

# A bibliometric analysis of malaria research in India during 1998–2009

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## ABSTRACT

**Objective:** This study analyses the research output of India in malaria research in national and global context, as reflected in its publications output during 1998–2009.

**Methods:** SCOPUS Citation database has been used to retrieve the publication data, which has been further analysed 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 and patterns of research communication in most productive journals. The publications output, impact and collaborative publication share of India is also compared with South Africa, Brazil and China.

**Results:** Indian scientists together have published 2786 papers in malaria research during 1998–2009 and registered an average citation per paper of 3.49. The country ranks 4th among the top 20 most productive countries in malaria research with its global publications share of 6.47% during 1998–2009.

**Conclusion:** Quantum of Indian research output in malaria research is high but its citations per paper is low compared to select developing countries, which can be improved by investing more funds in international and national collaborative research projects, as well as increasing the participation of researchers in such projects.

**Key words** India; malaria research; publication output

## INTRODUCTION

Malaria is a mosquito-borne infectious disease caused by a protozoan parasite *Plasmodium*. Five species of the *Plasmodium* that infect humans are *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi*<sup>1</sup>.

As per WHO World Malaria Report 2010<sup>2</sup>, the number of estimated cases of malaria rose from 233 million in 2000 to 244 million in 2005, but decreased to 225 million in 2009. The number of deaths due to malaria is estimated to have decreased from 985,000 in 2000 to 781,000 in 2009. Decreases in malaria burden have been observed in all WHO regions, with the largest proportion of decrease in the European Region, followed by the Region of the Americas. The largest absolute decreases in deaths were observed in Africa.

About 3.3 billion people are currently at risk from malaria and there are 109 countries where malaria is endemic. People living in the poorest countries are the most vulnerable to this disease and the vast majority of cases (85.5%) are reported from the African Region, followed by the Southeast Asia (10%) and the Eastern Mediterranean Regions (4%)<sup>3</sup>. In Africa, malaria is especially a serious problem, where one in every five childhood deaths is considered to be the consequences of the disease directly or indirectly<sup>4</sup>. In Southeast Asia region, 10 of the

11 countries are malaria-endemic.

International funding for malaria control has risen steeply in the past decade. After the massive scale-up in malaria control programme, as a result in global investment, between 2008 and 2010 namely, the increased provision and use of insecticide-treated mosquito nets and of indoor residual insecticide spraying – both the number of cases and deaths from malaria had dropped worldwide<sup>2</sup>.

In India, malaria continues to pose a major public health threat, particularly due to *P. falciparum*. At the time of independence, there were an estimated 75 million malaria cases and 0.8 million deaths annually<sup>5</sup>. The cases declined to 0.1 million in 1965 with the use of DDT, but in 1976 malaria resurged back and the cases reached to 6.4 million with many deaths<sup>6</sup>. Revised malaria control strategies brought the situation under control in later years. Currently, around two million cases are reported every year and 80% of the population lies in malaria risk areas.

The rationale of this study was to analyze the quantity and quality of Indian research output in malaria research in national and global context, its patterns of collaborative research, characteristics of high cited papers, patterns of research communications in most productive journals and evaluating the research output of different institutional groups, as reflected in their publications output during 1998–2009.

## MATERIAL &amp; METHODS

This study is based on the Indian publication data in malaria retrieved from the *Scopus Citation database* for 12 years (1998–2009). The main search strategy was developed using the following key words to retrieve the data on malaria, viz. “malaria\*, falciparum\*, *Plasmodium\**, *Anopheles\**, mosquito control\*, antimalaria\*”. This becomes finally our main string. For citations data, three years, two years and one year citations window has been used. For example, for papers published in 1999, citation window is three years from 1999–2002. For papers published in 2000, citation window is three years from 2000–2003 and so on. For calculating the total international collaborative papers, a separate search strategy, which combines India’s collaboration with 140 major countries, was prepared and this string was combined with the main string to generate India’s total international collaborative output. For analyzing the institutional and journals output, separate search strategies for generating institutional and journal outputs were developed. It is also to be noted that the accumulation of malaria research output published under different subjects comes higher than the total research output in malaria during 1998–2009, due to the overlapping of subject areas. Similarly, the total of collaborative papers of partner countries is higher than the

total international collaborative research output of India.

