

## Executive Summary

1. Malaria is a public health problem today in more than 90 countries worldwide. Prevalence of the disease is estimated to be in the order of 300-500 million clinical cases each year. More than 90% of all malaria cases are in sub-Saharan Africa.
2. Mortality due to malaria is estimated to be over 1 million deaths each year. The vast majority of deaths occur among young children in Africa, especially in remote rural areas with poor access to health services.
3. Other high-risk groups are women during pregnancy, and non-immune travelers, refugees, displaced persons and laborers entering endemic areas. Malaria epidemics related to political upheavals, economic difficulties and environmental problems also contribute in the most dramatic way to death tolls and human suffering.
4. With the recent breakthrough in Genomics and Proteomics and availability of quantum of information on Human, Mosquito and Parasite Genome and the application of advanced molecular and biotechnological techniques the research has entered in to a new arena with more prospects on vaccine development, drug delivery system, diagnostics, alternative methods of control and evaluation of newer insecticides and drugs.
5. Given the significant growth in the malaria research infrastructure and malaria research investments in the country, India needs to monitor and measure its performance in malaria research on regular basis. This requires building suitable indicators of malaria research performance, designed to understand the dynamics of research at institutional, sectoral, geographical and subject level. Some indicators are required for depicting how Indian research is performing vis-à-vis a select other similarly placed countries and against countries from the developed world.
6. The present report is first of its kind to provide a consolidated and comprehensive Bibliographical Database (MALPUB) on Malaria Research Papers, in the field of malaria around the Globe and in post independent India. The database have been developed on the basis of records captured from Science Citation Index (Expanded-online version), MEDLINE, Ovid (Global Health), Tropical Disease Bulletin and Indian Science Abstracts, and will facilitate a quick access to all the malaria related work carried out during last 50 years (1955-2005) published in a journal. Where-ever it was needed; the data have been completed manually also.
7. Finally, the database of Journal Research Papers on Malaria (MALPUB) was developed on a CD, through specially developed software using Microsoft Visual Studio 2005 with back end MS Access. The software has two versions: User Version is having facilities for simple and advance search, summarization, saving

in desire format & printing. The Full Version is having additional facilities, such as, data editing, data updating, data entry, deletion or addition of records *etc.* The 50 years database is common to both the versions.

### ***Analysis of MALPUB***

1. The report presents a Scientiometric analysis of the research efforts being made worldwide to combat the menace of malaria. The data have been analyzed from the resultant database MALPUB after properly removing the duplicates. Efforts have been made to carry out institutional affiliation and their growth also.
2. A 25 years of publications data from 1981 to 2005 on India and top 20 productive countries have been used for developing indicators for Malaria research, at country level
3. The total numbers of papers published during 1955-2005 is 122055. During 1996-2005 the number of papers in the field of Malaria was at it's maximum with 47.21%. The cumulative publication share in world research output indicated an exponential growth of papers from 3.34 ( 1955-65) to 47.21 (1996-2005).
4. The total number of countries involved in malaria research have increased from 130 (1981-85) to 135 (2001-05). India has maintained it's position among the top 4 countries through out the period of study (1981-2005) in the bracket of USA, UK, and France. In this way India has established itself as one of the giants in the field of malaria research, and ranks 4th among the top 20 countries, with its global publications share of 6.57% computed on cumulative publications output during the period of 1981-2005. The other countries that contributed publication in the range of more than 2% were Switzerland (2.78%), Japan (2.55%) & Brazil (2.41%).
5. The overall global publication share of top 20 countries in Malaria research ranged from 0.82% to 26.89%. The United States tops the list with global publications share of 26.89%. The United Kingdom ranks second, followed by France, India, Australia and, Germany, (their global publication share ranging from 3.32-6.47 %).
6. USA, UK, India, France , Netherlands, Switzerland, Germany, Thailand, China, Australia, South Africa, Italy, Brazil, Japan, Nigeria, Sweden are the strong contributing countries and show their continuous presence among top 20 countries.
7. The average growth rate of developing countries in top 20 is from (-)14.39 to (+)29.35 during successive years. India and Brazil are the top most growing countries. Their annual growth rate increased from (-)14.39 to (+)15.12. Thailand also came up with increased share but its average growth rate decreased from 15.82 to 0.92.

