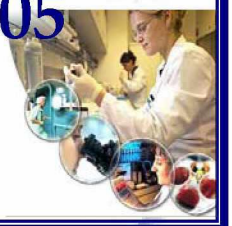
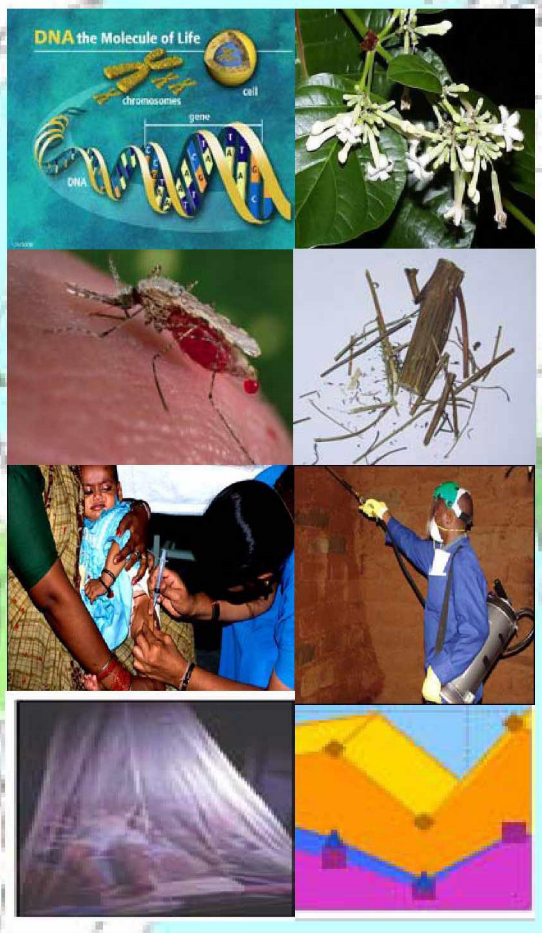
Global Database of Research Papers on Malaria (MALPUB) 1955-2005

An Analysis





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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.* Artemesinin (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 form 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 Artemesinin 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).

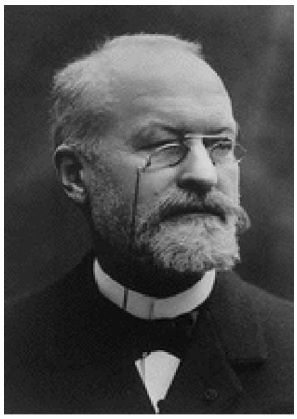
5. The contribution of total no. of articles in MEDLINE is more as compared to SCI during 2001-05 as well as during 1986-90. But while looking at the percentage contribution of both the databases there is no significant change as the total no. of articles on malaria covered in SCI is less.

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

Introduction

Malaria has been one of the most potent scourges of mankind from time immemorial, and it remains, with AIDS and tuberculosis, one of the three major communicable diseases. Previously it was widespread, with many deaths in Europe, but it is now mainly confined to Africa, Asia and Latin America. Most of the estimated 900,000 deaths each year occur among children in sub-Saharan Africa, and malaria is responsible for over 10% of the disease burden in 15 African countries, and for between 5% and 10% in a further 19[1]. The problems of malaria control in tropical countries are aggravated by inadequate health infrastructures and poor socio-economic conditions. Moreover, in the last few decades the disease has shown resistance to the drugs normally used to combat the protozoan parasite (Plasmodium) that causes it, and the vector (the mosquito, Anopheles) has become resistant to some of the insecticides used to control it. The spread of malaria has been facilitated by population movements, some water development projects and the effects of climate change, and between 300 million and 500 million people now suffer episodes of the disease.

Although the bitter-tasting component of the bark of Cinchona ledgeriana was known as an effective anti-malarial since the 15th century in Peru, and an infusion of qinghao (Artemesia annua) has been used for more than 2000 years in China, the active ingredients were only isolated by pharmacists in the early 19th and late 20th centuries, respectively. Systematic control of malaria really began with the discovery of the malaria parasite by



Laveran (left) in 1880, and the demonstration by Ross (right) that the mosquito was the carrier (vector) in 1897 – both discoveries leading to the award of Nobel prizes for medicine or physiology (in 1907 and 1902, respectively). One of the most effective means of control was through the removal of surface water in which the mosquitoes could breed: this was applied with great effect to the region around Rome in the 1930s. The second World War stimulated the search for new methods, and DDT was developed as an insecticide to kill the mosquitoes, and the chloroquine group of drugs were synthesised as an effective treatment.

Because malaria depends solely on human hosts for its onward transmission, if all the members of a population are free of the disease, then it will not be spread to any newcomers.

[1] *Based on Disability Adjusted Life Years (DALYs), as reported on the WHO website (2002 estimates). The percentage burden of disease from malaria is higher in 39 African countries than in any Asian one.*

Thus the possibility that malaria could be eliminated from the planet took hold in the post-war period, and major campaigns were carried out in many countries to kill the mosquitoes and distribute drugs. There was also a major effort by USAID, unfortunately badly managed, to produce a malaria vaccine (Desowitz, 1993).

The consequence was a big reduction in the death toll from the disease in many countries (Spielman *et al*, 1993), but over-confidence led to a reduction in the research effort. Data for India are fairly typical: the annual number of recorded deaths from malaria was about 800,000 at Independence, and then fell rapidly in the 1960s and 1970s to a low of fewer than 100, only to rise again to 200-300 at the end of the 1980s and over 1100 in the mid-1990s when there were several outbreaks, often caused by heavy rains (Sharma, 1996; Lal *et al.*, 2000). Since then better control measures have brought the toll down to below 700, but it is still a persistent problem and malaria control absorbed a quarter of the national health budget from 1977-1997, with most of the money being spent on insecticides (Dhingra *et al.*, 1998). However these figures may well under-state the actual death toll from malaria in India, which was estimated by the WHO as 9400 in 2002, or just under 0.1% of all deaths.

During the 1990s, a renewed effort was made to reduce the burden from malaria, with major initiatives in research. The Multilateral Initiative on Malaria was started in 1997, following an initial meeting in Dakar in January and a further meeting of potential donors in Den Haag in July, but money built up rather slowly at first (Butler, 1997; Gallagher, 1997; Pennisi, 1997). Much more money has subsequently been forthcoming (Davies, 1999; Marshall, 2000; Butler, 2003; Das, 2003), particularly for research in Africa (Kilama, 2001; Ntoumi *et al.*, 2004), and this seems to have had some positive results (anon, 2002). Other initiatives include the Roll Back Malaria Project; the Global Fund for HIV, Tuberculosis and Malaria (the Global Fund); the Medicines for Malaria Venture; and the Malaria Vaccine Initiative (Alilio *et al.*, 2004). The focus has been on high-tech approaches, such as the development of vaccines (Hagmann, 2000; anon, 2001; Gulland, 2003) and the sequencing of the malaria genome (Gavaghan, 1994; anon, 1996; Gardner *et al.*, 2002; Holt *et al.*, 2002). These approaches have been criticised because more conventional methods may be much more cost-effective and produce results more quickly (Curtis, 2000; Enserink, 2004). Moreover, social science research may also have a substantial role to play in the fight against malaria (Williams *et al.*, 2002). The other methods include the promotion of insecticide-treated bednets (anon, 2003; anon, 2005) and the spraying of interior walls with DDT, which has recently been encouraged by the World Health Organization (Mandavilli, 2006) despite the opposition of some environmentalists and the Bayer Crop Science company, who had a rival (and more expensive) insecticide (Beattie, 2005).

As per the World Malaria Report 2005, malaria still continue to prevalent in 107 countries and approximately 3.2 billion people live is such areas and face the risk of infection. An estimated 3.2 billion dollars annually are needed to confront the disease. The disease cost Africa an estimated 12 billion dollars in GDP and increase poverty by reducing productivity and social stability.

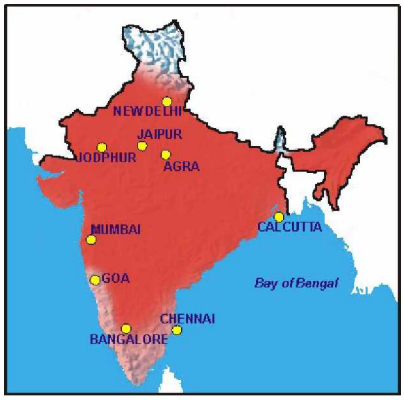
P. falciparum is the predominant parasite. More than 120 million clinical cases and over 1 million deaths occur in the world each year.

The distribution of malaria varies greatly from country to country and within the countries themselves. In 1990, 75% of all recorded cases outside of Africa were concentrated in nine countries:

India
Brazil
Afghanistan
Sri Lanka
Thailand
Indonesia
Vietnam
Cambodia
China

Asia: Malaria is widespread in numerous countries in Asia and Oceania, including India, Pakistan, Bangladesh, Thailand, Vietnam, Laos, Myanmar, Cambodia, Indonesia, Papua New Guinea. Malaria also occurs in portions of Iran and the Middle East. *P. falciparum* is common, as is *P. vivax*. *P. falciparum* infections unfortunately increased during the 1990s in India and Sri Lanka. Resistance in *P. falciparum* to multiple drugs is present in portions of Cambodia, Myanmar, Thailand, and Laos, and chloroquine resistance is widespread in Asia. *P. malariae* also occurs in this area.

India - Malaria Map



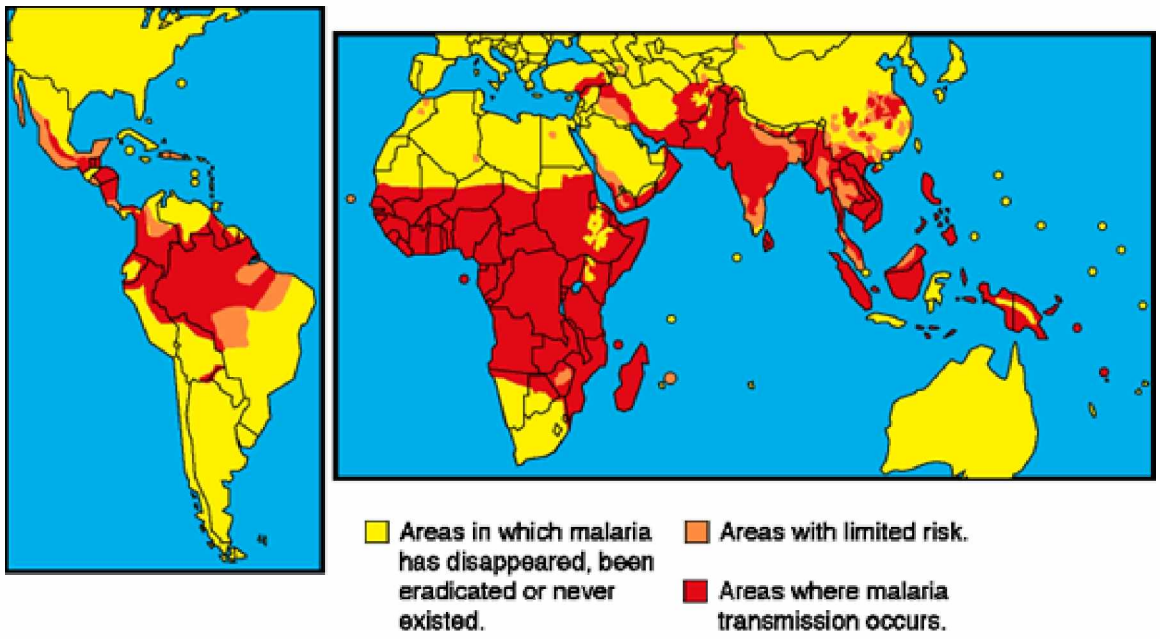
This map is only intended as a guide since mosquitoes do not respect boundaries and the risk areas shown may not be exact. Substantial malaria risk is shaded in dark red - becoming a lighter red where the risk is minimal.

In pre-independent India about 75 million malaria cases with 0.8 million deaths were estimated with extremely grim and bleak scenario. With the advent of DDT on insecticidal horizon and Global efforts to eradicate malaria using vector control and anti-malarial drugs brought unprecedented success with the result malaria cases declined to only 100,000 with no death in 1964. The complacency reached to a state that research on malaria was almost stopped, one time famous The Malaria Institute of India was converted into The National Institute of Communicable Diseases and the renowned Indian Journal of Malariology was

terminated. But the euphoria of success short lived and the malaria resurged back with vengeance touching the all time high peak with 6.4 million cases in 1976, due to various technical, administrative and operational constraints coupled with the threatening problem of insecticide resistance in mosquito vectors and drug resistance in malaria parasite. However, the revised control strategies were planned and implemented thereafter, which brought back the situation under control. During last few decades, problem is still persisting with newer paradigms and dimension with focal outbreaks, increase in *P. falciparum* cases and increasing vector and drug resistance requiring strategies tailor made to local conditions. Urban malaria is also emerging as a new threat.

In the next decade i.e. seventies these problems further multiplied and as a result malaria resurgence was wide spread. In the eighties, malaria problem further aggravated and focal out-breaks were reported and research work also increased. In the nineties, malaria situation in the country has deteriorated further.

Malaria Program



Map of Malaria endemicity
Source: World Health Organization

The significance of malaria as a health problem is increasing. Epidemics are even occurring around traditionally endemic zones in areas where transmission had been eliminated. These outbreaks are generally associated with deteriorating social and economic conditions, the main victims being underprivileged rural populations. Demographic, economic and political pressures compel entire populations (seasonal workers, nomadic tribes and farmers migrating to newly-developed urban areas or new agricultural and economic developments) to leave malaria free areas and move into

endemic zones. People are non-immune are at high risk of severe disease. Unfortunately, these population movements and the intensive urbanization are not always accompanied by adequate development of sanitation and health care. The absence of adequate health services frequently results in a recourse to self-administration of drugs often with incomplete treatment. This is a major factor in the increase in resistance of the parasites to previously effective drugs.

Malaria and Children

Malaria kills one child every 30 seconds. This preventable disease has reached epidemic proportions in many regions of the world, and continues to spread unchecked. In absolute numbers, malaria kills 3 000 children per day under five years of age. It is a death toll that far exceeds the mortality rate from AIDS.

Indian children from lower strata, under five years of age are chronic victims of malaria, suffering an average of six bouts a year. Fatally-afflicted children often die less than 72 hours after developing symptoms. In those children who survive, malaria also drains vital nutrients from children, impairing their physical and intellectual development. Malarial sickness is also one of the principal reasons for poor school attendance. Yet protection of children can often be easy. Randomized control trials show that about 30 per cent of child deaths could be avoided if children slept under bed nets regularly treated with recommended insecticides such as pyrethroids. Unlike early insecticides such as DDT, pyrethroids are derived from a naturally occurring substance, PYRETHRUM, which is found in chrysanthemums and will remain effective for 6 to 12 months.

Malaria is also particularly dangerous during pregnancy. It causes severe anemia, and is a major factor contributing to maternal deaths in malaria endemic regions. Pregnant mothers who have malaria and are HIV-positive are more likely to pass on their HIV status to their unborn child. Malaria also affects pregnant women, their fetuses, and their newborns. This comprises an extremely large but often hidden burden, especially in Africa. It is estimated that over 400,000 women develop anemia during pregnancy annually as a result of malaria in sub-Saharan Africa alone. Severe anemia due to malaria occurs in 1.5 to 6.0 million African children annually with a case fatality rate of nearly 15%. Malaria is a major public health problem in India and its dynamics vary from place to place. In central India malaria is complex because of vast tracts of forest with tribal settlement. According to a 1987 estimate, 54 million tribal of various ethnic origins residing in forested areas and accounting for 8% of the total population contributed 30% of total malaria cases, 60% of total *P. falciparum* cases and 50% of malaria deaths in the country. Keeping this in view a new malaria control strategy named Enhanced Malaria Control Project (EMCP) was introduced in 1998 by the National Anti Malaria Programme (NAMP) in seven peninsular states of India with World Bank assistance. The main components of the EMCP are early case detection and prompt treatment, selective vector control, personal protection measures, information, education and communication with community involvement for malaria control activities and distribution of more potent and less toxic drugs in resistant areas as identified by NAMP. In Madhya Pradesh (MP) and Chhattisgarh districts having more than 25% tribal population have been brought under EMCP. The gravity of the problem can be

assessed by the fact that in MP (pop 63,668,000), 19% population of the 15 districts of state is under EMCP which contribute 53% malaria and 71.5% *P. falciparum* cases. Similarly Chhaittisgarh has a total population of 23,070,000 of which 41% are under EMCP, which contribute 91% of malaria and 96% of *P.falciparum* cases in the state. Almost all the deaths (91%) in Chhattisgarh were from EMCP districts. The ethnic tribal population of Chhattisgarh is one third of total population which is highest for any state in the country. Further, it is the 2nd highly malaria infested state in India after Orissa. The annual blood examination rate (ABER) and annual parasite incidence (API) of India were 8.5 and 1.8 respectively in 2002, while the corresponding figures for Chhattisgarh were 16.22 and 10.65.