## RESULTS

*Global publication share and rank*

The global publication share of the top 20 most productive countries in malaria research varied from 0.29 to 27.05% during 1998–2009. India ranked 4th among the top 20 most productive countries in malaria research, with its global publication share of 6.47% during the reported period. Compared to India, Brazil, South Africa and China ranked 9th, 13th and 15th with global publication share of 3.09, 1.81 and 1.64%, respectively. India’s global publications share increased from 4.59 to 8.27% from the year 1998 to the year 2009 and so also its world ranking from 4th to 3rd during the same period. Compared to India, global publications share of Brazil increased from 2.78 to 4.44% and that of China from 1.43 to 2.40% and their global ranking improved from 10th to 8th and 16th to 14th respectively from the year 1998 to the year 2009. South Africa’s global publications share although increased from 1.47 to 2.23%, but its global ranking remained the same at 15th during the same period.

On analyzing the global publications share of developed and developing countries, some developed countries such as France, Japan and Netherlands have shown de-

Table 1. Ranking and world share of top 20 most productive countries in malaria research 1998–2009

Country	No. of papers			% share of papers			Publication rank		
	1998	2009	1998–2009	1998	2009	1998–2009	1998	2009	1998–2009
USA	558	1095	11642	23.49	26.57	27.05	1	1	1
UK	357	626	6237	15.03	15.19	14.49	2	2	2
France	203	327	3461	8.55	7.93	8.04	3	4	3
India	109	341	2786	4.59	8.27	6.47	4	3	4
Germany	91	222	2331	3.83	5.39	5.42	6	6	5
Australia	89	236	2099	3.75	5.73	4.88	7	5	6
Switzerland	104	193	1911	4.38	4.68	4.44	5	7	7
Japan	86	139	1397	3.62	3.37	3.25	8	9	8
Brazil	66	183	1330	2.78	4.44	3.09	10	8	9
Netherlands	81	127	1141	3.41	3.08	2.65	9	10	10
Italy	57	102	1045	2.40	2.48	2.43	11	13	11
Canada	43	111	958	1.81	2.69	2.23	12	11	12
South Africa	35	92	778	1.47	2.23	1.81	15	15	13
Spain	27	103	724	1.14	2.50	1.68	17	12	14
China	34	99	705	1.43	2.40	1.64	16	14	15
Sweden	40	85	704	1.68	2.06	1.64	13	17	16
Belgium	39	87	630	1.64	2.11	1.46	14	16	17
South Korea	5	52	292	0.21	1.26	0.68	20	18	18
Russia	13	10	123	0.55	0.24	0.29	18	20	19
Taiwan	13	14	123	0.55	0.34	0.29	19	19	20
World	2375	4121	43032						

cline in their global publications share from the year 1998 to the year 2009, in contrast, rise in global publications share is observed in case of U.S.A., United Kingdom, Germany, Australia, Switzerland, Italy, Canada, Spain, Sweden and Belgium during the same period. All developing countries, on the other hand, have shown rise in their publications share in malaria research from the year 1998 to the year 2009: India by 3.68% (from 4.59 to 8.27%), China by 0.97% (from 1.43 to 2.40%), Brazil by 1.66% (from 2.78 to 4.44%), South Africa by 0.76% (from 1.47 to 2.23%) and South Korea by 1.05% (from 0.21 to 1.26%) (Table 1).

#### *India's publications output in malaria*

India's cumulative publications output in malaria consists of 2786 papers during 1998–2009, with an average number of 232.16 papers per year, rising from 980 papers in 1998–2003 to 1806 papers in 2004–09 and witnessing a growth of 84.29% (Table 2). Compared to India, the publications output of Brazil, South Africa and China during the same period consists of 1330, 778 and 705 papers respectively, with an average number of papers per year as 111, 65 and 59 respectively, also shown an increase from 469 to 861 papers, 269 to 509 papers and 190 to 515 papers respectively from 1998–2003 to 2004–09 and witnessing a growth of 83.58, 89.22 and 171.05%, respectively. India's annual average publications growth rate during 1998–2009 was 12.17%, compared to 12.14% for Brazil, 10.82% for South Africa and 12.49% for China (Table 2).