8. In spite of top rank of USA, it has not shown any considerable increase of annual growth, only its percentage share was more to keep it at the top position. Similarly UK get top position due to its share but annual growth have decreased from 9.41 to 8.67. France and Australia have got an increase in their annual growth rate.
9. India has nearly 442 high productive institutions in the field of Malaria Research, as seen from the cumulative national publications data during 1986-2005 publishing a total of 5669 papers. The top 10 institute contributed approximately 55% papers with an average of 285.8 paper per Institute. The rest of the papers were published by the rest 432 research institution and University Departments with an average of 5.53 paper per institute.
10. National Institute of Malaria Research (Earlier Malaria Research Center) Delhi, contributed maximum papers (18.64%) during the period of study followed by Central Drug Research Institute, Lucknow (10.06%), Vector Control Research Center, Pondicherry (5.66%) and International Center for Genetic Engineering & Biotechnology, New Delhi with 4.44%.
11. The apex institutions in the field of malaria research for India on the basis of analysis are; NIMR, CDRI, VCRC, ICGEB, RMRC-Bhubaneswar, AIIMS, PGIMER, IISc, and Ispat Gen. Hospital.
12. 18 subject areas within malaria research were identified. They comprised around 52% of all malaria papers. There were some noticeable variations with time in the popularity of the subjects.
13. Analysis indicates, an increase in the relative effort devoted to modern research in the field of control measures and understanding of vectors *e.g.* Artemisinin (ACT), Genome or Gene Studies, Malaria Vaccine, *P. falciparum* and Mosquito or Vector Control. Vaccines research have shown an increase during 1986-95, and has remained at about 22% of the total world average.
14. Among the pharmaceutical approaches, it is striking that research on Chloroquine has also increased over a period of 1981-2005. Work related to Artemesinins has increased from almost none in the early 1980s to around 70% world average, in the 21st century.
15. It is remarkable to note that in the field of parasite biology most of the efforts are concentrated on *P. falciparum* with world average of 33.06 (1981-85), 35.77 (1986-95) and 71.18 during 1996-05 whereas the papers on *P. vivax* have shown only a marginal increase from 8.91 (1981-85) to 17.43 during 1996-05.
16. Recent report of *P. knowlesi*, the monkey malaria infecting human being in some areas of South-east Asia made new developments from no paper during 1981-85 to the global output of '4' during 1996-05.

17. New technologies such as use of Rapid diagnostic kits were adopted for research areas in later years and the data indicated that its growth increased from Nil during 1981-85 to 1.58 of world average during 1996-05.
18. Among the productivity of developing countries as compared to world average India have shown its strong commitment towards Artemisinin and ACT, Drug Resistance, Malaria in Pregnancy and Malaria in Children, Mosquito or Vector Control, DDT or DDT Resistance, Fish or Biological Control and Bed nets showing an steady increase from 1981 through 1996-05.
19. China has shown strong commitment in Artemisinin based combination therapy of malaria control whereas Thailand has also depicted the same trend as of India with main focus on drug resistance, ACTs, malaria in children *etc.*
20. There were total 6064 journals publishing a total of 122055 papers during the whole study period (1955-2005). The first 50% papers (around 61115) appeared in a total of 47 journals with an average of approximately 1300 papers per journal. The rest of the papers were distributed among a total of 6017 with an average of 11 papers per journal.
21. During the study period (1955-2005) total papers with a ten year break-up were 4026 (1956-65), 9799(1966-75), 18141 (1976-85), 32470 (1986-95) and 57619 during 1996-2005. All these papers appeared in a total of 502 (1955-65), 953 (1966-75), 1339 (1976-85), 2070 (1986-95) and 3072 journals during 1996-2005.
22. Both the number of journals and the number of articles grew exponentially. The number of articles has increased from 4026 to 57619 from 55-65 to 96-05. Also the number of journals has increased from 502 to 3072 (1955-65 to 1996-05).
23. The most important observation is that the number of least productive journal has increased from 463 to 2951. This is perhaps due to:
  - a. Interdisciplinary nature of research in Malaria and related topics
  - b. High growth rates (exponential in nature!) of journals and articles