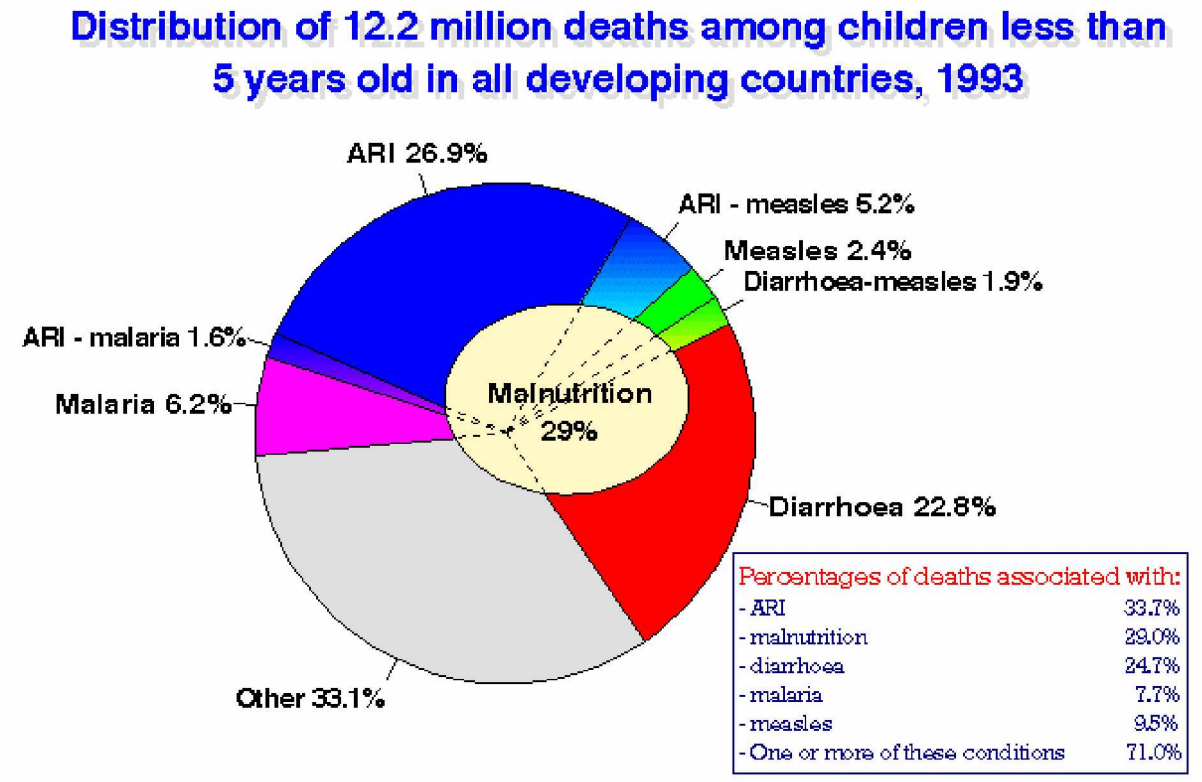
Mosquito repellents, coils and bed nets were not used by the communities as neither they have the knowledge about these gadgets nor they could afford such personal protection methods. But, in the evening most people burn dry leaves to drive mosquitoes out of their houses. People have faith in guinea as these traditional healers hail from the same community, live among them and are always available. Only when they did not get cured, they go to untrained and unlicensed practitioners or quacks, who may give adulterated, under dosed treatment which is often broad spectrum and focuses mainly on symptomatic relief. The quacks prefer to give them injections, as people believe that a single injection is more powerful than 10 tablets of chloroquine. Another point of concern is the strong misconception that malaria convulsions are due to evil spirits. Such misconceptions have a considerable impact on use of Antimalarial drug.

The use of larvivorous fishes has been successful in malaria control in many parts of India, but ethnic tribes consume larvivorous fishes as well during January-June. This is the time when their lean period of food resources start and they have nothing to eat and this nearly eliminates fishes. Insecticide impregnated bed net is an other alternative that has shown promise recently in most parts of the world, however, bed nets were not found effective in remote tribal villages because of outdoor life and forest based economy of the tribal population.

Review of the epidemiological data and an analysis of the relationship between transmission, morbidity and potential mortality from malaria suggested that no intervention aiming to reduce the malaria burden was on a long term basis in majority of epidemiological contexts. Gradually the transmission of *P.falciparum* is extending throughout the year. However, the effect of such a shift in *P.falciparum* season might only become apparent if PCR is used for monitoring drug resistance in parasite. It appears that the control of *P.falciparum* is unattainable in the absence of new tools. Therefore, a more diversified research programme might be needed in consonance with the cultural and social frame work of the population for sustainable results on long-term basis. Finally, it must never be forgotten that social and economic instability has helped perpetuate the burden of malaria, and wherever the conditions are stable, the prospects for disease control have greatly improved.

The human behavior is related to risk for malaria, and that such behavior is influenced by a range of cultural and social factors, including different explanatory models about etiology

and appropriate preventive and treatment actions, which are not precipitously pushed aside by the provision of "correct" knowledge – in this case, bio-medically derived information about the causes, symptoms, and appropriate preventive and therapeutic actions regarding malaria. A considerable gap remains between "correct scientific knowledge" and the accepted practices and beliefs about malaria held by disparate groups of people. The social science literature on malaria shows quite powerfully that socio-cultural, political, and economic circumstance not only influence behavior, but are themselves key factors in determining both immediate and more fundamental risk factors. Tanner & Vlassoff are two of the many authors who make similar statements in this regard, namely that "Perceptions of illness, knowledge and understanding of illness are socially and culturally constructed, as are actions taken with regard to treatment". While most attention is placed on understanding the behavior and significant socio-cultural factors of the communities of potential malaria sufferers, it is also important to understand the socio-cultural and behavioral characteristics of the health system itself, the predominant environments within health facilities, and the factors influencing the behavior of health personnel. Relatively little malaria research attention has been turned toward the health-care system and dominant attitudes on the part of health personnel as factors influencing acceptability and utilization of preventive and curative malaria services. Yet innumerable studies have shown that the attitude of health personnel is a crucial influence on the level of general health services use. Much can be learned in this regard from the manner if not the substance of the positive therapeutic alliances quite often established between traditional healers and their patients, which is one of the main reasons why people continue to seek these services. UNICEF recognizes that malaria is one of the five major causes of under-five child mortality. The agency has made the disease a top priority, supporting malaria control programmes in 32 countries.



Malaria's reach is spreading

"Global warming" and other climatic events such as "El Niño" also play an important role in increasing risk of disease. The disease has now spread to highland areas of Africa, for example, while El Niño events have an impact on malaria because the associated weather disturbances influence vector breeding sites, and hence transmission of the disease. Many areas have experienced dramatic increases in the incidence of malaria during extreme weather events correlated to El Niño. Moreover, outbreaks may not only be larger, but more severe, as populations affected may not have high levels of immunity. Quantitative leaps in malaria incidence coincident with ENSO (El Niño/Southern Oscillation) events have been recorded around the world: in Bolivia, Columbia, Ecuador, Peru and Venezuela in South America, in Rwanda in Africa, and in Pakistan and Sri Lanka.

In all situations, control programmes should be based on four objectives:

- Provision of early diagnosis and prompt treatment to all people at risk
- Selective application of sustainable preventive measures, including vector control adapted to the local situations
- An immediate, vigorous and wide-scale response to epidemics
- The development of reliable information on infection risk, living conditions of concerned populations, and vectors

Malaria is by far the world's most important tropical parasitic disease, and kills more people than any other communicable disease except tuberculosis. In 1995 annual loss due to malaria in India was estimated between US $ 0.5 to 1.0 billion, as we enter the next millennium malaria situation in the country has become a formidable challenge in public health.

Prevalence

The geographical area affected by malaria has shrunk considerably over the past 50 years, but control is becoming more difficult and gains are being eroded. Increased risk of the disease is linked with changes in land use linked to activities like road building, mining, logging and agricultural and irrigation projects, particularly in "frontier" areas .Other causes of its spread include global climatic change, disintegration of health services, armed conflicts and mass movements of refugees. The emergence of multi-drug resistant strains of parasite is also exacerbating the situation.

The current global picture

Malaria is a public health problem today in more than 90 countries, inhabited by a total of 2 400 million people -- 40% of the world's population. 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.

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.

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.

What Are Some of the Bright Spots for the Future?

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.

India has followed the policy of excellence through self-reliant scientific research, with the purpose to initiate, advance and accelerate national development in all segments of malaria research. Given this policy initiative, India has been able to usher significant growth in its capacity and capability building in basic research, applied research, and developmental

research in the field of malaria research. Its infrastructure has also become very large, comprising more than 300 universities, 400 research laboratories, 13 institutes of national importance and 1300 in-house R&D units, besides several other government departments, private, international and non-profitable institutions. Investments in vector control research have grown multi-fold, from Rs. 350 crore in 2006-07 to Rs. 472 crore (allocated) in 2008-09 budget. The total annual expenditure on research in the field of malaria is now close to 0.8% of the Gross Domestic Product (GDP). In the current government's projected vision, the size of the education sector is expected to grow almost 10-fold during the current XI Five-Year Plan. With such significant expansion expected in the higher education sector, it is certain that the malaria research infrastructure in Indian research activity will witness significant expansion in the near future.

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 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. Several studies made in the past have looked at indicators of research in the field of Malaria from India. These studies did highlight the status of Indian research in terms of research papers during different periods. Some of these studies developed indicators on institutional productivity, scattering across Indian and foreign journals, quality of research, and nature of collaboration, *etc.* With the changing paradigm in malaria research, there is a need for more specific indicators. The present study analyses 25 years of comprehensive malaria research papers from India in particular *vis a vis* global research. Study has also been done on the yearly growth of papers from 1955-2005 and the growth of journals at global level

New communication technologies have resulted not only in new tools that are useful for epidemiology but also in a wealth explosion in the developed world. These tools should be used to their capability to integrate the developing world into the rest of the world and its affairs. The increasing availability of computer technology and the World Wide Web have enhanced communication capabilities. The transfer of these capabilities from developed to developing countries has positive impacts on the ability of people within regions of developing countries to communicate with international agencies. These communication technologies, when implemented, are also useful for communication within countries between national administrators and regional malaria control workers. These capabilities should be installed and utilized to their full potential in the saving of lives and health.

In view of the importance of malaria research in the field of human health and well being it becomes important to map out the research activities being carried out by researchers around the world and in India by Indian Scientist. Since research publications are one of the major outputs of any research activity and which can be quantified also may reveal the trend of work being carried out in this area. For this purpose we need a searchable consolidated database, but there is no exclusive comprehensive Global database on malaria publications and for Indian efforts also in the field of malaria, there is no available single

source. Whatever literature is being generated by Indian Scientists is dispersed in various documents, thus making any efforts of mapping research efforts difficult. With this backdrop a comprehensive database have been developed for Bibliographical Details of all the research Papers published in any scholarly journal around the world. The project is first of its kind to provide a consolidated and comprehensive database, on amount of work/research done in the field of malaria around the Globe and in post independent India. It is hoped that the database will facilitate a quick access to all the malaria related research papers appearing in a journal during last 50 years. For the work, data have been captured from Science Citation Index (Expanded-online version), MEDLINE, Ovid (Global Health), Tropical Disease Bulletin and Indian Science Abstracts, for the period of 1955-2005. Where-ever it was needed; the data have been completed manually also.

Scientometrics and bibliometrics are used to measure scientific activities, using statistics on scientific publications indexed in a database. They are flexible tools used to study the sociological phenomenon associated with scientific communities, to conduct scientific/strategic, technical, technological or competitive monitoring, to design and manage research programs and to evaluate research. The methods employed for evaluating research output, positioning studies and conducting foresight studies in the field of Malaria Research. Few scientiometric studies have been reported in the literature on malaria research prominent among them are Garg K. C. ; Dutt B. ; Kumar Suresh, 2006, as per this study malaria research output is highly scattered both in terms of the sub-fields of the journals as well as the publishing country of the journals. MacLean *et al* studied international funding for research in malaria, analyzed malaria publications output for 1984, 1989 and 1994 and its impact using citations for different countries and funding agencies. The results of this study are based on PRISM Report No. 7 carried out by Anderson *et al*. In another study, Lewison *et al* used a bibliometric approach to estimate research funding for malaria for the years 1996-2000. All these studies have used the Science citation index (SCI) on CD-ROM, published by the Institute for Scientific Information (now Thomson Reuters) as the source of data. The SCI does not index a large number of journals published from developing countries such as Brazil, China and India. An estimate of research outputs on malaria which predominantly affects developing countries, using the SCI will be flawed. In order to have a better view of the malaria research output, it will be appropriate to use database(s) that are more representative of the overall malaria research output.

The captured 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. A study to map out the growth of malaria research in the world as well as in India according to prevalence or pattern of the disease reveals interesting trend for the productivity and research related to control and drug development. The report presents a Scientiometric analysis of the research efforts being made worldwide to combat the menace of malaria. Analyses have also been done 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 *eg.* SCI, MEDLINE, TDB and ISA individually. An analysis has also been carried out to find out comparative coverage and trend of papers between two databases also.

Specific objectives of the Analysis

The objectives of the present study are: (i) To analyse the growth of literature (ii) India's publications growth rate and global publications share, in comparison with select leading countries, (iii) similarities of India's research profile with select developing countries (iv) identify sub-fields of malaria research in which the research efforts are concentrated, (iv) characteristics of high productive institutions, scientists and papers and (v) identify Journals- core & others wherein R & D literature on malaria is published (vi). identify research gaps areas of intense activity in the field. These indicators are of special significance to planners and policy makers in measuring progress in malaria research and in formulation of a malaria research policy for long-term planning and implementation in the country.

About the Database (MALPUB)

In view of the importance of malaria research in the field of human health and well being it becomes important to map out the research activities being carried out by researchers around the world and in India by Indian Scientist. For this purpose we need a searchable consolidated database, but there is no exclusive comprehensive Global database on malaria publications and for Indian efforts also in the field of malaria, there is no available single source. Whatever literature is being generated by Scientists, is dispersed in various documents, thus making any efforts of mapping research efforts, difficult. With this backdrop a comprehensive database have been developed for Bibliographical Details of all the research Papers published in any scholarly journal around the world.

The effort is first of its kind to provide a consolidated and comprehensive database on amount of work/research done in the field of malaria around the Globe and in post independent India, and will facilitate a quick access to all the malaria related work carried out during last 50 years. For the work, data have been captured from Science Citation Index (Expanded-online version), MEDLINE, Ovid (Global Health), Tropical Disease Bulletin and Indian Science Abstracts, for the period of 1955-2005. Where-ever it was needed; the data have been completed manually also.

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. MALPUB 2008 is a compilation of Bibliographical details of Research Papers appearing during 1955-2005 in a journal, on Malaria, a project conceived and executed by Indian Council of Medical Research, India and funded by NSTMIS Division of Department of Science and Technology, Government of India.

The software has two versions: User Version is having facilities for search and summarization, saving in the desired format, and printing. The Full Version (Admin CD) is having additional facilities, such as data editing, data updates, deletion or addition of records, data entry and saving mode. The 50 years database is common to both the versions. Searchable fields for data base are as follows:

- Title (Title)
- Author (Author)
- Address (Author Affiliation)
- Journal (Only Journal Abbreviation)
- Source (Full detail-Journal, Year, Volume, Page)
- Country (Pull down menu)
- Year (Pull down menu)
- Key Words.

It is proposed that the database will be updated at regular intervals covering the successive years of Publications in a Journal. Options are available for sending a feedback about the content and the presentation of the data. Suggestions for improvement are welcomed. The

provisions will be made to upload the database along with the software on the server of the DST and ICMR. In this way the user would be able to download the whole database on their system, along with set up files, thus the search will be possible for the user.

Methodology

To carry out this project, efforts were made to collect Global information on research publications in the field of malaria and Indian research papers published during last 50 years .The data sources (see table below) have been searched using the search string *'malaria OR plasmodium OR anopheles OR mosquito control OR malaria epidemiology OR malaria outbreak OR malarial drug resistance OR malaria remote sensing OR malaria vaccines OR malaria in pregnancy OR economic loss due to malaria OR malaria in children OR malaria in child OR antimalaria OR bednets OR bed nets OR P. vivax OR P. vivax OR vivax malaria OR plasmodium falciparam OR P. falciparum OR plasmodium knowlesi OR p. knowlesi OR vivax genome OR malaria disease burden' etc* for research papers in Web of Science (WOS) from 1955 to 2005, MEDLINE 1955-2005, Tropical Diseases Bulletin (TDB) 1955-2005, Ovid (Global Health Database) 1972- 2005, Indian Science Abstracts (ISA) 1965-2005, Indian institutes active in the field over a period of study. Some of the left out journals were physically consulted, which were not covered by any of these services but were important as identified by the peer group of the field. Malaria research output is highly scattered both in field of research papers and patents in terms of the sub-fields of the journals as well as the publishing country of the journals, publication years of patent, subject category, language, country *etc.*

Source	Period	Number of papers
Web of Science (WOS)	1955-2005	42713
MEDLINE	1955-2005	51563
TDB	1955-2005	30000
Ovid	1972-2005	38138
ISA	1965-2005	5000

The data from hard copies were collected on pre-designed formatted input sheets. The fields were decided in consultation with subject specialist of the area as well as experts from Information Science. Each record is provided with suitable keywords and Institutional affiliation of the author (wherever available).

Once the basic data for other than Indian research papers, were captured from the digital sources, it was converted into searchable database format (compatible to database for the data from hard copy) through a specifically developed conversion programme for the purpose. Duplicate entries from different secondary services were removed by systematically screening the records, by special utility programme for the purpose.

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 search, (simple and advanced), summarization, saving (in desired format) and printing. The Full Version (Admin CD) is having additional facilities, such as data editing, data updates, deletion or addition of records, data entry and saving mode. The 50 years database is

common to both the versions. Once the data was converted into a CD with the software, a formal validation, editing and corrections were also carried out to make sure that errors are removed completely. Computer inputs were also validated and checked, and many test run (s) were carried out.