In terms of citation impact and quality, the average citations per paper registered by India's publications during 1998–2009 was 3.49, declining from 3.60 during 1998–2003 to 3.42 during 2004–09. Compared to India, South Africa, Brazil and China have registered higher citation impact of 6.35, 4.54 and 4.03 respectively for their publications during the same period. A decline in citation was also observed for South Africa (7.10 to 5.96), Brazil (5.43 to 4.05), and China (4.36 to 3.91) from 1998–2003 to 2004–09 (Table 2).

#### *International collaboration in India's publications output*

Indian international collaborative efforts consist of 409 papers during 1998–2009, accounting for 14.68% share in the cumulative publications output of India in malaria research and witnessed an increase in its share from 10.20% during 1998–2003 to 17.11% during 2004–09. Compared to India, international collaborative papers share of South Africa was 58.48% (with 455 international collaborative papers), Brazil with 37.29% share (with 496 international collaborative papers) and China with 34.33% share (with 242 international collaborative papers) and also witnessed an increase from 42.01 to 67.19% in South Africa, from 35.39 to 38.33% in Brazil and 28.95 to 36.31% in China from 1998–2003 to 2004–09 (Fig. 1)

Among the major international collaborative partners of India in malaria research as reflected in its international co-authored papers, 18 countries have published two or more collaborative papers with India during 1998–2009.

Table 2. Growth and impact of India, China, Brazil and South Africa research in malaria 1998–2009

Period	India			China			Brazil			South Africa		
	TP	TC	ACPP	TP	TC	ACPP	TP	TC	ACPP	TP	TC	ACPP
1998	109	342	3.14	34	128	3.76	66	284	4.30	35	161	4.60
1999	161	491	3.05	29	161	5.55	56	255	4.55	46	359	7.80
2000	173	524	3.03	30	129	4.30	79	453	5.73	39	406	10.41
2001	156	576	3.69	23	87	3.78	68	404	5.94	40	211	5.28
2002	167	707	4.23	32	130	4.06	82	432	5.27	46	345	7.50
2003	214	889	4.15	42	194	4.62	118	721	6.11	63	427	6.78
2004	245	1103	4.50	65	465	7.15	101	506	5.01	69	772	11.19
2005	265	1426	5.38	69	387	5.61	127	809	6.37	85	696	8.19
2006	256	1488	5.81	75	338	4.51	124	856	6.90	69	630	9.13
2007	311	1307	4.20	98	554	5.65	174	880	5.06	92	531	5.77
2008	388	732	1.89	110	216	1.96	152	382	2.51	102	330	3.24
2009	341	126	0.37	98	53	0.54	183	57	0.31	92	76	0.83
1998–2003	980	3529	3.60	190	829	4.36	469	2549	5.43	269	1909	7.10
2004–2009	1806	6182	3.42	515	2013	3.91	861	3490	4.05	509	3035	5.96
1998–2009	2786	9711	3.49	705	2842	4.03	1330	6039	4.54	778	4944	6.35

TP—Total papers; TC—Total citations; ACPP—Average citations per paper.

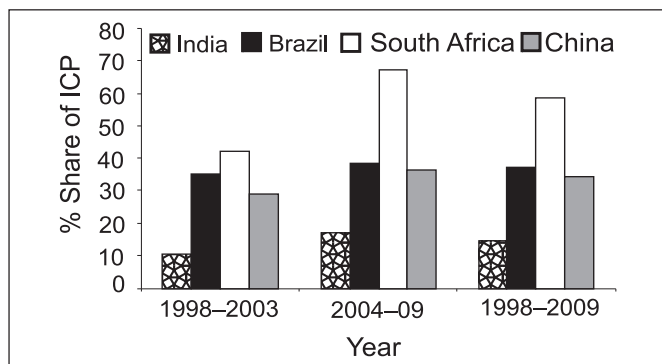


Fig. 1: International collaborative publications share of India, Brazil, South Africa and China in malaria research during 1998–2009.