The literature survey of the papers in the field of Malaria also compliment this assumption, as the research is going into the area of modern biology, molecular biology, proteomics, Genetics and Immunological Studies at Genomics level, in search of control measure for the disease as well as the vectors

24. The top most journal contributing more than world average (21 papers per journal) were *Trans R Soc Trop Med Hyg* with an average of 112 papers followed by *Am J Trop Med Hyg*, *Mol Biochem Parasitol*, *Lancet*, *Ann Trop Med Parasitol*, *Exp Parasitol*, *J Am Mosq Control Assoc*, *Infect Immun*, *Trop Med Int Health*, *Parasitol Today*, *J Med Entomol*, and *Parasitol*.

25. In the next group, contributing papers between the range of 11-20, *Indian J Malariol* stood at the top position (13 papers per journal) much closure to world average. The other journals in this category were *Proc Natl Acad Sci USA*, *J Infect Dis*, *Southeast Asian J Trop Med Public Health*, *Med Vet Entomol*, *J Biol Chem*, *Acta Trop*.
26. *Indian J Malariol*'s cumulative publications share among all the developing countries was maximum and in world context also the journal occupies the position of top 10 ranking journals in field of Malaria research during 1955-2005.
27. *J Med Entomol* and *J Infect Dis* are new entrants in the publishing journals for malaria research occupying position among the top 10 world ranking journals during 1995-2005.

The captured data have been analyzed to compute time trend analyses, subject-wise analyses and the type of the study – whether basic or applied, individually for the data from different global database *e.g.* SCI, MEDLINE, TDB and ISA also. An analysis has also been carried out to find out comparative coverage and trend of papers between two different databases also.

### ***Analysis of the Data Captured from SCI***

1. The analysis has been done for the records from SCI, over the quarter-century from 1980 to 2004, and national outputs of malaria papers with their production of biomedical papers overall were compared, so as to show their relative commitment to malaria research also in terms of the approaches being researched for malaria control. These include the study of mosquitoes and their habitats; spraying with DDT and other insecticides; the use of Bed nets; Vaccine development; and Genetic approaches. We have also looked at five sets of drug-based methods of attack: Quinine; Chloroquine; Mefloquine; Pyrimethamine; and the new Artemesinins.
2. Interest in malaria research is very widespread, and some 155 countries (out of 192 members of the World Health Organization) were represented among the addresses on the papers.
3. Malaria research is a small sub-field and currently represents about 0.4% of biomedical research output in the SCI, though it was only about 0.3% in the early 1980s.
4. The distribution of the research levels of the malaria papers, with, for comparison, papers in three other biomedical sub-fields – AIDS, cancer and respiratory medicine were also evaluated. The malaria papers are the most basic of the four, with a median value of RL of 2.66 compared with 2.10 for AIDS, 1.98 for cancer

and 1.77 for respiratory medicine. This suggests that much still has to be learned about the fundamentals of the disease, whereas for the other research sub-fields, the emphasis of research is very much on the development of new and better drugs.