Searchable fields for data base are as follows:

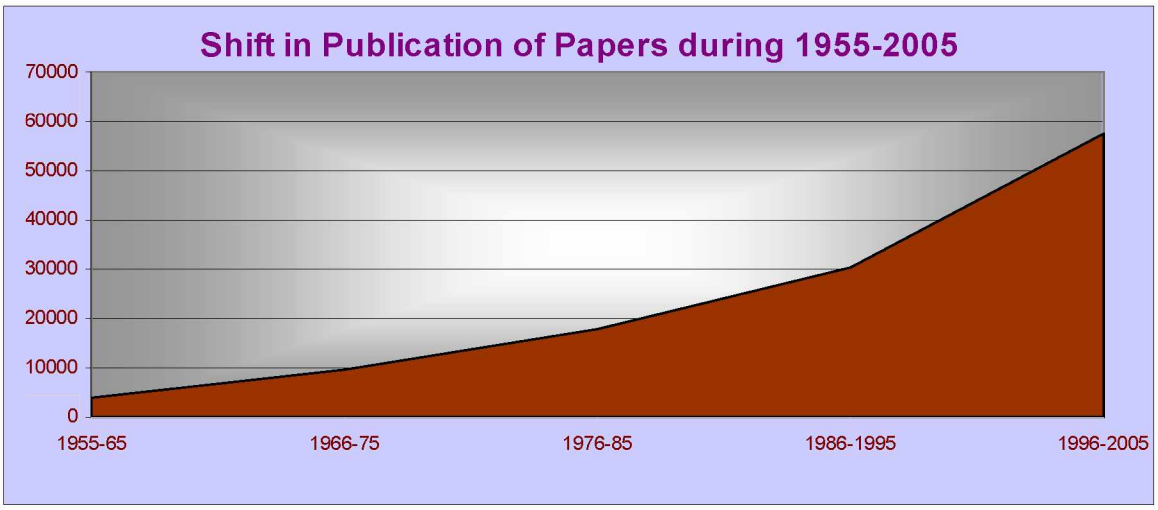
Title (Title)
Author (Author)
Address (Author Affiliation)
Journal (Only Journal Abbreviation)
Source (Full detail-Journal, Year, Volume, Page)
Country (Pull down menu)
Year (Pull down menu)
Key Words.

A number of measures have been developed for indicators as needed for Malaria research, depicting India's status from 1981-2005. The analysis and mapping has been done on the basis of data available on MALPUB, for various indices of the scientometric study. We have used 25 years of publications data from 1981 to 2005 on India and top 20 productive countries for developing indicators for Malaria research. Larger time coverage of data have been used to ensure accurate and reliable results. For analysis, the original data captured from WOS, MEDLINE and ISA were used to access the trend individually and in comparison to each other. Thus analyzed data have been presented in the report as independent chapters. For analysis, the original data captured from WOS, MEDLINE and ISA were used to access the trend individually and in comparison to each other. Thus analyzed data have been presented in the report as independent chapters.

Analysis of MALPUB

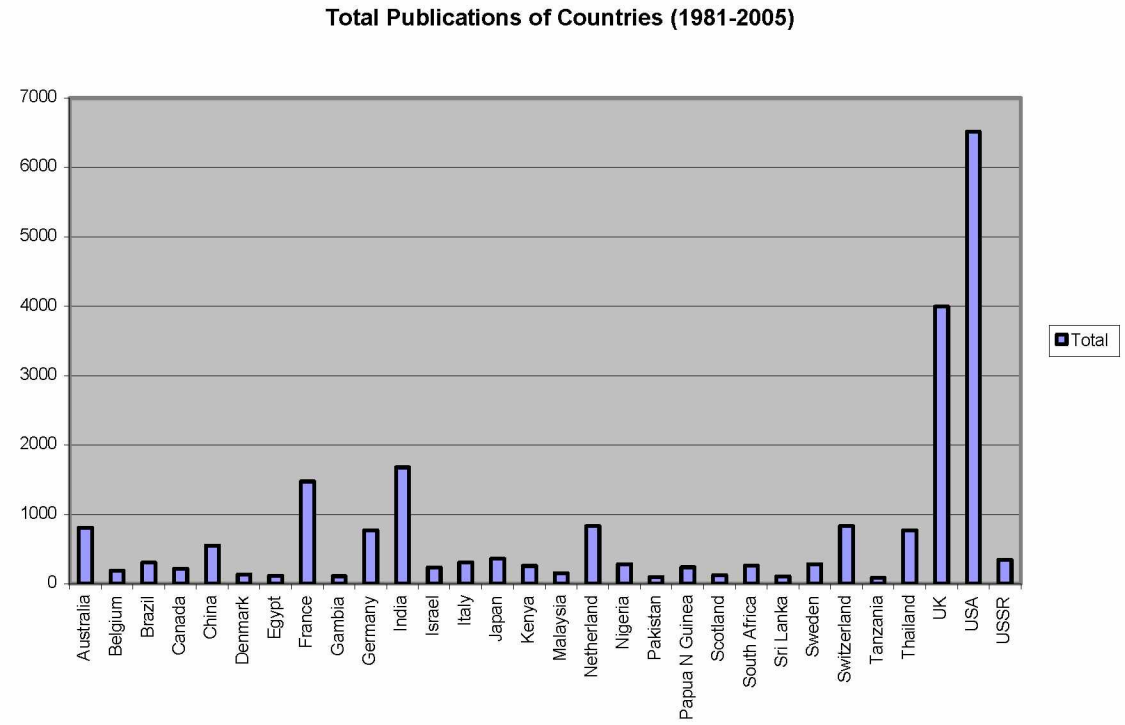
Global Publications Analysis

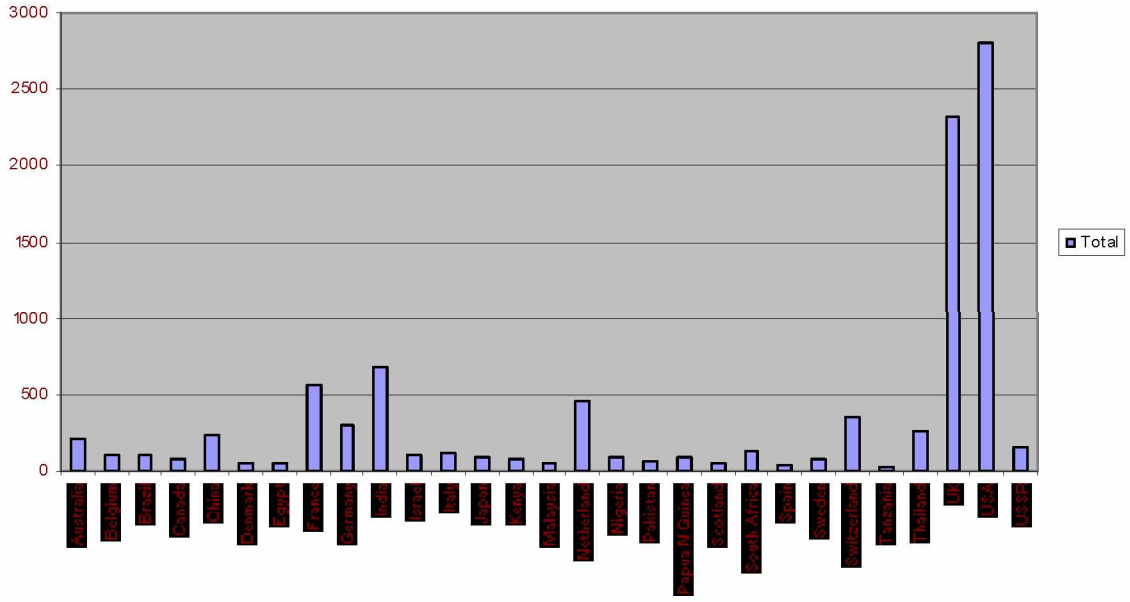
The total numbers of papers published during 1955-2005 is 122055. During 1996-2005 the number of papers in the field of Malaria was at it's maximum with 48.16% as shown by the graph. The cumulative publication share in world research output indicated an exponential growth of papers from 3.34 (1955-65) to 48.16 (1996-2005).



Commitment of Countries towards Malaria Research

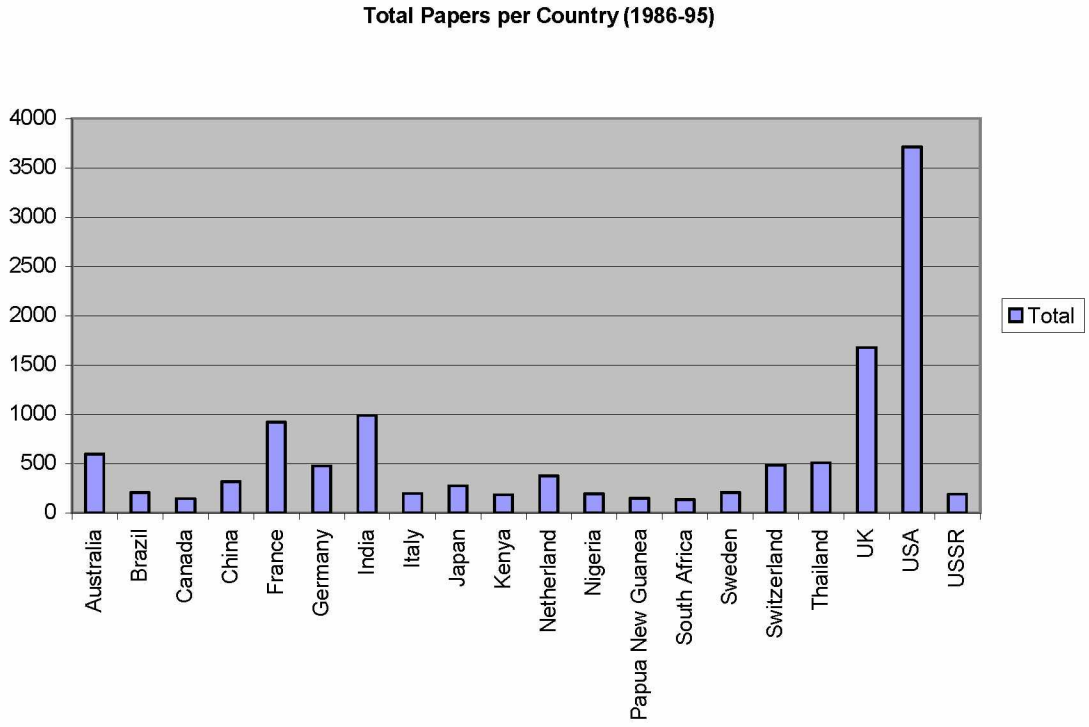
India ranks 4th among the top 20 countries in Malaria research, with its global publications share of 6.57% computed on the basis of cumulative publications output during the period of 1981-2005. The other countries that contributed publication in the range of more than 2% were Switzerland (2.78%), Japan (2.55%), Brazil (2.41%). 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 %). Switzerland, Japan, Netherlands, China, Italy, and Kenya seventh to twelfth positions (their global publication share ranging from 1.69% to 2.78%). The countries that rank between 13th and 20th positions are Nigeria, Canada, Brazil, Sweden, South Africa, Denmark and Belgium with their global publication share ranging from 1.07% to 1.25%. 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. USSR, Belgium, Israel, Papua N Guinea, Kenya, Denmark and Spain appear at intervals.



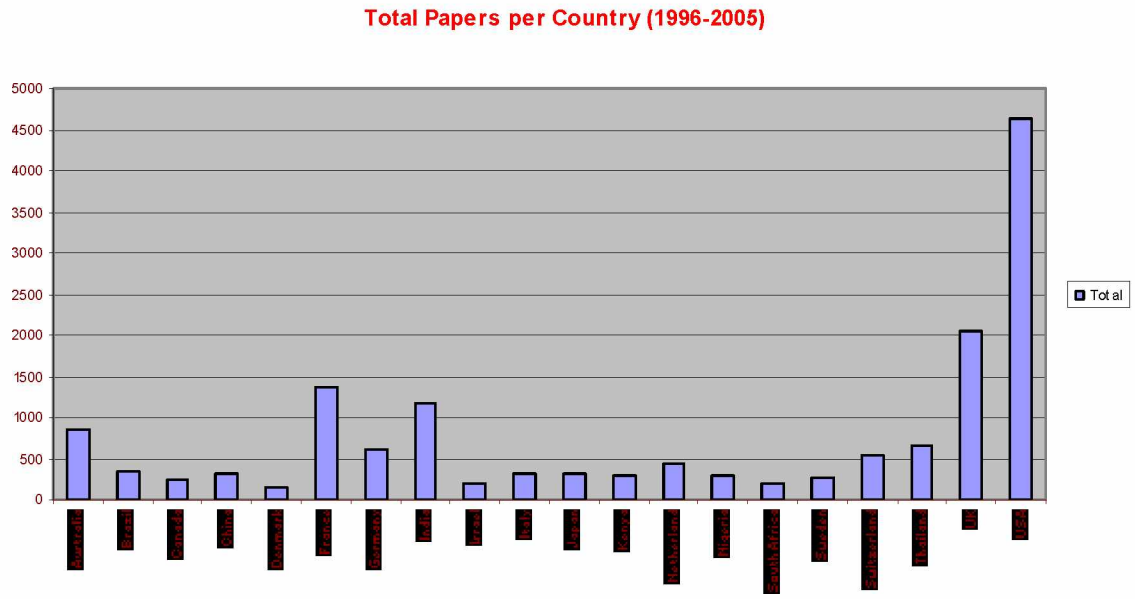


USSR is the country that is present continuously among top 20 till 1990. During 1981-85 it gets 11th position with 1.25% total contribution. In 1986-90 it got 16th position with

1.34% total contributions among MALPUB publishing countries. It's share increased , but in world context the share decreased and the position fell down. Belgium shows its presence among top 20 in 1981-85 and 1996-2000 with 14th and 20th position (s) respectively. Israel introduced itself in 1981-85 and in 1991-95 with percentage share of 0.95 and 1. In spite of increasing in it's share the ranks fell down from 15th to 18th. Papua N Guinea also came in the range of countries among top 20. It published papers in 1981-85 and in 1986-90 with share of 0.82 & 1.03.



Kenya, Canada and Denmark appeared among top 20 after 1986 and since then they are increasing their share in field of Malaria Research. Kenya introduced itself among top 20 with share of 1.29 and reaches up to 2.03 of total world share, in 2001-05.It also improved its rank from17th to 11th position. Denmark introduced in 1991-95 with world ranking of 20th position having a share of 0.81. Since then it is increasing its contribution. During 2001-05 its total share was 1.07 with improved rank of 19th position.



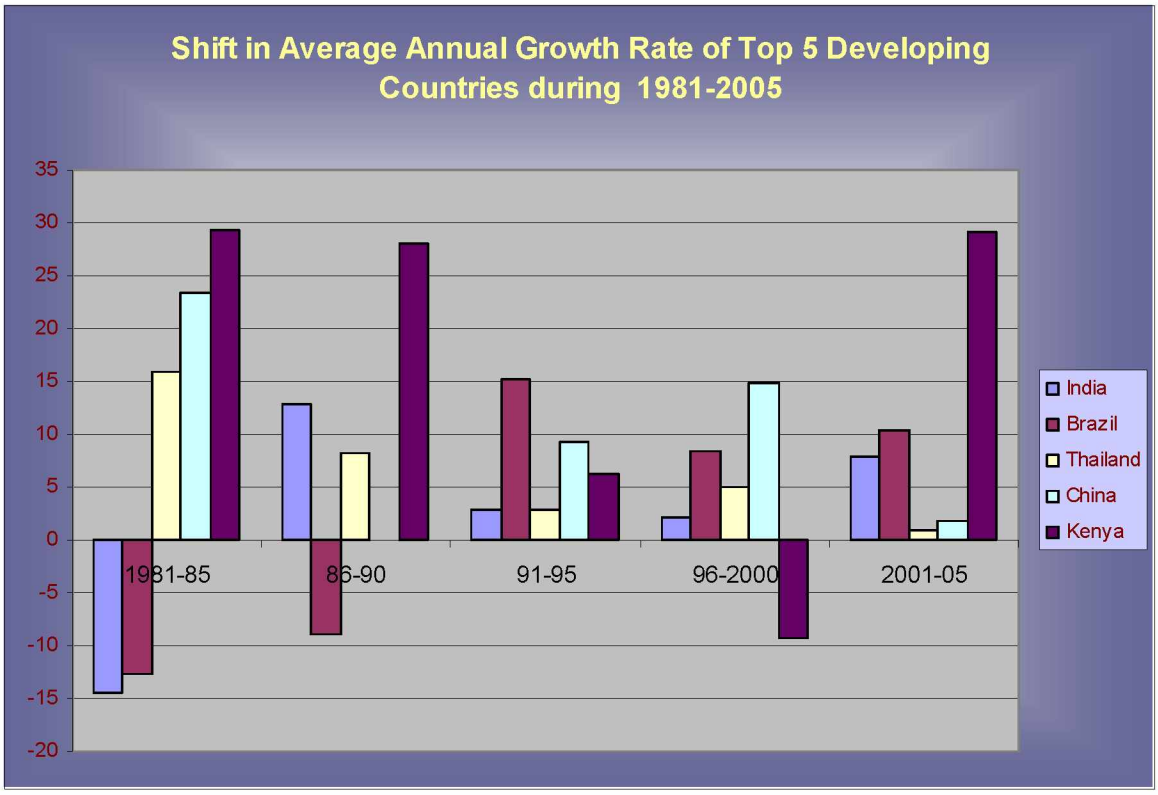
Spain is the newly introduced country among top 20 .It appeared during 2001-05 with world ranking at the 20th position, having share of 0.95.