United States is the major collaborating partner of India during 1998–2009 by contributing 59.9% publications share (245 papers), followed by United Kingdom (with 20.05% share), Switzerland, Germany, Australia and France (between 5 and 9% share), Canada, Belgium, China, Japan, Brazil, Italy, Netherlands and South Korea (between 2 and 4% share) and Spain and Sweden (between 1 and 2% share).

On analyzing the shift in international collaborative publications share of the major collaborative partner countries of India from 1998–2003 to 2004–09, it was found that the publications share of United Kingdom has decreased by 1.26% (from 21 to 19.74%), followed by Germany by 0.53% (from 7 to 6.47%), Canada and Belgium by 0.44% (from 4 to 3.56%), Italy by 0.41% (from 3 to 2.59%) and Sweden by 2.03% (from 3 to 0.97%), while

the share of all other collaborating partner countries have increased by 5.17% in case of USA (from 56 to 61.17%), followed by Australia by 4.12% (from 3 to 7.12%), Switzerland by 3.39% (from 6 to 9.39%), South Korea by 2.91% (from 0 to 2.91%), Brazil by 2.24% (from 4 to 6.24%), Netherlands by 1.91% (from 1 to 2.91%) and so on during the same period (Fig. 2).

*Contribution of different subjects to malaria research output*

On analyzing the publication data, it was found that the Indian research output in malaria had been published in nine broad subject categories, with highest publications output coming from medicine with 50.93% share (1419 papers), followed by immunology & microbiology with 32.3% share (900 papers), biochemistry, genetics & molecular biology with 24.08% share (671 papers), agricultural & biological sciences with 11.95% share (333 papers), pharmacology, toxicology & pharmaceuticals with 10.41% share (290 papers), chemistry with 7.47% share (208 papers) (Table 3). On measuring the citation impact and quality of malaria research output under different subjects, it was found that chemistry had scored the highest citations of 5.35 per paper, followed by biochemistry, genetics & molecular biology (4.83 citations), pharmacology, toxicology & pharmaceuticals (4.6 citations), immunology & microbiology (3.64 citations), veterinary science (3.6 citations), neuro science (3.12 citations), etc. The citation impact (measured in terms of average number of citations per paper) witnessed the rise from 3.95 to 4.84

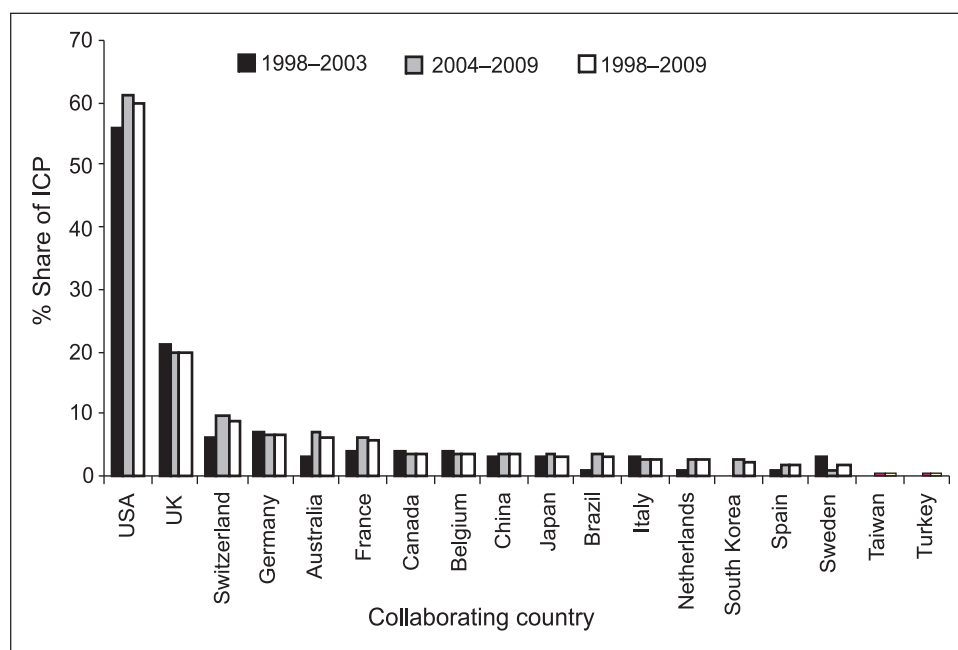


Fig. 2: Share of major collaborative partners of India in malaria research during 1998–2009