5. Although normally countries with less scientific output collaborate more internationally, it is striking that India collaborates so little with other countries – this finding applies to other fields of science as well. During the quarter-century, most countries among the leading 19 have increased their relative presence in malaria research, particularly Kenya and Brazil, but four (Israel, Nigeria, the USA and India) have decreased their presence. For Israel and the USA, malaria is not a domestic problem, but it certainly is for Nigeria, where malaria causes a burden twice that in any other country and is responsible for over 11% of the total burden of disease (compared to 0.3% in India). Nigeria also tends to collaborate rather little with other countries.
6. The countries most committed to malaria research in relation to their biomedical research output are all ones affected by the disease, but Kenya, Thailand and Nigeria are in a different group from India, South Africa and Brazil. Among the industrial countries, Australia, Switzerland and the UK are relatively the most active, followed by France and the Netherlands.
7. Subject areas within malaria research were comprised between 40% and 45% of all malaria papers. The overall numbers of papers in each subject area, indicates some noticeable variations with time in the popularity of the subjects.
8. There has been a steady relative decline in the amount of attention given to mosquitoes and their habitat, but, an increase in the relative effort devoted to genetics. Vaccines research increased in the 1980s, and has remained at about 9% of the total.
9. Work on Bed nets is still sparse among the pharmaceutical approaches; the amount of research on Chloroquine has declined whereas that on the Artemesinins has increased from almost none in the early 1980s to around 6% in the 21st century.
10. Among the non-pharmacy approaches, mosquito control research is undertaken most by the USA and Canada. South Africa concentrates heavily on the insecticidal approach and Kenya and the UK on the Bed net approach. Malaria vaccines have been most favored by Switzerland, although Colombia has a RC of 5.5 to this subject area.
11. Among the pharmaceutical approaches, the new Artemesinins have principally engaged the attention of the Chinese, followed by the Thais. Chloroquine research has been the main interest of Nigeria, and Mefloquine research in Thailand, Switzerland, Nigeria and Sweden. Nigeria has also been active in work on Pyrimethamine (as has Kenya), and Thailand in work on the traditional remedy for

malaria, quinine, which is now making something of a comeback as resistance develops to some of the newer drugs

### ***Analysis of Data from MEDLINE***

1. The growth of malaria research parallels that of biomedical research (0.36% of the total during 1980s and 0.43% in the 21st century). Country-wise data was USA (30.73%), UK (26.88%) France (5.34%) among developed and India (3.59%), China (2.04%), Thailand (1.67%) and Brazil (1.21%) from developing nations.
2. The year-wise data on drugs indicates work on Chloroquine has decreased because of many resistant strains of malaria. The trend of research activities related to drugs in the field of malaria for the years 1980-2005 revealed India was having maximum (29.58%) papers related to Chloroquine followed by Thailand for Mefloquine (19.30%) , Pyremethamire (17.82%) and Chloroquine (11.84%). Down the line again next was India with Pyremethamine (11.72%), China (7.87%) in Chloroquine followed by Brazil for Mefloquine (5.45%).
3. Results for India indicates that most effort , during earlier years was on research on spraying with DDT, Dieldrin and other insecticides, but later years the trend have changed in favour of rather modern and front line areas of control measure like Bed nets, Biological Control and use of Pyrethroids etc . India also has a slightly above-average RC on Bednets, on Mosquito Control and on the newer drugs (Artemesinins), but does very little work on Mefloquine .

### ***Comparative Study of SCI & MEDLINE Data***

1. The papers from two very important International databases namely SCI & MEDLINE for the two-time period 1986-90 & 2001-05 with a gap of 10 years have indicated the total coverage of malaria papers during 1986-90, - MEDLINE 5888 and SCI covered 3967 papers.
2. During 2001-05 the coverage of MEDLINE leaped many folds (12,491). In SCI also, number of papers covered was more (10123). This indicates that MEDLINE is the world's most comprehensive source of life sciences and biomedical bibliographic information.
3. The Relative Commitment (RC) of USA leaped from 22.03(1986-90) to 35.72(2001-05) among the developed countries followed by UK, France, Germany and Israel. Among the developing countries the RC of India has increased from 4.16(1986-90) to 6.04(2001-05) followed by Thailand, South Africa, China and Malaysia.
4. The trend of journals enlisted in both the database shows that the topmost journals covering malaria papers were almost same in both MEDLINE and SCI. American

Journal of Tropical Medicine and Hygiene has grabbed 1st position (2001-05) replacing Transactions of the Royal Society of Tropical Medicine and Hygiene (1st during 1986-90).

5. The contribution of total no. of articles in MEDLINE is more as compared to SCI during 2001-05 as well as during 1986-90. But while looking at the percentage contribution of both the databases there is no significant change as the total no. of articles on malaria covered in SCI is less.
6. The journals covered in SCI are more from the developed countries with USA standing at the top followed by UK, Germany, Netherlands, France *etc* (In recent years UK is at the top position followed by USA (2001-2005). While in MEDLINE, journals from the developing countries like India, China, Brazil, Thailand are having better percentage share