Global Share of Developing Countries

Some of the developing countries that have shown rise in their global publications share include India, Thailand, Brazil and Kenya. India has grown significantly in terms of papers from 5.34% to7.02%.The shift in number of papers from top developing countries are from 0.34 (Papua N Guinea) to 3.07% (Thailand). The total percentage for 25 years was in the range of 0.65 (Korea) to 14.02 % (Thailand) apart from India. The new countries over the years entering into top group are Kenya and Nigeria. The ranking of Papua N Guinea has fallen from 17th to 47th position.

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.China's Average growth fell down, from 23.49 to 1.84 during the period of 25 years. Kenya's average growth rate decreased but finally improved in terms of annual growth rate.

Top 5 Developing Countries					
Country	**1981-85**	**86-90**	**91-95**	**96-2000**	**2001-05**
India	-14.39	13.37	2.86	2.10	7.88
Brazil	-12.6	-8.89	15.12	8.4	10.27
Thailand	15.82	8.25	2.91	5.03	0.92
China	23.41	0	9.37	14.76	1.84
Kenya	29.35	28.09	6.24	-9.27	29.13

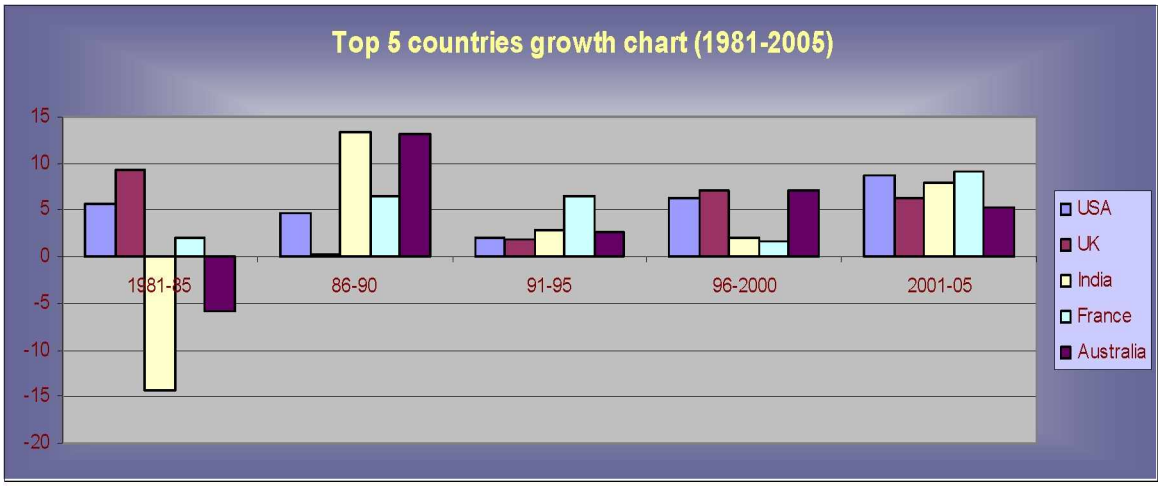


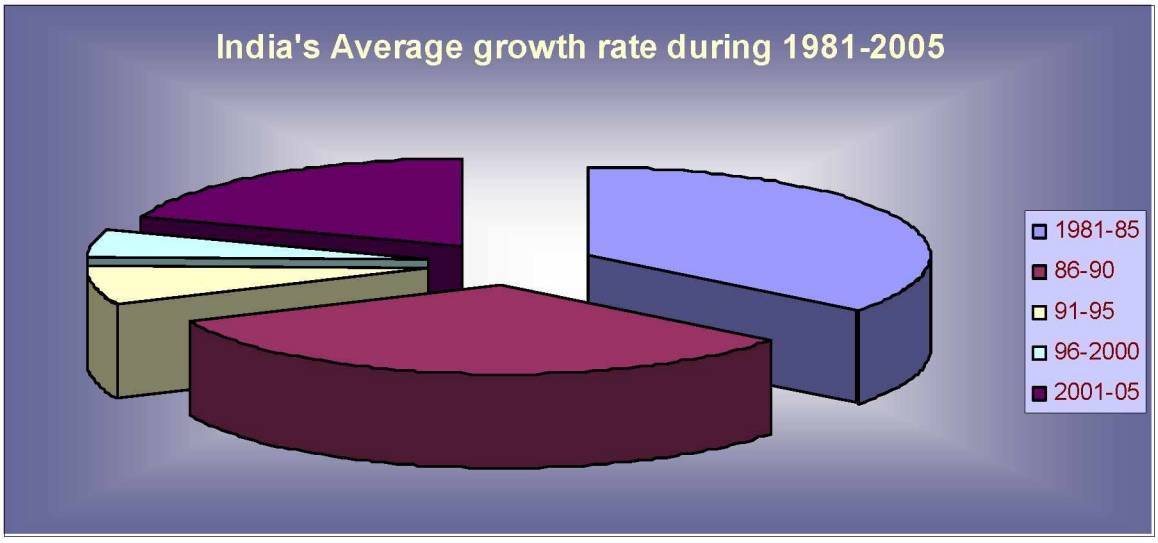
India's Publication Growth Rate in World Context

The total number of countries involved in malaria research from 1981-2005 have increased many folds from 130 (1981-85) to 135 (01-05). 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. Developed and developing countries differ significantly in their annual publication growth rate in the field of malaria research. The developed countries, with a few exceptions, have been very slow in their publications growth rate.

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 9.42 to 6.36. France and Australia have got an increase in their annual growth rate. Among the top 5, India is the top most growing country. India's average growth rate during 1981-85 was -14.39 and during 86-90 it increased up to 13.38 but there was a sudden decrease during 1991-95, but again the growth rate picked up by 1996-2000.

Top 5 Countries(1981-2005)					
Country	**1981-85**	**86-90**	**91-95**	**96-2000**	**2001-05**
USA	5.63	4.69	1.97	6.21	8.67
UK	9.42	0.27	1.80	7.17	6.36
India	-14.39	13.38	2.86	2.10	7.88
France	2.10	6.58	6.58	1.63	9.18
Australia	-5.76	13.19	2.65	7.19	5.36

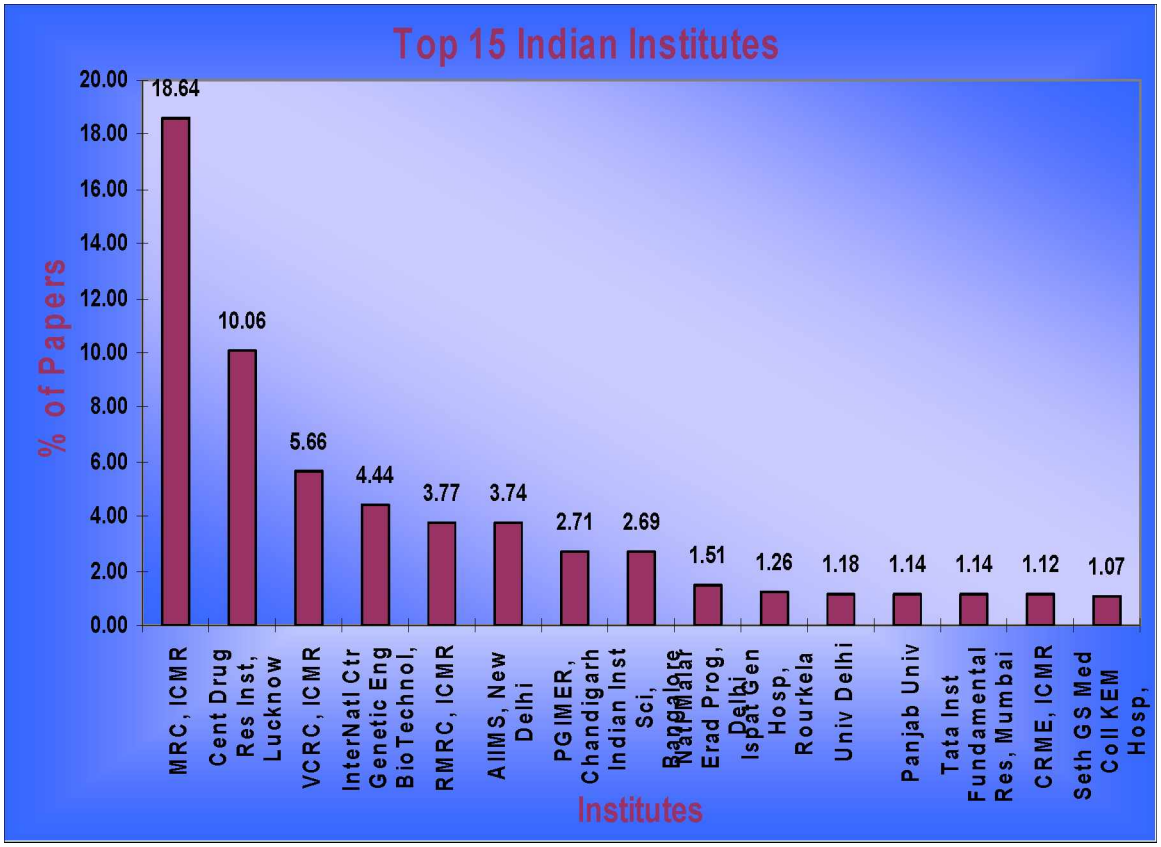




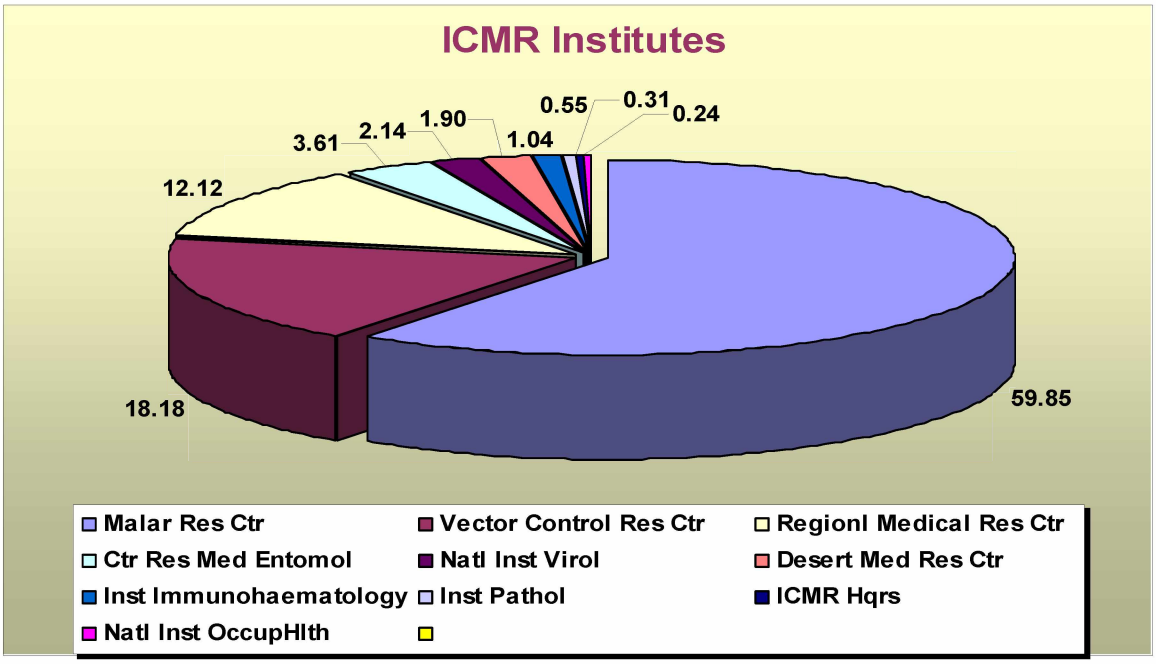
Brazil achieved the fastest average publication growth rate of 0.87% during the last 25 years, rising to 2.27% in the recent five years, During 2001-2005 Kenya was the second fastest growing country with average publication growth of 2.03%, rising marginally from 0.57% (1981-1985). Nigeria is the next country to register it's publications along with other developing countries (0.74%-1981-85 to 1.55% 2001-05).

High Productivity MALARIA RESEARCH Institutions in India

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. 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%. 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. Thus the apex institutions in the field of malaria research for India are; NIMR, CDRI, VCRC, ICGEB, RMRC-Bhubaneswar, AIIMS, PGIMER, IISc, and Ispat Gen. Hospital.

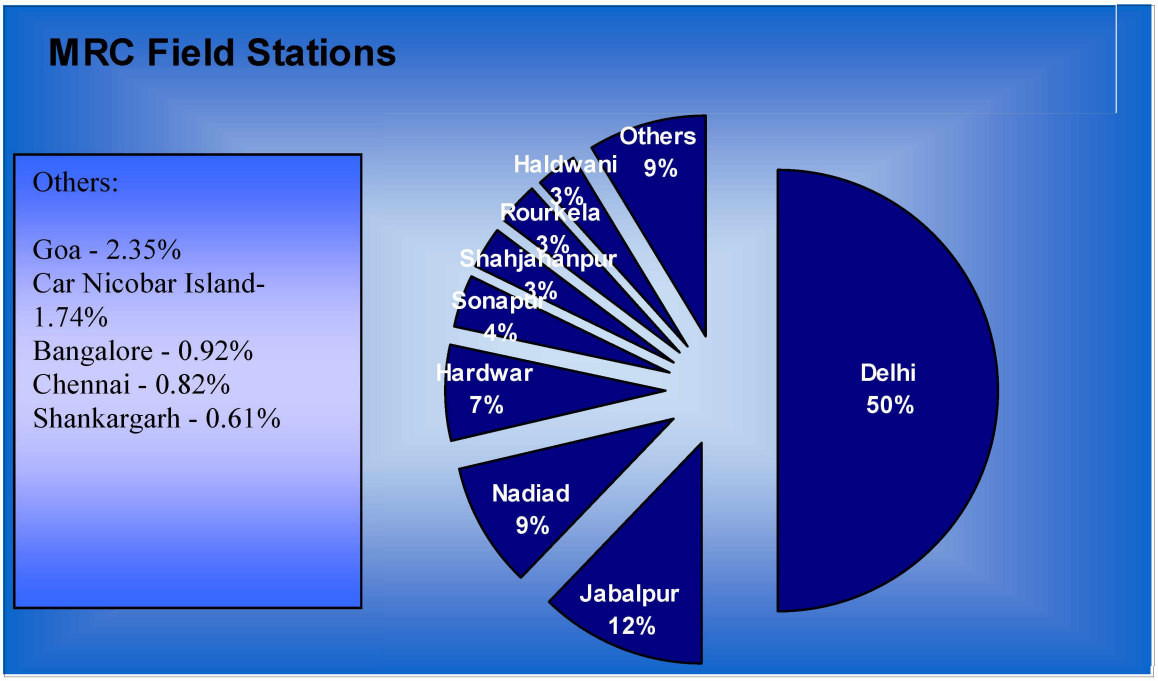


Of these top 15 institutes, 8 belongs to R & D institutions like Indian Council of Medical Research (ICMR), Council of Scientific & Industrial Research (CSIR) and Department of Biotechnology (DBT) including Indian Institute of Science, Bangalore. Rest of the institute are from Medical Colleges and Academic Institutions of India *e.g.* AIIMS, New Delhi, PGIMER, Chandigarh, NMEP, Delhi, Ispat Gen. Hospital, Rourkela, Univ. Of Delhi, Punjab University, Chandigarh, Seth GS Medical College and KEM Hospital, Mumbai.



Among the R&D institutions from India, Institutes from ICMR contributed maximum (31.2%) papers. The top most ICMR institutes contributing papers were NIMR-Delhi, VCRC-Pondicherry, RMRC-Bhubaneswar, CRME-Madurai, NIV- Pune, DMRC-Jodhpur and IIH,-Mumbai.

NIMR (MRC), Delhi has got field stations in various parts of India where the disease is prevalent. The main institute at Delhi contributed 50% papers and among the field stations maximum contribution came from Jabalpur followed by Nadiad, Hardwar, Sonapur and Shahjahanpur.



Analysis of Papers on the basis of Subject area (1981-2005)

18 subject areas within malaria research were identified, as shown in the list of 'key words'. They comprised around 52% of all malaria papers. Although the table shows the overall numbers of papers in each subject area, there were some noticeable variations with time in the popularity of the subjects. Tables show these variations for non-pharmaceutical and pharmaceutical approaches (the others, not shown, are small and relatively constant) but, as might be expected, an increase in the relative effort devoted to modern research in the field of control measures and understanding of vectors *e.g.* Artimesinin, Genome or Gene Studies, Malaria Vaccine, *P. falciparum* and Mosquito or Vector Control. Vaccine research have shown an increase during 1986-95, and has remained at about 22% of the total world average. Work on Bednets is still sparse, probably because the technology is by now well understood and the main questions are how best to distribute them (in some African countries, they are still taxed by the government). Among the pharmaceutical approaches, it is striking how the amount of research on Chloroquine has also increased over a period of 1981-2005, along with Chloroquine, work related to Artemesinins has increased from almost none in the early 1980s to around 70% world average, in the 21st century.