Table 3. Subject-wise break-up of Indian publications output in malaria during 1998–2009

Subject	No. of papers			No. of citations			ACPP		
	1998–2003	2004–2009	1998–2009	1998–2003	2004–2009	1998–2009	1998–2003	2004–2009	1998–2009
Medicine	479	940	1419	1402	2704	4106	2.93	2.88	2.89
Immunology & Microbiology	320	580	900	1158	2119	3277	3.62	3.65	3.64
Biochemistry, Genetics & Molecular Biology	196	475	671	1280	1960	3240	6.53	4.13	4.83
Agricultural & Biological Sciences	111	222	333	300	577	877	2.70	2.60	2.63
Pharmacology, Toxicology & Pharmaceutics	76	214	290	300	1035	1335	3.95	4.84	4.60
Chemistry	54	154	208	319	794	1113	5.91	5.16	5.35
Veterinary science	14	33	47	41	128	169	2.93	3.88	3.60
Neurology	9	16	25	32	46	78	3.56	2.88	3.12
Public health	4	6	10	20	6	26	5.00	1.00	2.60

ACPP—Average citations per paper.

citations in pharmacology, toxicology & pharmaceutics, from 3.62 to 3.65 citations in immunology & microbiology and from 2.93 to 3.88 citations in veterinary science, respectively from 1998–2003 to 2004–09 (Table 3).

#### *Research output in different types of malaria parasites*

On analyzing the Indian research output under different types of malaria parasites, it was found that the highest research output comes from malaria caused by *P. falciparum* with 1056 papers, followed by *P. vivax* with 356 papers and *P. malariae* with 33 papers during 1998–2009. The Indian research output from various types of malaria showed increase in their number of papers published from 1998–2003 to 2004–09.

#### *Research profile of Indian institutes/groups engaged in malaria research*

On analyzing the research profile of the Indian institutions and various groups, it is seen that the research institutes as a group contributes the highest (46.63%) share in the cumulative research output of India in malaria during 1998–2009, witnessing the decline from 47.35 to 46.23% from 1998–2003 to 2004–09. University & Colleges group and Institutes of National importance group witnessed the rise in their publication share of 4.63% (from 12.04 to 16.67%) and 1.48% (from 8.27 to 9.75%) respectively from 1998–2003 to 2004–09.

Considering the research quality of these institutions and various groups in terms of average citations received per paper, University and Colleges as a group leads among these five groups with 5.15 citations per paper, followed by Research Institutes (5.09 citations per paper), Institutes of National Importance (4.48 citations per paper), Medical Colleges (2.97 citations per paper) and Hospitals (2.27 citations per paper).

#### *Research profile of most productive Indian institutions in malaria research*

The top 30 most productive Indian institutions involved in malaria research have published 18 and above papers each during 1998–2009. The list of these Indian institutions along with their research output, citations received and H-index values are presented in Table 4. These 30 Indian institutions together have contributed 61.05% share (with 1733 papers) in the cumulative publications output of India in malaria research, with an average of 56.7 papers per institution. Only seven Indian institutions have registered higher publications share than the group average. These are: National Institute of Malaria Research, New Delhi with 396 papers, followed by Central Drug Research Institute, Lucknow (with 176 papers), All India Institute of Medical Sciences, New Delhi (with 121 papers), Indian Institute of Science, Bengaluru (with 104 papers), International Centre for Genetic Engineering & Biotechnology, New Delhi (with 99 papers), Vector Control Research Centre, Puducherry (with 91 papers) and Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru (with 81 papers).

The average citations per paper registered by the total papers of these 30 Indian institutions was 3.98. Only 14 Indian institutions have registered higher average citations per paper than the group average. Among these, BHU Institute of Medical Sciences, Varanasi has scored the highest impact of 8.43 citations per paper, followed by Indian Institute of Science, Bengaluru (with 7.86 citations per paper), National Institute of Immunology, New Delhi (with 7.31 citations per paper), National Institute of Pharmaceutical Education & Research, Mohali (with 7.12 citations per paper), Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru (with 7.09 citations per paper), National Centre for Cell Science, Pune (with 6.82

citations per paper), International Centre for Genetic Engineering & Biotechnology, New Delhi (with 5.85 citations per paper), Central Drug Research Institute, Lucknow and Indian Institute of Chemical Technology, Hyderabad (with 5.13 citations per paper) and so on (Table 4).

