 papers) and South Korea's (3069 papers) during 1999-2008 India's cumulative publications output increased from 1534 papers to 3290 papers from 1999-03 to 2004-2008 showing a growth rate of 114.47 per cent. The annual average growth rate of Indian publications in diabetics was 13.71 per cent. India holds 11th rank among the top 18 countries in diabetes research, compared to China (7th rank), Brazil (15th rank) and South Korea (16th rank). India's global publications share was 1.92 per cent compared to China's (2.95 per cent, Brazil's (1.28 per cent) and South Korea's (1.22 per cent). India's share in global publications output and rank increased from 1.36 per cent (12th rank) in 1999 to 2.41 per cent (10th rank) in 2008. In comparison, China's global share and rank increased from 0.79 per cent (14th rank) to 5.03 per cent (5th rank), Brazil's from 0.66 per cent (18th rank) to 1.93 per cent (12th rank) and South Korea's from 0.70 per cent (17th rank) to 1.74 per cent (13th rank) in 1999 to 2008. The citation impact as measured by the average citations per paper registered by India's publications in diabetes was

Table 8. Productivity and impact of top 20 Indian authors in diabetes research

Name	Address	TP	TC	ACPP	H-Index
V. Mohan	Madras Diabetes Research Foundation, Chennai	157	1367	8.71	26
A. Ramachandran	Madras Diabetes Research Foundation, Chennai	99	829	8.37	19
R. Deepa	Madras Diabetes Research Foundation, Chennai	88	1039	11.81	24
L. Pari	Annamalai University, Annamalainagar	77	410	5.32	18
C. Snehalatha	Diabetes Research Centre, Chennai	68	676	9.94	17
A. Misra	Diabetes Foundation, Delhi	52	641	12.33	19
V. Vijay	MV Hospital for Diabetes, Chennai	43	433	10.07	15
A. Bhansali	PGIMER, Chandigarh	41	175	4.27	8
V. Viswanathan	MV Hospital for Diabetes, Chennai	33	241	7.30	10
M. Rema	Madras Diabetes Research Foundation, Chennai	31	243	7.84	11
K.V. Pugalendi	Annamalai University, Annamalaiinagar	31	118	3.81	8
N.K. Vikram	All India Institute of Medical Sciences, New Delhi	29	432	14.90	12
C.S. Yajnik	KEM Hospital & Research Centre, Pune	29	503	17.34	12
C.V. Anuradha	Annamalai University, Annamalaiinagar	28	131	4.68	10
M. Latha	Annamalai University, Annamalainagar	28	159	5.68	10
R.K.Goyal	L.M.College of Pharmacy, Ahmedabad	27	97	3.59	8
R. Gupta	Fortis Escorts Hospital, Jaipur	26	62	2.38	9
R. Chakrabarti	Dr. Reddy Laboratories Ltd., Hyderabad	25	240	9.60	12
N.Z. Baquer	Jawaharlal Nehru University, New Delhi	25	139	5.56	10
	Country Output	4824			
	Publication's Share of 20 authors Output in Country's Output	19.96			
	Total	**963**	**8025**	**8.33**	**13.2**

4.29, compared to China's (3.38), Brazil's (6.45) and South Korea's (7.79) during 1999-2008. India's citation impact as reflected in average citations per paper has increased from 3.99 to 4.42 from 1999-2003 to 2004-2008, similar to China's (from 3.23 to 3.42), but decreased in case of Brazil (from 7.05 to 6.24) and South Korea (from 7.83 to 7.77). The share of India's international collaborative papers in its total output in diabetes during 1999-2008 was 12.15 per cent, compared to China's (20.50 per cent), Brazil's (20.83 per cent) and South

Korea's (23.98 per cent). India's share of international collaborative papers increased from 9.65 per cent to 13.31 per cent from 1999-2003 to 2004-2008, similar to China's (from 18.45 per cent to 20.50 per cent) and South Korea's (from 21.40 per cent to 23.98 per cent), but decreased in Brazil (from 21.20 per cent to 20.83 per cent) during similar period. On subject-wise break-up of Indian diabetes papers, the maximum contribution (58.87 per cent) came from medicine, followed by biochemistry, genetics and molecular biology (28.65 per cent), pharmacology, toxicology and pharmaceutics (22.95 per cent), agricultural and biological sciences (7.44 per cent share), chemistry (6.07 per cent), neurosciences (2.92 per cent) and immunology and microbiology (2.59) during 1999-2008.

Among the subjects contributing to diabetic research, the maximum impact (5.63) was registered by chemistry, followed by biochemistry, genetics and molecular biology (4.90), neurosciences (4.79), immunology and microbiology (4.57), pharmacology, toxicology and pharmaceutics (4.47), medicine (4.12) and agricultural and biological sciences (4.08). In terms of break-up by type of diabetes, the maximum (1170 papers) came from Type 2 diabetes, followed by type 1 (282 papers) and gestational diabetes (163 papers). Among the diabetes complication, the maximum effect came on heart (with 1100 papers), followed by nephropathy (649 papers), neuropathy (451 papers), brain and cerebral circulation (377 papers), retinopathy (187 papers) and diabetes affecting feet or foot (113 papers). The 20 most productive institutions participating in diabetic research in India accounted for 37.81 per cent share in total Indian research output in diabetes and registered an average citation impact of 5.66 and h-index of 13.45 during 1999-2008. Similarly the top 20 most productive scholars participating in diabetic research in India together accounted for 19.96 per cent share in India's research output, registered an average citation impact of 8.33 and h-index of 13.20.The top 100 highly-cited papers (of which 27 involved international collaborations received citations ranging from 45 to 266.

The authors of these highly-cited papers were affiliated to 52 Indian institutions, including 21 papers from All India Institute of Medical Sciences, New Delhi; 10 papers from Madras Diabetes Research Foundation, Chennai; 6 papers each from KEM Hospital and Research Centre, Pune and MV Hospital for Diabetes, Chennai; etc.) and were published in 64 journals, including 11 papers in *Journal of Ethnopharmacology,* 7 papers in *Diabetologia*, 5 papers in *Diabetes Research & Clinical Practice*, etc. Compared to the share of incidence of diabetes, the global share of Indian research output in diabetes is very small. In addition, the quality of research as reflected in average citation per paper is weak compared to Brazil and South Korea. Similarly, the share of international collaborative papers is small compared to China, Brazil and South Korea. It means that funding of research in diabetes is quiet inadequate. It is suggested that Indian government and health establishment in the country should look at national health policy more critically, reorient their research priorities and help bring more funds for research in diabetes. Further, there is need to strengthen the existing international linkages and create new international linkages for increasing the research output and quality. Also within the country, there is a need for close collaboration between clinical research and basic science researchers in diabetes.

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