List of Keywords used for extracting data on Subject Area

ACT OR Artemesinin
Bed nets OR ITN OR LLINS
Bio Environmental control
Chloroquine
DDT OR DDT Resistance
Drug OR Drug Resistance
Fish OR Biological Control
Genome OR Genes
Malaria Burden OR Malaria Disease Burden
Malaria in Children OR Malaria in Child
Malaria Vaccines
MIP OR Malaria in Pregnancy
Mosquito Control OR Vector Control
Plasmodium falciparum OR *P. falciparum*
Plasmodium knowlesi OR *P. knowlesi*
P. vivax OR *P. vivax*
RDT OR Diagnostics
Socio-economic factor

Table 1:

Subject Area **Artemesinin**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	25.1	42	27	132	49	3	286	222	180	56	6
1986-95	45.12	245	148	355	0	19	800	453	559	186	147
1996-05	62.45	447	230	229	218	96	1371	751	696	339	231

Subject Area **Bed Nets**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	2.45	16	1	0	1	1	7	7	0	0	1
1986-95	4.82	11	2	3	8	1	47	19	2	6	4
1996-05	5.27	11	0	4	0	6	18	54	10	1	2

Subject Area **Bio Environmental Control**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	0	0	0	0	0	0	0	0	0	0	0
1986-95	0	0	0	0	0	0	0	0	0	0	0
1996-05	3.93	12	1	0	8	2	24	16	4	2	5

Subject Area **Chloroquine**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**

1981-85	13.26	48	14	23	15	25	135	227	38	28	16
1986-95	18.15	127	50	56	16	19	234	137	187	42	46
1996-05	24.56	194	54	34	39	58	334	210	227	85	73

Subject Area **Drug Resistance**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	26.05	96	68	103	29	33	380	429	69	57	36
1986-95	25.83	158	182	89	36	24	399	272	258	72	96
1996-05	63.91	524	446	106	122	123	1363	948	603	336	285

Subject Area **DDT & DDT Resistance**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	3.69	18	7	1	2	1	15	12	2	0	1
1986-95	4.17	19	1	5	3	8	9	14	2	0	0
1996-05	7.07	29	16	5	8	16	63	53	8	4	2

Subject Area **Fish OR Biological Control**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	3.5	12	2	0	0	0	30	1	3	1	3
1986-95	3.3	5	1	1	0	0	28	3	8	0	4
1996-05	3.93	12	1	0	8	2	24	16	4	2	5

Subject Area **Genome OR Gene**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	5.62	0	1	2	0	0	26	28	1	2	0
1986-95	17.45	11	3	2	4	0	211	99	42	20	67
1996-05	38.9	91	47	43	40	12	907	473	175	117	194

Subject Area **Malaria Disease Burden**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	0	0	0	0	0	0	0	0	0	0	0
1986-95	0	0	0	0	0	0	0	0	0	0	0
1996-05	1.55	2	0	0	0	0	4	1	0	1	0

Subject Area **Malaria in Children**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	13.43	42	23	26	14	7	96	198	60	9	9
1986-95	20.8	151	63	26	33	21	219	230	200	31	34
1996-05	38.06	207	87	33	54	27	522	551	247	138	72

Subject Area **Mosquito Control OR Vector Control**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	6.25	41	11	12	3	1	45	24	6	2	2
1986-95	11.46	118	23	44	19	9	244	71	44	4	9
1996-05	160.6	132	28	26	62	18	374	169	61	14	70

Subject Area **Malaria Vaccines**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	5.56	2	4	0	0	0	33	46	11	3	1
1986-95	16.51	21	12	2	6	0	263	81	30	22	46
1996-05	21.72	33	13	39	40	2	426	169	49	19	85

Subject Area **Malaria in Pregnancy**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	7.61	0	1	2	0	8	36	71	21	2	3
1986-95	6.52	32	10	2	4	6	55	48	26	5	10
1996-05	10.27	24	27	2	5	5	134	108	43	14	12

Subject Area **RDT OR Diagnostics**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	0	0	0	0	0	0	0	0	0	0	0
1986-95	1.66	2	0	0	0	0	2	1	0	0	0
1996-05	1.58	0	1	0	1	0	5	1	1	3	1

Subject Area **Socio-Economic Factor**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	0	0	0	0	0	0	0	0	0	0	0
1986-95	0	0	0	0	0	0	0	0	0	0	0
1996-05	1.14	0	0	0	0	0	0	2	1	0	1

Studies realted to Parasite:

Subject Area ***P. falciparum***

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	33.06	73	43	41	35	21	366	431	102	41	20
1986-95	35.77	174	160	111	52	28	765	418	336	122	165
1996-05	71.18	590	388	146	151	102	1448	1102	694	442	432

Subject Area **P. knowlesi**

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	0	0	0	0	0	0	0	0	0	0	0
1986-95	4.5	12	0	0	0	0	8	1	1	0	0
1996-05	4	5	1	3	0	0	12	4	2	0	2

Subject Area ***P. vivax***

	Developing Countries						Developed Countries				
Year(s)	**World Av.**	**India**	**Thailand**	**China**	**Brazil**	**South Africa**	**USA**	**UK**	**France**	**Germany**	**Australia**
1981-85	8.91	37	5	26	11	3	64	54	15	9	13
1986-95	10.65	50	34	49	16	0	112	40	26	6	10
1996-05	17.43	166	103	38	68	1	216	74	49	7	52

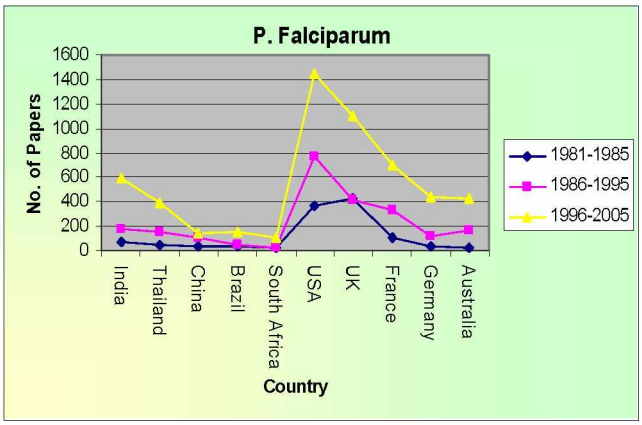
It is remarkable to note that in the field of parasite biology most of the efforts are concentrated on *P. falciparum* with world average of 33.06 (1981-85), 35.77(1986-95) and 71.18 during 1996-05 whereas the papers on *P. vivax* have shown only a marginal increase from 8.91 (81-85) to 17.43 during 1996-05.

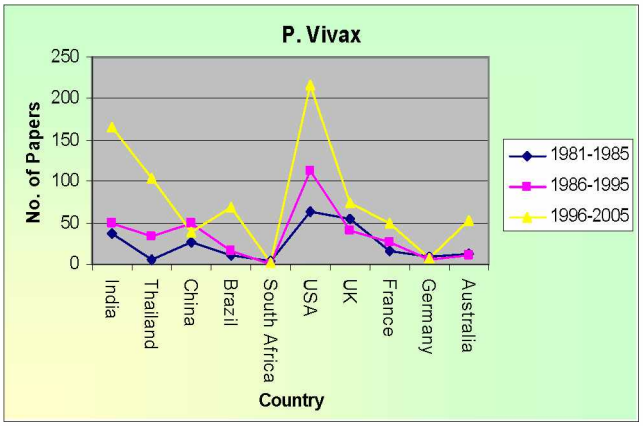
Recent report of *P. knowlesi* the monkey (primate) malaria infecting human being in some areas of South-east Asia made new developments and is evident in terms of research publication as well as there were no paper on this plasmodium species during 1981-85 and now it has the global output of 4 during 1996-05.

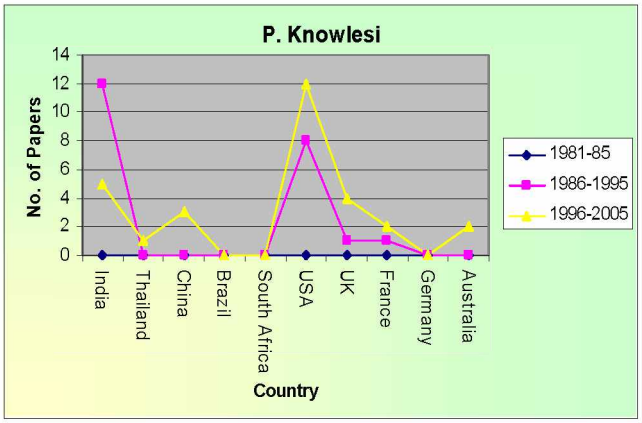
New technologies such as use of Rapid diagnostic kits were adopted for research areas in later years and the data indicated that its growth increased form Nil during 1981-85 to 1.58 of world average during 1996-05.

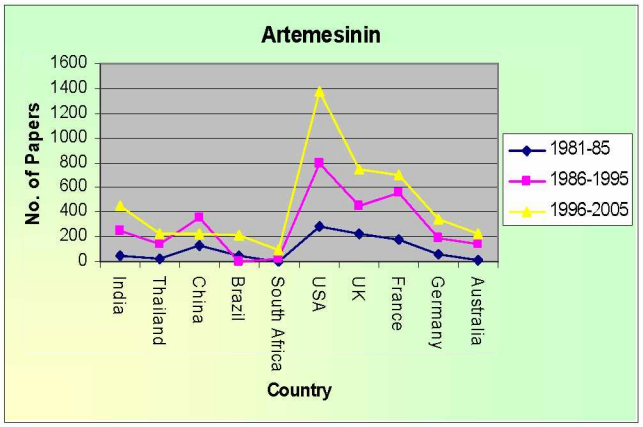
Among the productivity of developing countries as compared to world average India have shown its strong commitment towards Artemesinin and ACT, drug resistance, malaria in pregnancy and malaria in children, mosquito or vector control, DDT or DDT resistance, fish or biological control and bed nets showing an steady increase from 1981 through 1996-05.

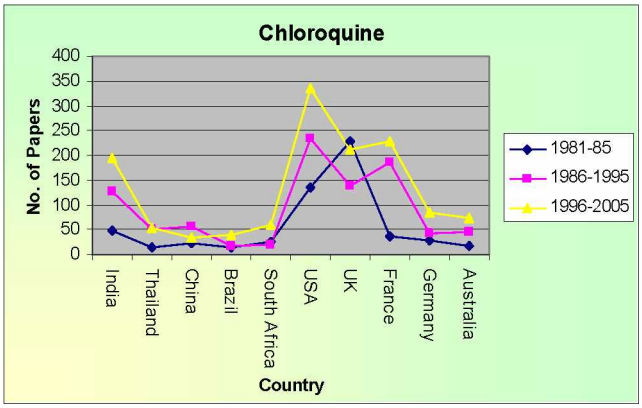
China has shown strong commitment in Artemesinin based combination therapy of malaria control whereas Thailand has also depicted the same trend as of India with main focus on drug resistance, ACTs, malaria in children *etc*.

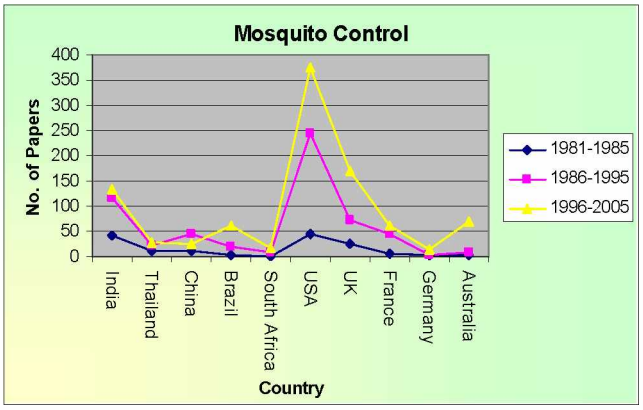








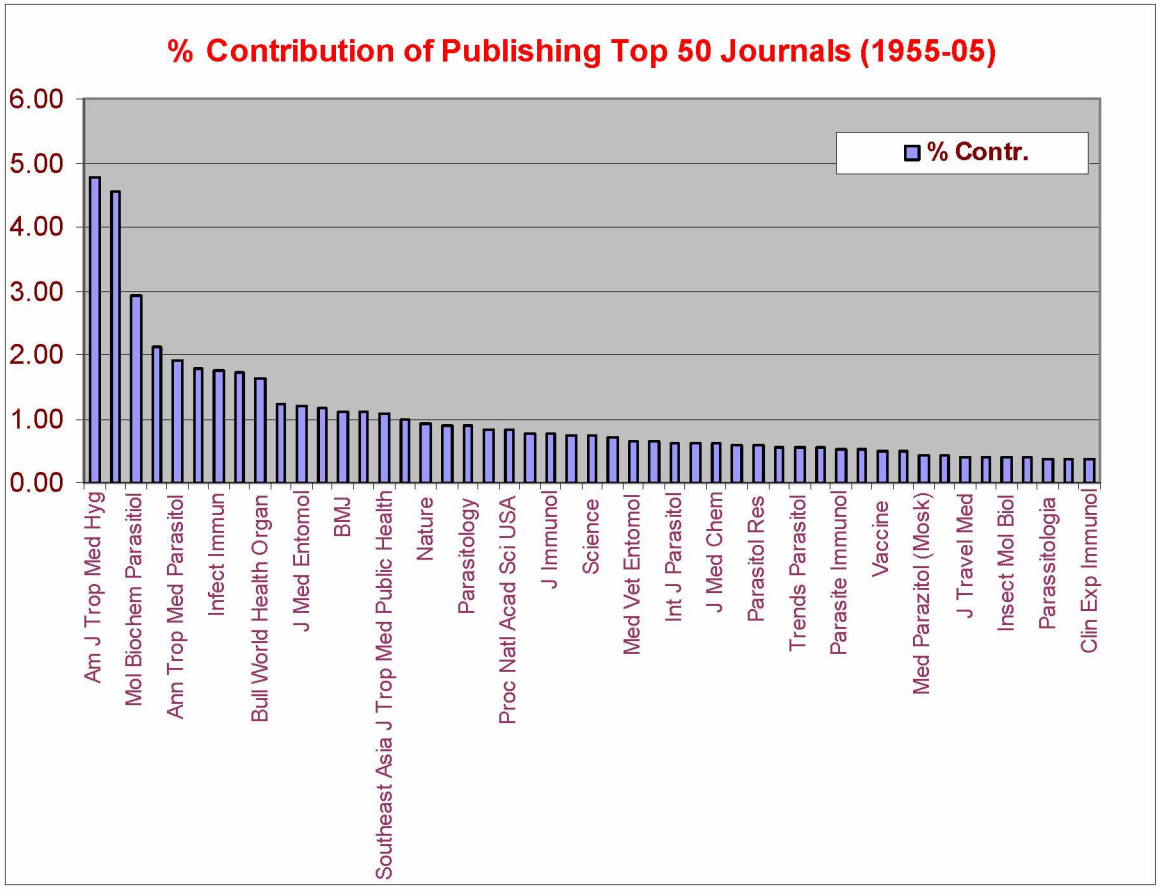




Most Productive Journals

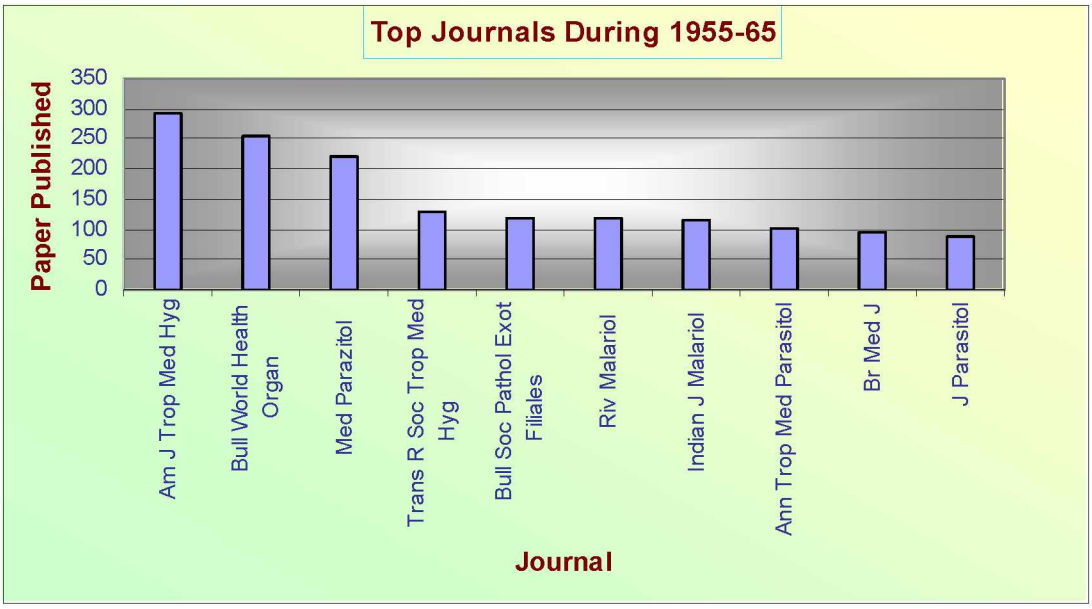
There were total 6064 journals publishing a total of 122055 papers during the whole study period (1955-2005). The first 50% papers (around 61115) appeared in a total of 47 journals with an average of approximately 1300 papers per journal. The rest of the papers were distributed among a total of 6017 with an average of 11 papers per journal.