The average H-index value of these 30 Indian most productive institutions is 9.13. The 12 Indian institutions have scored higher H-index value than the group average. Among them Indian Institute of Science, Bengaluru had scored the highest H-index of 21 for their papers during 1999–2008, followed by Central Drug Research Institute, Lucknow (20), National Institute of Malaria Research, New Delhi (19), International Centre for Genetic Engineering & Biotechnology, New Delhi (14), All India Institute of Medical Sciences, New Delhi (13), National Institute of Immunology, New Delhi (12), Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru (11), Vector Control Research Centre, Puducherry (10), KEM Hospital, Mumbai (10), Jawaharlal Nehru University, New Delhi (10), and National Institute of Pharmaceutical Edu-

cation & Research, Mohali (10) (Table 4).

#### *High productive journals in terms of malaria research*

The top 29 most productive Indian and foreign journals contributing to Indian malaria research, together contributed 1292 papers, which accounts for 46.37% share in the cumulative publications output of India during 1998–2009. Of these 29 journals, 13 journals are of Indian origin contributing 24.12% share in the total output during 1998–2009 and witnessed the decrease from 31.22% during 1998–2003 to 20.27% during 2004–09. The reason being as more papers are now sent for publication to foreign journals. The 16 international journals contributing 22.25% share in the total publications output of India in malaria during 1998–09 and showing a rise from 20.31% during 1998–2003 to 23.31% during 2004–09. The cumulative publications output share of these 29 most productive journals showed decrease in India's publications output from 50.51% during 1998–2003 to 43.58% during 2004–09 (Table 5).

Table 4. Productivity & impact of top 30 major Indian institutions in malaria research 1998–2009

Name of the Institute	TP	TC	ACPP	H-Index
National Institute of Malaria Research, New Delhi	396	1040	2.63	19
Central Drug Research Institute, Lucknow	176	902	5.13	20
All India Institute of Medical Sciences, New Delhi	121	443	3.66	13
Indian Institute of Science, Bengaluru	104	817	7.86	21
International Centre for Genetic Engineering & Biotechnology, New Delhi	99	579	5.85	14
Vector Control Research Centre, Puducherry	91	222	2.44	10
Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru	81	574	7.09	11
Postgraduate Institute of Medical Education & Research, Chandigarh	46	86	1.87	7
University of Delhi, Delhi	41	123	3	7
Regional Medical Research Centre, Bhubaneswar	38	93	2.45	7
Regional Medical Research Centre, Dibrugarh	37	50	1.35	5
National Institute of Immunology, New Delhi	36	263	7.31	12
KEM Hospital, Mumbai	35	140	4	10
Ispat General Hospital, Rourkela	34	164	4.82	8
National Institute of Virology, Pune	34	107	3.15	8
Jawaharlal Nehru University, New Delhi	33	136	4.12	10
Tata Institute of Fundamental Research, Mumbai	32	131	4.09	9
National Centre for Disease Control, Delhi	30	71	2.37	6
National Institute of Pharmaceutical Education & Research, Mohali	25	178	7.12	10
Desert Medicine Research Centre, Jodhpur	25	53	2.12	6
Dayalbagh Educational Institute, Agra	24	64	2.67	6
Indian Institute of Chemical Technology, Hyderabad	24	123	5.13	6
Armed Forces Medical College, Pune	24	17	0.71	3
Indian Institute of Chemical Biology, Kolkata	23	113	4.91	9
BHU Institute of Medical Sciences, Varanasi	23	194	8.43	8
National Centre for Cell Science, Pune	22	150	6.82	8
Christian Medical College & Hospital, Vellore	21	29	1.38	5
Defence Research & Development Establishment, Gwalior	20	50	2.5	5
Indian Institute of Technology, New Delhi	20	54	2.7	6
M.D. University, Rohtak	18	48	2.67	5

TP—Total papers; TC—Total citations; ACPP—Average citations per paper.