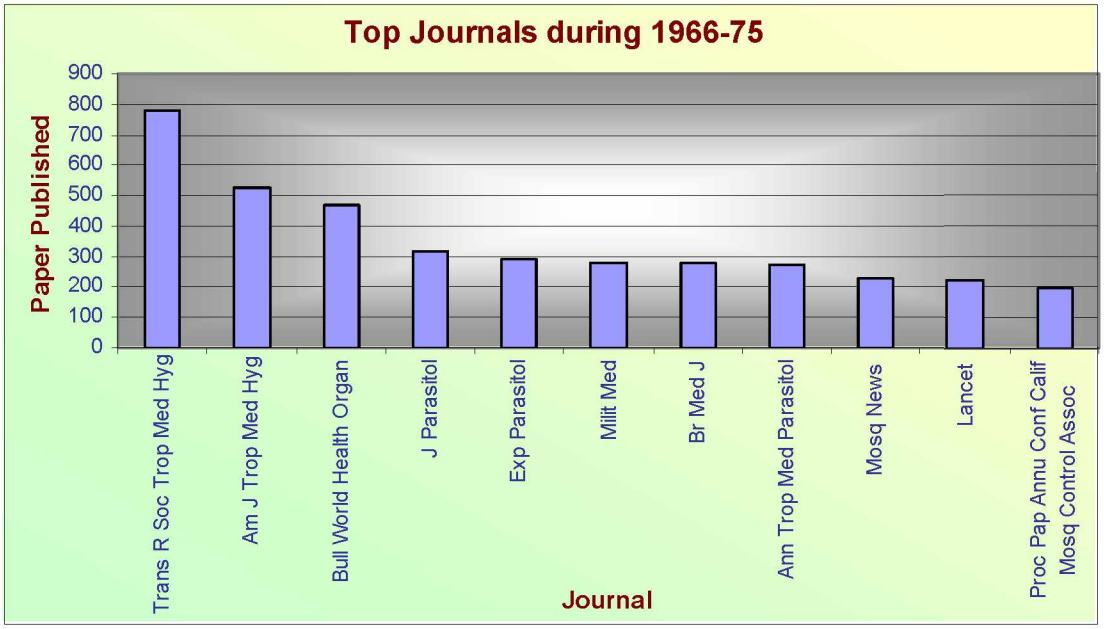
The top most journal contributing more than world average (21 papers per journal) were *Trans R Soc Trop Med Hyg* with an average of 112 papers followed by *Am J Trop Med Hyg, Mol Biochem Parasitol, Lancet, Ann Trop Med Parasitol, Exp Parasitol, J Am Mosq Control Assoc, Infect Immun, Trop Med Int Health, Parasitol Today, J Med Entomol,* and *Parasitol.* All these journals contributed between the range of 22-112 papers per journal. The next group contributed papers between the range of 11-20. *Indian J Malariol* stood at the top position (13 papers per journal) much closure to world average, among the journals from Developing countries. 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.*

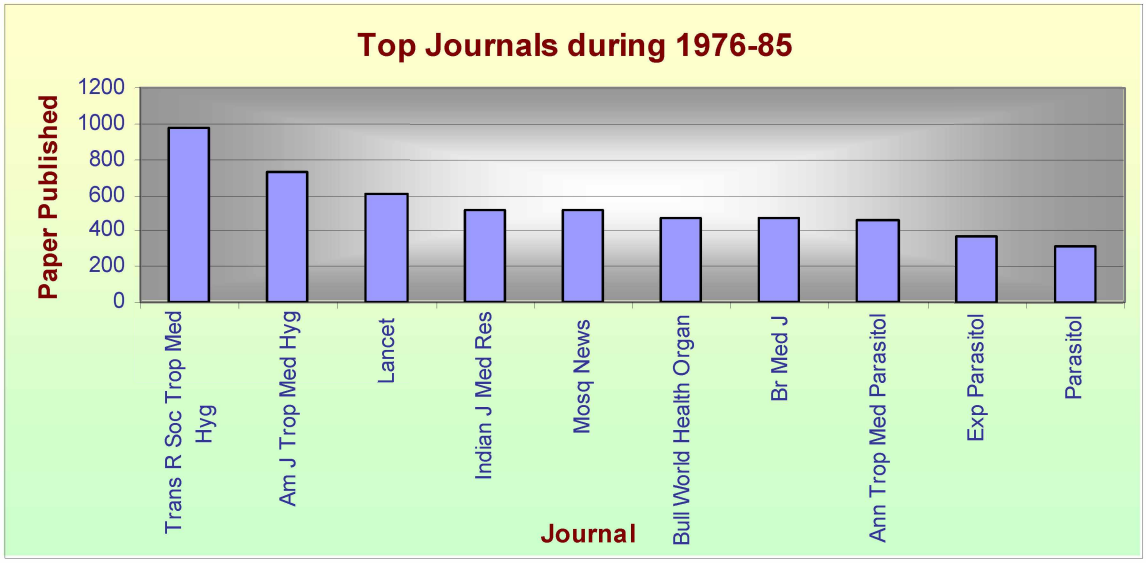


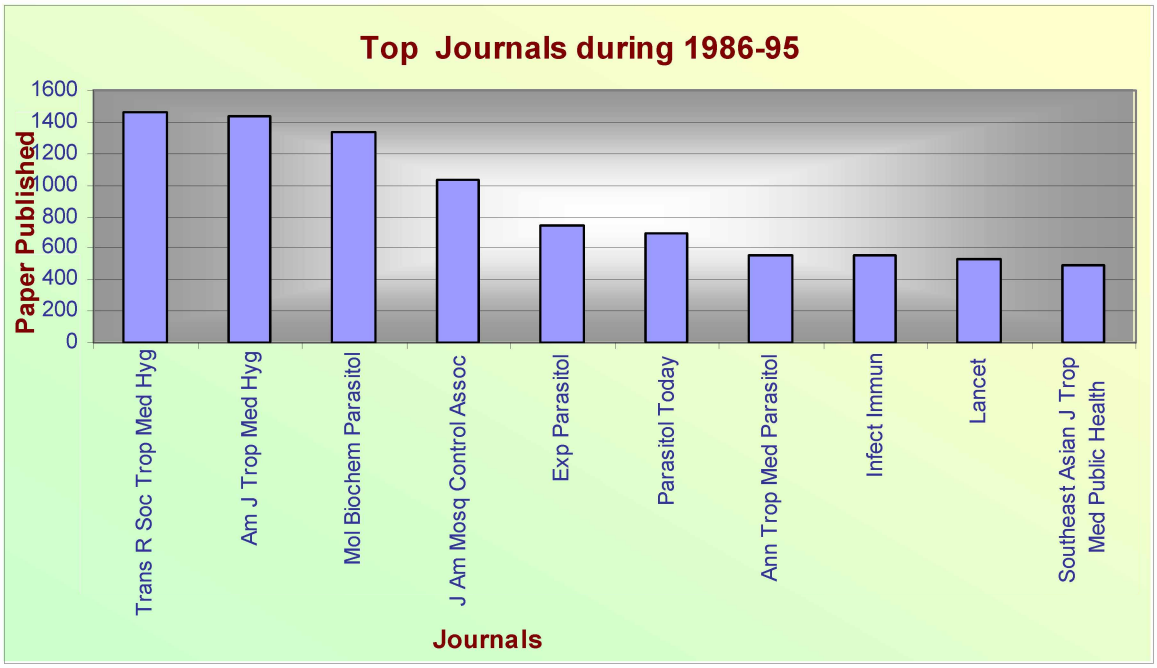
We also computed the data for total percentage contribution of paper in a journal. In this Category of publishing journals at global level *Trans R Soc Trop Med Hyg* is at the top

position during 1955-2005 followed by *Am J Trop Med Hyg*, *Mol Biochem Parasitol*, *Trop Med Int Health, Infect Immun*, *J Am Mosq Control Assoc*, *Lancet*, *Ann Trop Med Parasitol*, *J Infect Dis* and *J Med Entomol. 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. *J Med Entomo*l 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 .






Top Journals during 1976-85
Paper Published
1200
1000
800
600
400
200
0
Trans R Soc Trop Med Hyg
Am J Trop Med Hyg
Lancet
Indian J Med Res
Mosq News
Bull World Health Organ
Br Med J
Ann Trop Med Parasitol
Exp Parasitol
Parasitol
Journal


Top Journals during 1986-95
Paper Published
1600
1400
1200
1000
800
600
400
200
0
Trans R Soc Trop Med Hyg
Am J Trop Med Hyg
Mol Biochem Parasitol
J Am Mosq Control Assoc
Exp Parasitol
Parasitol Today
Ann Trop Med Parasitol
Infect Immun
Lancet
Southeast Asian J Trop Med Public Health
Journals

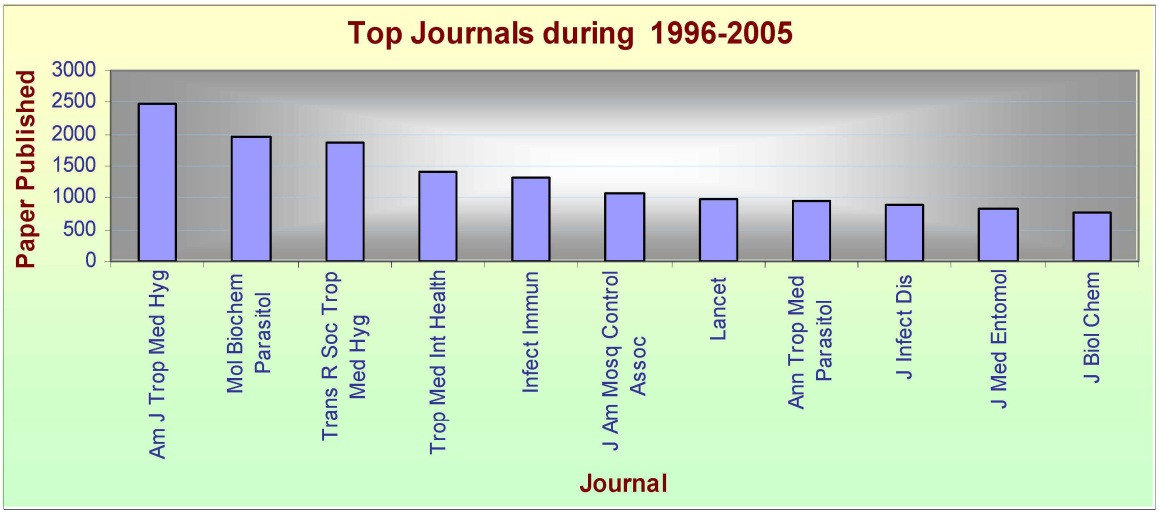


Table 2: **Core Journals and their Ranks over a period of time**

Journal	96-05	86-95	76-85	66-75	56-65
Acta Trop	12	23			1
Am J Trop Med Hyg	1	2	2	2	
Ann Soc Belg Med Trop					13
Ann Trop Med Parasitol	8	7	8	8	8
Br Med J				7	20
Bull Soc Pathol Exot			21	20	5
Bull World Health Organ		14	6	3	2
Exp Parasitol	14	5	9	5	15
Indian J Malariol	11				7
Indian J Med Res			4		
Infect Immun	5	8	15		
J Am Mosq Control Assoc	6	4			
J Biol Chem	11				
J Immunol		12			
J Infect Dis	9				
J Med Chem				14	
J Med Entomol	10	16		19	
J Parasitol		21	11	4	10
J Protozool			14	11	17
J Travel Med	20				
J Trop Med Hyg		22	23	16	12
Lancet	7	9	3	10	19
Med Parazitol			22		3
Med Parazitol (Mosk)				13	
Med Vet Entomol	22	19			
Mol Biochem Parasitiol	2		12		
Mosq News		3	5	9	
Nature			16	15	11
Parasitol			10		
Parasitol Today	16	6			
Parasitology	18	15		17	

Proc Natl Acad Sci USA	17	18			
Southeast Asia J Trop Med Public Health	24	10	13	22	
Trans R Soc Trop Med Hyg	3	1	1	1	4
Trop Geogr Med	4		18	23	
Z Tropenmed Parasitol				24	14

Growth of Journals and Articles

Table below gives the number of Journals and Articles in the area of Malaria Research. It suggests that both the journals and articles increase exponentially. The number of articles has increased from 4,026 to 57,619 from 55-65 to 96-05. Also the number of journals has increased from 502 to 3,072 (1955-65 to 1996-05). The figures clearly show that the exponential model fit the empirical data. The R^2 value for the trend for journals and articles are 0.9363 and 0.9351 respectively. Under the assumption that the data confirm to exponential model, the growth rates have been computed; the growth rates of the journals and articles are 5.24% and 7.26% respectively. The most important observation is that the number of least productive journal has been increased to 2,951 from 463. This perhaps due to

- Interdisciplinary nature of research in Malaria and related topics
- High growth rates (exponential in nature!) of journals and articles

Table 3: **Number of Articles and Journals in Malaria Research**

Year	# of Journals	# of Articles	Year	# of Journals	# of Articles	Year	# of Journals	# of Articles
1955	127	419	**1973**	320	1070	**1991**	588	3827
1956	109	370	**1974**	332	1048	**1992**	586	3735
1957	92	328	**1975**	302	1138	**1993**	579	3101
1958	93	244	**1976**	275	1292	**1994**	621	3832
1959	89	242	**1977**	295	1466	**1995**	704	3888
1960	76	248	**1978**	310	1477	**1996**	734	4346
1961	92	352	**1979**	349	1730	**1997**	793	4712
1962	78	311	**1980**	344	1580	**1998**	782	4440
1963	104	400	**1981**	349	1744	**1999**	859	5259
1964	158	543	**1982**	397	2111	**2000**	855	5374
1965	163	569	**1983**	398	2138	**2001**	901	5603
1966	160	760	**1984**	417	2290	**2002**	1079	6145
1967	187	755	**1985**	429	2313	**2003**	1170	6820
1968	201	868	**1986**	451	2408	**2004**	1201	7371
1969	210	1031	**1987**	437	2706	**2005**	1273	7549
1970	278	979	**1988**	492	2897			
1971	286	1014	**1989**	490	2893			
1972	312	1136	**1990**	527	3183			

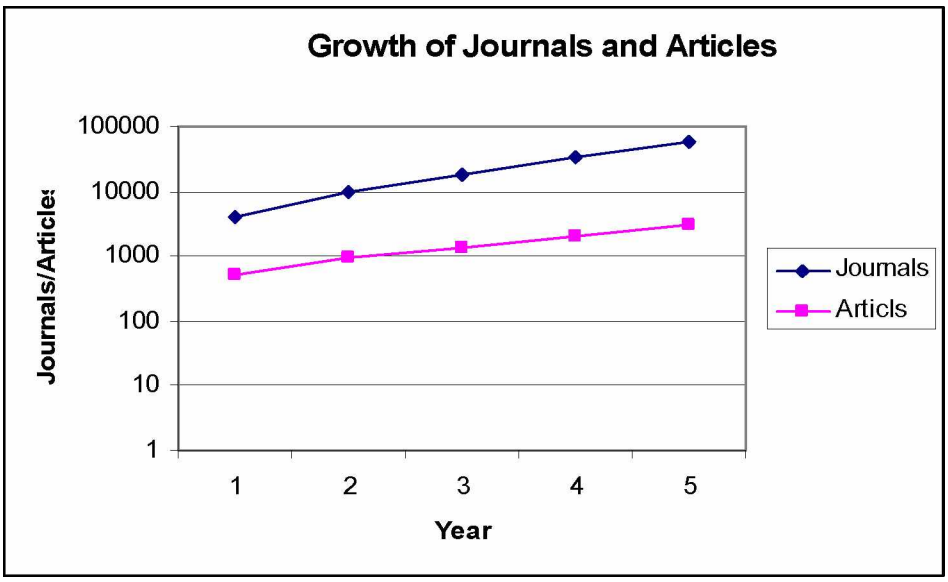
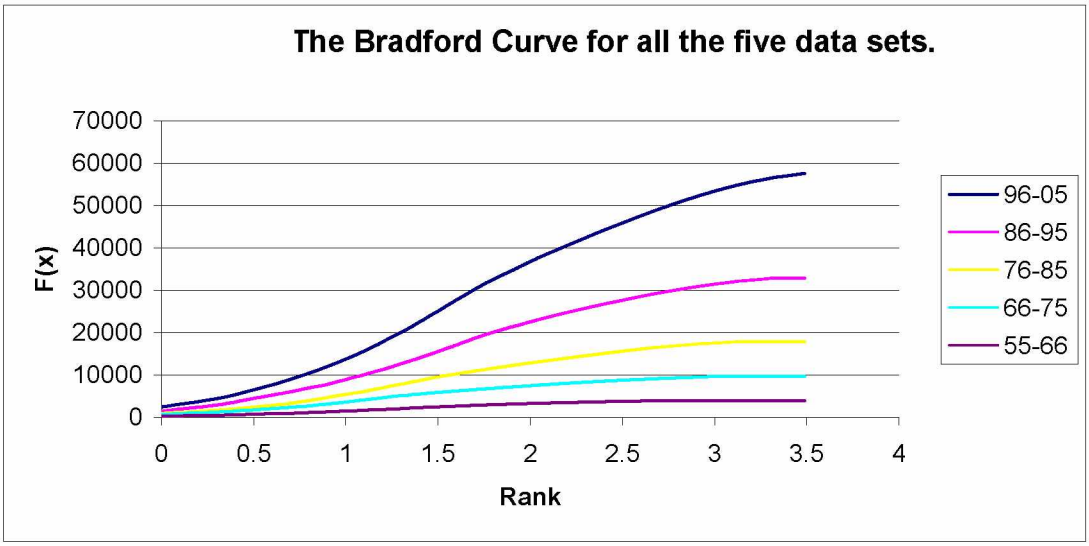
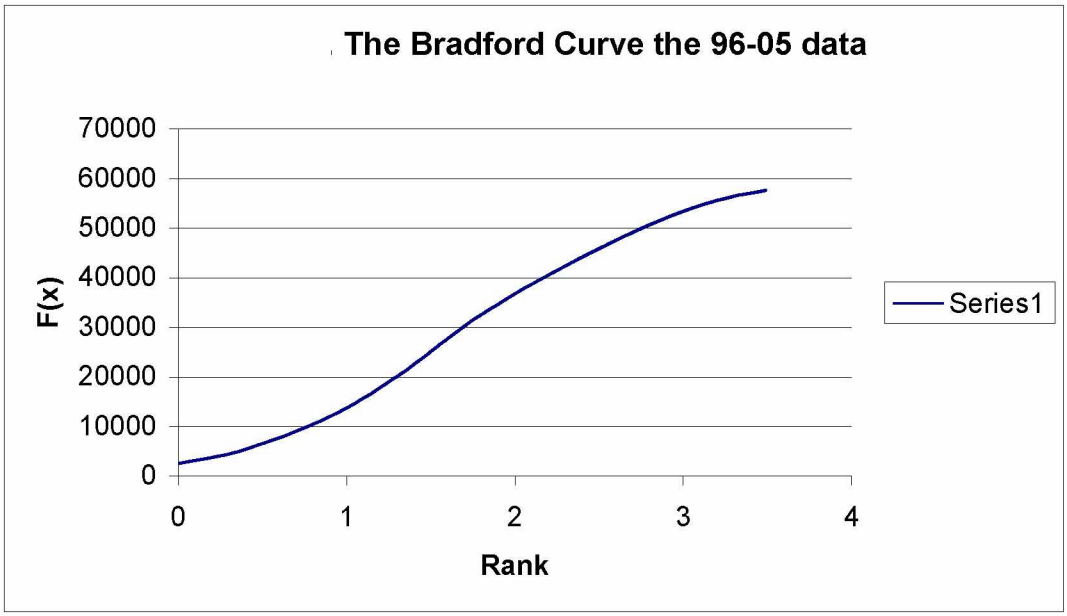


Table 4: **The data for different zones (as defined by Bradford)**

	55-65	66-75	76-85	86-95	96-05
# of articles in zone 1 (# of Journals).	1348 (8)	3212 (8)	6082 (12)	11028 (15)	19140 (18)
# of articles in zone 2(# of Journals)..	1322 (31)	3242 (38)	5854 (59)	10880 (73)	19269 (103)
# of articles in zone 3 (# of Journals)..	1326 (463)	3213 (907)	5987 (1268)	10989 (1982)	19218 (2951)
Total # of articles (Total # of Journals)	3996 (502)	9667 (953)	17923(1339)	32897 (2070)	57627 (3072)
# of articles per journal	7.94	10.14	13.39	15.90	18.76
$1 : n : n^2$	1:3.88: 57.88	1: 4.75: 113.38	1: 4.92: 105.67	1: 4.87: 132.13	1: 5.72: 163.94

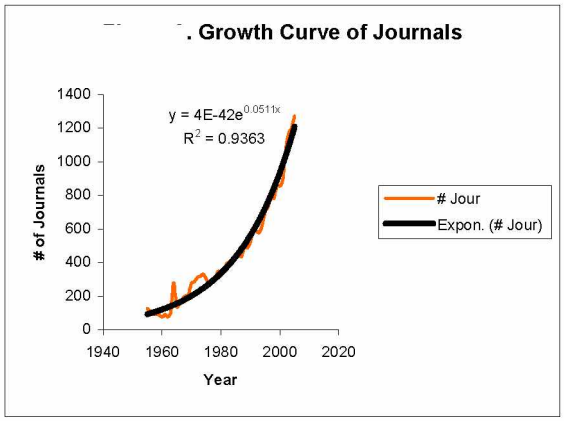
In the last row of the *Table 4*, we may note that the ratio does not confirm to $1: n: n^2$. Thus, table suggests that the rank distribution of journals is unlikely to follow Bradford's distribution.

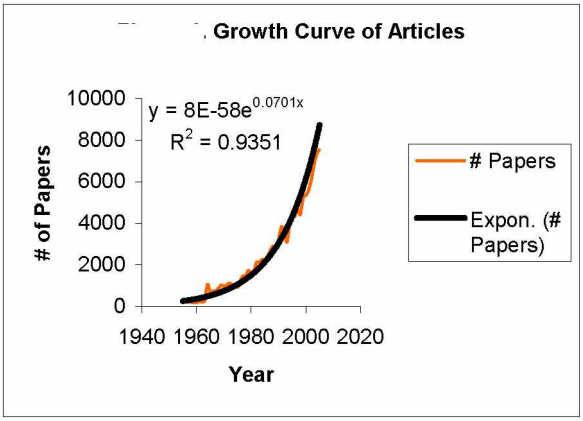




Further, the figures indicate that the curves are nor log-linear in nature; they are similar to S-shape -- data are unlikely to follow Bradford distribution. The data analysis of the literature in Malaria research suggests that the rank distribution of articles is unlikely to follow the Bradford's law. It is mostly due to the fact that there are too many articles are being published in relatively less known journals in the area of Malaria and related topics. Also it may be due to the interdisciplinary nature of the research in Malaria and related topic. 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, proteonomics, Genetics and Immunological Studies at Genomics level, in search of control

measure for the disease as well as the vectors. This study indicated that in the area of Malaria research both the journals and articles increase exponentially.





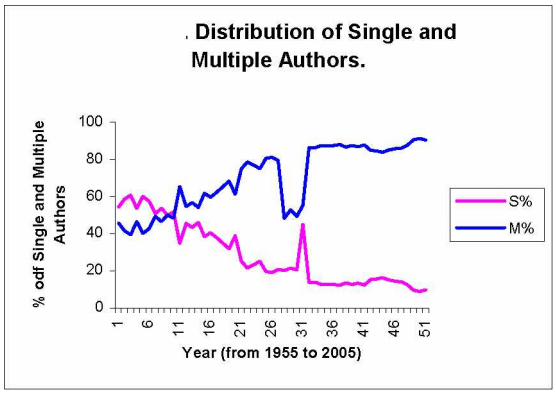
Multiple Authorship

An attempt has been made to study the co-authorship. Table below, gives the data on single and multiple authorship in the area of Malaria Research for the period 1955-05. Above Figures clearly indicate that the percentage of papers with multiple authors significantly increased, indicating that the research is towards interdisciplinary in nature.

Table 5: **Distribution of Single and >2 author Papers**

Year	# of one Author	# of ≥ 2 Authors	% one Author	% of ≥ 2 Authors	Year	# of one Author	# of ≥ 2 Authors	% one Author	% of ≥ 2 Authors
1955	186	157	54.23	45.77	1981	361	1382	20.71	79.29
1956	174	123	58.59	41.41	1982	421	1014	19.97	80.03
1957	162	105	60.67	39.33	1983	456	1126	21.37	78.63
1958	106	92	53.54	46.46	1984	457	1107	20.30	79.70
1959	120	80	60.00	40.00	1985	452	1392	44.98	55.02
1960	103	76	57.54	42.46	1986	332	2076	13.79	86.21
1961	124	120	50.82	49.18	1987	387	2409	13.84	86.16
1962	115	100	53.49	46.51	1988	366	2532	12.63	87.37
1963	145	145	50.00	50.00	1989	370	2523	12.79	87.21
1964	299	128	55.06	23.57	1990	399	2784	12.54	87.46
1965	263	147	48.16	26.92	1991	463	3364	12.10	87.90
1966	345	415	45.39	54.61	1992	503	3232	13.47	86.53
1967	327	428	43.31	56.69	1993	390	2715	12.56	87.44
1968	398	468	45.96	54.04	1994	515	3345	13.34	86.66
1969	395	636	38.31	61.69	1995	528	3785	12.24	87.76
1970	396	583	40.45	59.55	1996	658	3685	15.15	84.85
1971	384	630	37.87	62.13	1997	729	3981	15.48	84.52
1972	394	742	34.68	65.32	1998	722	3704	16.31	83.69

1973	340	730	31.78	68.22	1999	787	4461	15.00	85.00
1974	407	641	38.84	61.16	2000	766	4600	14.28	85.72
1975	287	851	25.22	74.78	2001	789	4820	14.07	85.93
1976	276	1014	21.40	78.60	2002	764	5375	12.45	87.55
1977	340	1126	23.19	76.81	2003	649	6175	9.51	90.49
1978	370	1107	25.05	74.95	2004	651	6729	8.82	91.18
1979	338	1392	19.54	80.46	2005	729	6813	9.67	90.33
1980	299	1280	18.94	81.06					



Analysis Based on Data Captured from SCI

We have examined the outputs of malaria research over the quarter-century from 1980 to 2004, as revealed by papers recorded in the Science Citation Index (SCI). Quantitative surveys of malaria research have been undertaken before, but mainly as a means to estimate the financial resources going into malaria research (Anderson *et al*, 1996; Beattie *et al*., 1999; Lewison *et al*., 2002). An exception is the survey of malaria research in Brazil by Rodrigues *et al*. (2000) which compared its geographical distribution with that of cancer and cardiovascular research. We have analyzed the malaria research papers in our database geographically, and compared national outputs of malaria papers with their production of biomedical papers overall so as to show their relative commitment to malaria research – this comparison to some extent compensates for biases in the SCI against tropical countries.
We have also analyzed the database of papers 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. There are major differences between countries in the relative emphasis that they give to these ten approaches. This diversity may well be highly desirable, but it is not clear that the national research profiles necessarily relate to the local situation. In fact, as we shall see, the large majority of the malaria research, as covered in the SCI, comes from high-latitude industrial countries with very little malaria.

Finally, we speculate that a high relative commitment to malaria research may well generate dividends in the form of a reduced burden from the disease, probably because a research-based healthcare environment is likely to lead to the adoption of appropriate control methods and the allocation of sufficient resources to make them effective, through more detailed examination of one particular country that has been in the forefront of the battle (Thailand).

The malaria research papers were identified within the SCI (CD-ROM version) by means of a filter, developed by Andres de Francisco and Stephen Lipworth, on the basis of selected title words; details are given in Lewison *et al*., 2002. Only articles, notes and reviews were chosen, and their bibliographic details (authors, title, full source, document type and addresses) were downloaded to a file and then analysed using MS Excel. There were a total of 23,916 papers so listed, covering the 25 years 1980-2004, though a few 2004 papers would have been absent because of late processing for the SCI.

The addresses on the papers were analysed by country on both an integer and a fractional count basis using a macro written by Philip Roe. 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. The papers were also classified by their research level on the basis of the journal in which they were published

and the presence of "clinical" or "basic" words in the titles of papers in that journal (Lewison and Paraje, 2004). Research level (RL) is a decimal number between 1.0 = clinical observation and 4.0 = basic research. *Table 1* shows some examples of the RLs of leading journals.

Table 6. *Some leading journals used by malaria researchers with their research levels for 2000-04. RL1 = clinical observation; RL4 = basic research*

Journal	**Papers**	**RL**
Bulletin of the World Health Organization	307	1.03
Lancet	201	1.24
Transactions of the Royal Society of Tropical Medicine and Hygiene	1257	1.28
Journal of the American Mosquito Control Association	799	1.42
American Journal of Tropical Medicine and Hygiene	1443	1.59
Indian Journal of Medical Research	197	1.94
Journal of Medical Entomology	459	2.16
Memorias do Instituto Oswaldo Cruz	215	2.27
Journal of Parasitology	289	2.58
Parasitology	305	2.76
International Journal for Parasitology	178	3.28
Science	134	3.52
Proceedings of the National Academy of Sciences of the USA	259	3.70
Journal of Biological Chemistry	238	3.93

We were interested to see the amount of national research activity in malaria compared with each country's biomedical research output in all subject areas. For this purpose, an address-based filter was used (Lewison and Paraje, 2004) that identified biomedical research papers, and the (integer counts) of leading countries in biomedical research were determined from the SCI. The ratio of the percentages of a country's presence in malaria research to its presence in biomedical research then gave its relative commitment to malaria research. This was, of course, much higher than unity for many countries affected by the disease, and was mostly below unity for countries not so affected. The papers in the file were also sub-classified by subject area within malaria research, mostly on the basis of the presence of particular title words, but for two of the ten subject areas (vaccines and genetics), also on the basis of papers in relevant journals. The ten subject areas, each of which was given a three-letter (trigraph) code for ease of reference, with their corresponding title words, were as shown in *Table 7*.

Table 7. List of ten subject areas within malaria research, with trigraph codes, title words used to identify papers, and numbers of papers found in the file

Subject area	Code	Title words	N
Artemesinins/qinghaosu	AAQ	artemether, Artemesinin, artesunate, qinghaosu	828
bednets	BED	bednets	91
chloroquine	CHL	chloroquine	2073
DDT & other insecticides	DDT	DDT, dieldrin, insecticid	342
genetics	GEN	chromosom, gene, genes, genetic, genom + Genetics jnls	1613
mefloquine	MEF	mefloquine, lariam	475
mosquito habitats & control	MOS	mosquito	3701
pyrimethamine	PYR	fansidar, pyrimethamine	522
quinine & quinidine	QUI	quinidine, quinine	248
vaccine development	VAC	immuniz, vaccin + Vaccine	840

The relative commitment to each of these 10 subject areas for the leading countries was calculated relative to their presence in world malaria research overall, again as a number that could be either above or below unity.

Finally, some comparisons were made with the burden of disease from malaria in selected countries, so that their malaria research activity could be viewed in context. This burden can be calculated in terms of Disability-Adjusted Life Years (DALYs) or in terms of deaths. The World Health Organization publishes on its website estimates for both these numbers for all its member countries for the year 2002; for some countries the numbers of deaths from various diseases, including malaria, are given over a span of years. Each of these indicators should also be compared with overall DALYs and overall deaths, respectively: this can show if a country is over- or under-researching malaria compared with the need to combat the disease (among others). This is, of course, a rather crude comparison because in many tropical countries the biggest health burdens are attributable to a lack of good food, potable water and effective sanitation, which are not primarily susceptible to being tackled with more research.

Results

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. [The calibration factor of the filter was determined as 0.91, meaning that it over-estimated the number of malaria papers, because of a lack of precision, by about 9%.].

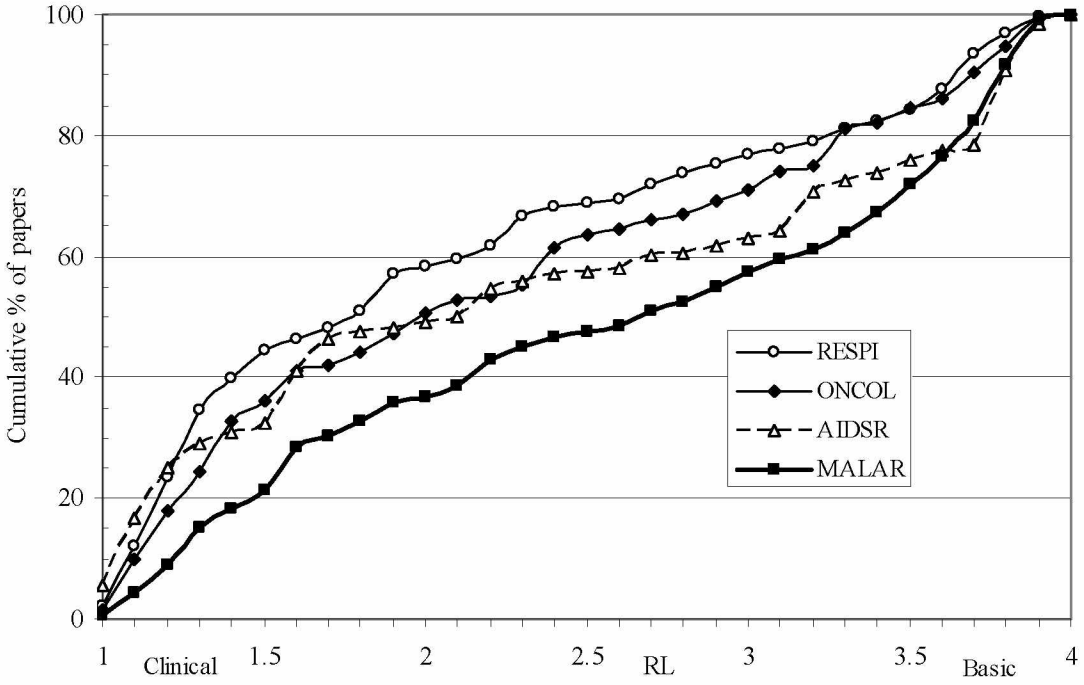
Figure shows the distribution of the research levels of the malaria papers, with, for comparison, papers in three other biomedical sub-fields – AIDS, cancer and respiratory

medicine. As can be seen 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.

Table 8 shows the numbers of papers in each quinquennium from 19 leading countries with both integer and fractional totals, in all cases as percentages of the world total. The integer counts are, of course, higher than the fractional ones, and the ratio between them gives a measure of the amount of international collaboration in a country's malaria research – the further the ratio is from unity, the more the collaboration. 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 (measured in Disability-Adjusted Life Years, DALYs) 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.

Figure shows the relative commitment to malaria research (on a log scale) of these 19 countries during the last 10 years (1995-2004). As would be expected, 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, most of them for historical reasons.

The leading countries vary also in the type of research that they undertake. Some do mainly basic research, and some, mainly clinical observation; Figure shows the distribution of mean RL values. The most basic research appears to be done in three Asian countries (Japan, Israel and China) but this may be an artifact of the SCI which may not cover the clinical journals from Japan and China, and perhaps not those of Israel if they are written in Hebrew. The three African countries, Nigeria, Kenya and South Africa are clearly doing very clinical work, which is likely to be of immediate benefit to their populations, which is appropriate.