Table 5. List of most productive Journals publishing Indian papers on malaria 1998–2009

Name of the Journal	Number of papers		
	1998–2003	2004–2009	1998–2009
Journal of Vector Borne Diseases*	84	88	172
Journal of Communicable Diseases	56	30	86
Indian Journal of Medical Research	24	59	83
Annals of Tropical Medicine and Parasitology	46	22	68
Journal of Association of Physicians of India	41	21	62
Current Science	26	35	61
Parasitology Research	1	59	60
Journal of the American Mosquito Control Association	18	37	55
Acta Tropica	15	37	52
Transactions of the Royal Society of Tropical Medicine and Hygiene	19	32	51
Malaria Journal	2	46	48
American Journal of Tropical Medicine and Hygiene	13	31	44
Medical Journal Armed Forces India	16	22	38
Bioorganic and Medicinal Chemistry Letters	10	27	37
Molecular and Biochemical Parasitology	14	22	36
Indian Journal of Pediatrics	11	24	35
Southeast Asian Journal of Tropical Medicine and Public Health	14	17	31
Indian Pediatrics	9	20	29
Bioorganic and Medicinal Chemistry	4	24	28
Tropical Medicine and International Health	11	15	26
Biochemical and Biophysical Research Communications	15	10	25
Indian Journal of Experimental Biology	17	6	23
Journal of Environmental Biology	3	20	23
Journal of Biological Chemistry	7	15	22
Infection and Immunity	8	13	21
Journal of Postgraduate Medicine	5	14	19
Vaccine	3	16	19
Experimental Parasitology	6	13	19
Indian Journal of Pathology & Microbiology	7	12	19

\*Earlier named as 'Indian Journal of Malariology' till 2002.

### High cited papers

Based on publications output of India, 100 papers are identified as highly cited those received citations (since their publications till 1st October 2009) from 30 to 231 during 1999–2008. Of these 100 papers, 72 appeared as articles, 25 as reviews, 2 as short surveys and one as conference paper. Of the 100 high-cited papers, 36 involve international collaboration (21 bilateral and 15 multilateral), 19 involve national collaboration and 48 papers no collaboration. These 100 papers are in citations range of 30 to 231. Of these 100 papers, one paper is in citations range of 201–231, five in citations range of 101–200, three in citations range of 91–100, two in citations range of 81–90, three in citations range of 71–80, 13 in citations range of 61–70, three in citations range of 51–60, 17 in citations range of 41–50, 47 in citations range of 31–40, and five in citations range of 21–30. The authors of these high cited papers are affiliated to 49 Indian institutions and these articles appeared in 68 journals.

### DISCUSSION

From the above analysis, it is concluded that to achieve more research output, India has to invest much more in terms of R&D expenditure, deploy more research manpower, and identify malaria research as a priority area in the current and future national S&T plans as well as in the plans of research agencies.

The studies undertaken in the past, particularly on the analysis of world funding provided by the research agencies for carrying out the malaria research by different countries at different intervals of time reveals that the country's research output and its quality very much depend upon the funds provided for research purpose<sup>7–9</sup>. Although majority of the earlier studies analysed the world research output in malaria in the context of disease burden, sub-fields of malaria research, malaria vaccines, amount and nature of research carried out in developed and developing countries, distribution of articles in journals, etc using

PubMed (web edition), MEDLINE, SCI etc databases<sup>10–16</sup>, yet very few studies have been carried out for assessing the specific country research output in malaria<sup>17–18</sup> using SCOPUS database which has extensive coverage of medical literature. On analyzing the Indian research output in malaria using SCOPUS database, it was observed that although the quantity of Indian research output ranks the country at 4th but its impact in terms of average citations per paper is quite low compared to other developing countries.

For increasing the impact of Indian research, national collaboration between basic research and clinical research institutes in India should be encouraged by allocating more resources for national collaborative research projects by funding agencies as well as through much enlarged international collaboration. Since our share of international collaborative papers is much less than South Africa, Brazil and China, the Indian government should encourage more scientists to participate in global international collaborative projects as well encourage bilateral research projects between India and other developed and developing countries in malaria research.

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