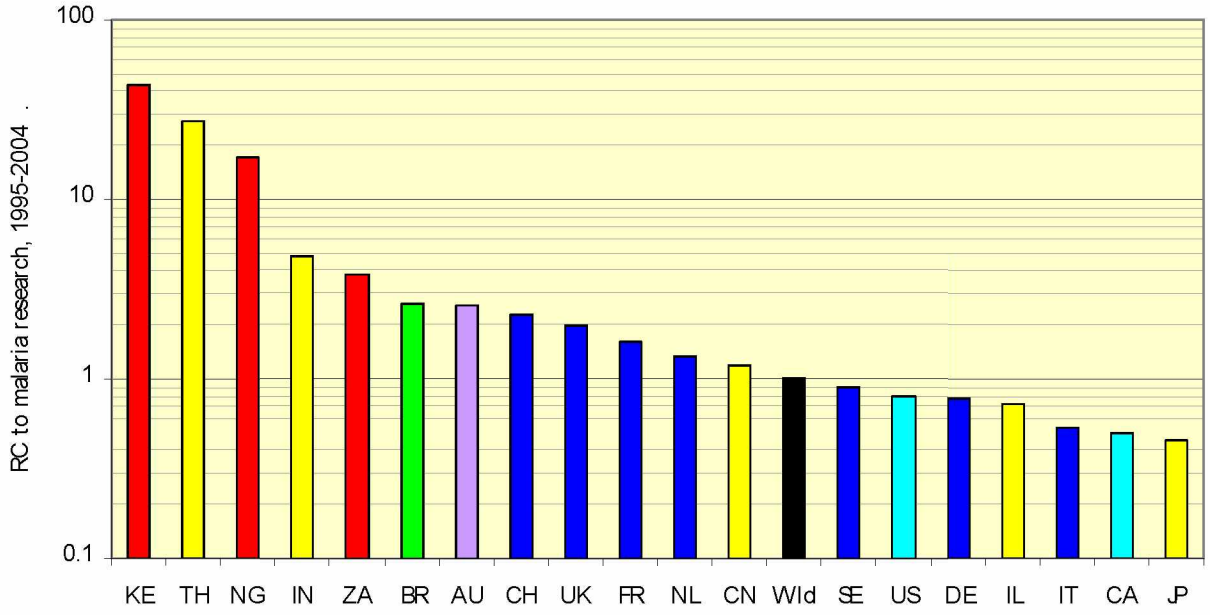


Numbers of biomedical papers (divided by 200) and malaria research papers in the SCI, 1980-2004 (three-year running means).Distribution of research level (journal) of papers in four biomedical sub-fields: MALAR = malaria, 1980-2004; AIDSR = AIDS research, 1997-2001; ONCOL = cancer research, 2000; RESPI = respiratory medicine, 1999-2001. RL1 = clinical; RL4 = basic.

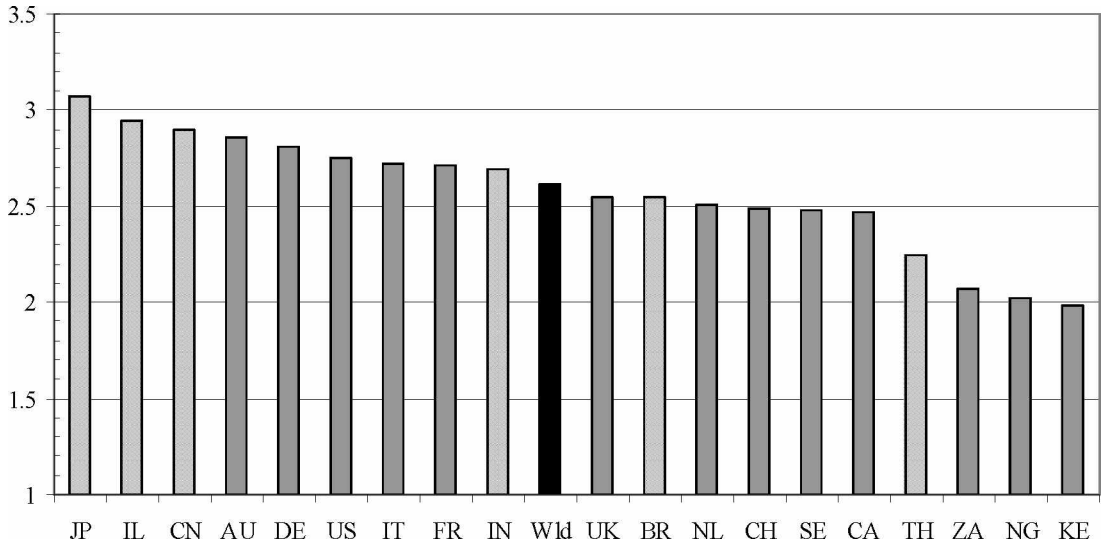
Table 8: Percentages of world total papers in each of five quinquennia, 1980-2004, for 19 leading countries in malaria research, integer and fractional counts and ratio between them for 25 years.

	Integer counts						**Fractional counts**					**FR/IN**
	80-4	85-9	90-4	95-9	00-4		80-4	85-9	90-4	95-9	00-4	
U S A	40.7	38.1	33.9	30.6	32.1		38.1	33.6	28.0	23.8	23.6	0.82
U K	14.2	13.5	16.6	19.4	19.7		12.7	10.9	11.4	12.3	11.3	0.68
France	4.8	7.3	9.5	9.2	10.2		4.2	5.7	7.1	6.4	6.5	0.72
India	6.9	4.9	4.6	5.0	5.8		6.7	4.8	4.4	4.7	5.4	0.95
Australia	2.7	5.0	6.4	6.5	7.4		2.4	4.3	5.2	4.9	5.1	0.77
Germany	3.4	4.2	4.3	5.3	7.5		2.8	3.6	3.3	3.3	4.5	0.69
Thailand	3.1	4.4	5.1	5.4	6.0		2.2	3.0	3.1	3.2	3.3	0.60
Japan	2.5	3.0	2.5	3.8	5.1		2.3	2.6	2.3	2.9	3.7	0.80
Switzerland	2.6	3.1	4.8	5.0	4.7		2.1	2.1	2.8	2.5	2.1	0.56
Netherlands	2.1	2.7	3.9	5.1	3.7		1.9	2.1	2.4	3.0	1.7	0.61
Brazil	0.6	1.3	2.4	2.8	3.2		0.5	1.0	1.8	2.1	2.4	0.75
Sweden	1.7	2.5	2.9	2.5	2.3		1.5	1.9	2.0	1.6	1.4	0.69

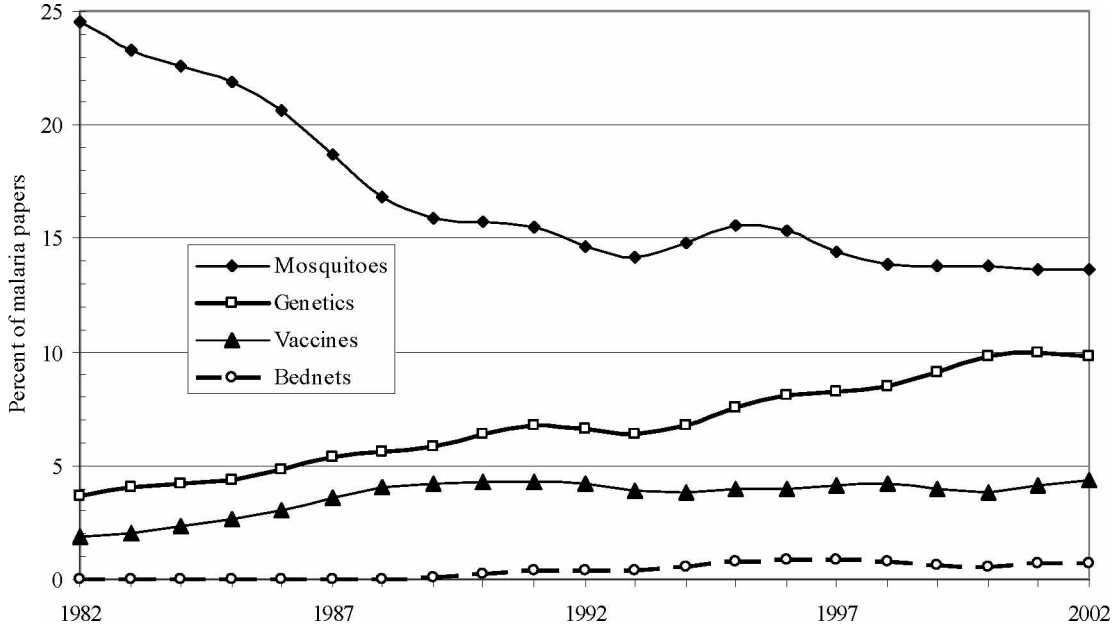
Canada	2.4	1.6	2.1	2.4	2.3		2.3	1.4	1.5	1.8	1.5	0.75
Nigeria	2.4	2.3	2.0	1.5	1.4		2.1	2.0	1.7	1.2	1.0	0.83
Kenya	1.1	1.4	2.2	3.3	4.8		0.8	0.9	1.4	1.6	2.0	0.51
China	1.3	2.0	1.5	1.7	1.9		1.2	1.8	1.0	1.4	1.5	0.82
Italy	0.9	1.1	2.1	2.4	2.6		0.7	0.8	1.3	1.5	1.5	0.61
Israel	1.6	1.9	1.8	0.9	0.9		1.5	1.6	1.5	0.7	0.6	0.81
South Africa	0.9	0.8	1.1	1.4	1.8		0.8	0.7	1.0	1.0	1.2	0.78
Total papers	3164	4114	5006	5415	6217		3164	4114	5006	5415	6217	



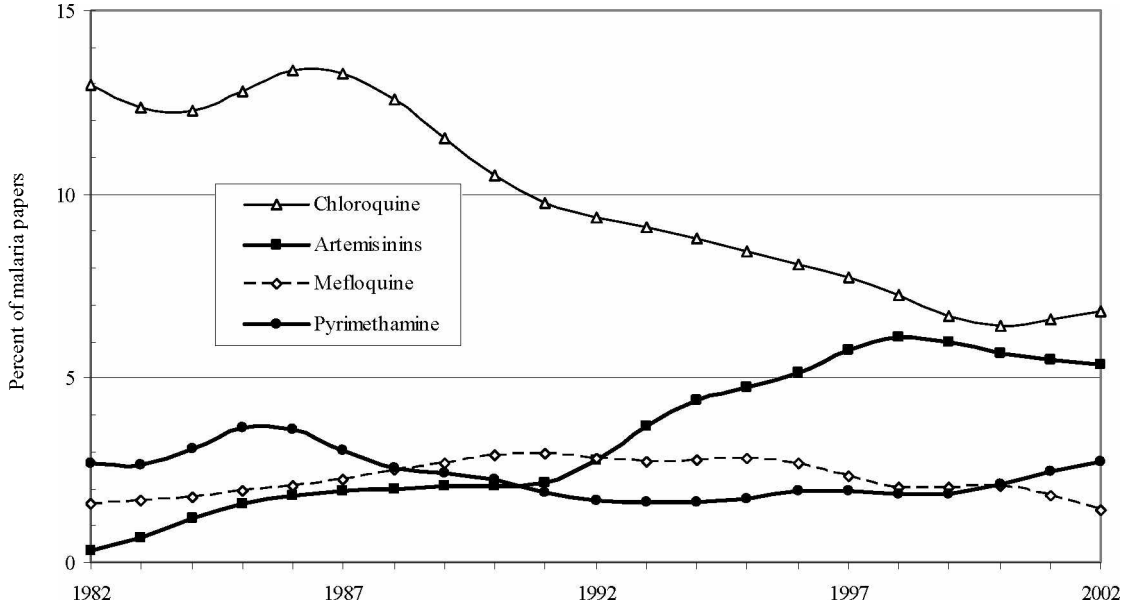
Relative commitment of 19 leading countries to malaria research, 1995-2004 (log scale). Asian countries shaded diagonally to upper right; African countries shaded horizontally; industrial countries solid grey; Latin American country shaded diagonally to upper left.



Mean research level of malaria papers in SCI from 19 countries, 1980-2004. (1 = clinical observation; 4 = basic research). Industrial countries (not much affected directly by malaria) shown in gray. Subject areas within malaria research were identified, as shown in *Table 7*. They comprised between 40% and 45% of all malaria papers. Although *Table* shows the overall numbers of papers in each subject area, there were some noticeable variations with time in the popularity of the subjects. *Figures* show these variations for four of the five non-pharmaceutical and pharmaceutical approaches (the others, not shown, are small and relatively constant). There has been a steady relative decline in the amount of attention given to mosquitoes and their habitat, but, as might be expected, an increase in the relative effort devoted to genetics. Vaccines research increased in the 1980s, and has remained at about 9% of the total. Work on Bednets is still sparse, probably because the technology is by now well understood and the main questions are how best to distribute them (in some African countries, they are still taxed by the government). Among the pharmaceutical approaches, it is striking how the amount of research on chloroquine has declined (although relatively rather than absolutely, and it may now be making a comeback: Vogel, 2006) whereas that on the Artemesinins has increased from almost none in the early 1980s to around 6% in the 21st century.



Variation with time of research articles on four non-pharma approaches to malaria control, 1980-2004 (five-year running means), as percent of all malaria research: worldwide



Variation with time of research articles on four pharmaceutical approaches to malaria control, 1980-2004 (five-year running means), as percent of all malaria research: worldwide

There are some big differences between individual countries in the amount of research effort that they devote to these subject areas. The relative commitment (in relation to their

number of malaria research papers overall) of the 19 leading countries over the whole period. Values of RC greater than unity indicate that more research is undertaken than the world average, and vice versa. Different fonts are used to identify countries and subject areas with particularly high RC values. Among the non-pharma approaches, mosquito control research is undertaken most by the USA and Canada. South Africa concentrates heavily on the insecticidal approach (and maintained the use of DDT for the internal spraying of houses when it was proscribed in other African countries), and Kenya and the UK on the Bednet approach. Malaria vaccines have been most favoured by Switzerland (led by F Hoffmann La Roche sa and the Swiss Tropical Institute), although Colombia (not shown in Table 4) has a RC of 5.5 to this subject area, largely because of the work of Manuel Patarroyo, who published 33 papers on malaria vaccines. Among the pharmaceutical approaches, the new Artemesinins have (not surprisingly) 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.

A keyword analysis was also applied to evaluate research trends of DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane) papers published between 1991 and 2005 in any journal of all the subject categories of the Science Citation Index compiled by ISI (Institute for Scientific Information, Philadelphia, USA). DDT was used as a keyword to search parts of titles, abstracts, or keywords. The published output analysis showed that DDT research steadily increased over the past 15 years and the annual publication output in 2005 was about twice that of 1991. The two peaks in 1997 and 2000 were closely related to two new research fields on DDT, namely the endocrine disruption and the persistent organic pollutants (POPs). A paper entitled "Persistent DDT metabolite -DDE is a potent androgen receptor antagonist" published in 1995 in Nature by Kelce *et al.* firstly discovered DDT's toxicity for humans. As a result, public concerns regarding DDT ballooned and now play a key role in DDT research. Keyword analysis indicated that the research interest changed remarkably from 1991 to 2005. "Endocrine disruption" was one of the most frequently used author keywords in the period between 2002 and 2005 whilst it did not appear before 1997. The new conception of POPs showed the same trend. The all the paper published by India and Mexico on the topic ranked at 6th and 13th. That showed that DDT research is often related with DDT's risk and benefits to humans.

Relative commitment of 19 leading countries to different subjects within malaria research, 1980-2004. Values above 4 shown bold; values above 2 shown underscored; values above 1.41 in normal type; values below 1.41 in light type.

Table 9:

		AAQ	BED	CHL	DDT	GEN	MEF	MOS	PYR	QUI	VAC
US	**U S A**	0.68	0.21	0.65	0.57	1.18	0.45	1.64	0.53	0.39	1.46
UK	**U K**	0.69	2.48	0.68	1.71	1.32	0.70	0.66	0.98	1.32	0.91
FR	**France**	0.91	0.29	1.33	1.51	1.23	1.47	0.66	0.68	1.41	0.66
IN	**India**	1.09	1.23	0.87	1.80	0.67	0.25	1.12	0.45	0.26	0.51

AU	**Australia**	0.56	0.38	0.60	0.24	1.14	0.60	0.73	0.74	0.47	1.66
DE	**Germany**	0.56	0.09	1.49	0.00	0.76	1.19	0.35	0.68	0.61	0.54
TH	**Thailand**	3.15	0.00	0.40	0.63	0.65	4.72	0.47	1.61	4.24	0.28
JP	**Japan**	0.30	0.00	0.84	0.55	0.94	0.19	1.32	0.96	0.29	0.67
CH	**Switzerland**	1.36	1.02	0.65	0.97	0.72	2.84	0.33	1.57	0.50	2.71
NL	**Netherlands**	1.92	0.49	1.14	0.65	1.11	1.23	0.50	1.03	0.88	0.78
BR	**Brazil**	0.55	0.00	0.51	0.60	0.91	1.38	0.69	0.54	1.58	1.51
SE	**Sweden**	1.96	0.00	2.51	0.05	0.61	2.71	0.43	1.73	2.34	0.85
CA	**Canada**	0.36	0.00	1.16	0.54	0.74	0.77	1.78	0.13	0.82	0.12
NG	**Nigeria**	0.85	0.00	5.09	0.29	0.10	2.78	0.17	3.36	2.30	0.25
KE	**Kenya**	0.30	8.47	0.96	1.56	0.59	0.34	0.60	2.79	1.71	0.43
CN	**China**	9.70	1.58	0.79	0.31	0.76	1.00	0.78	1.29	0.58	0.62
IT	**Italy**	0.59	0.27	1.03	0.91	1.83	1.16	0.53	0.55	1.16	0.21
IL	**Israel**	0.20	0.00	1.14	0.00	0.52	1.23	1.02	0.40	1.09	0.00
ZA	**South Africa**	0.93	1.90	1.66	6.11	0.65	0.56	0.66	1.09	1.47	0.00

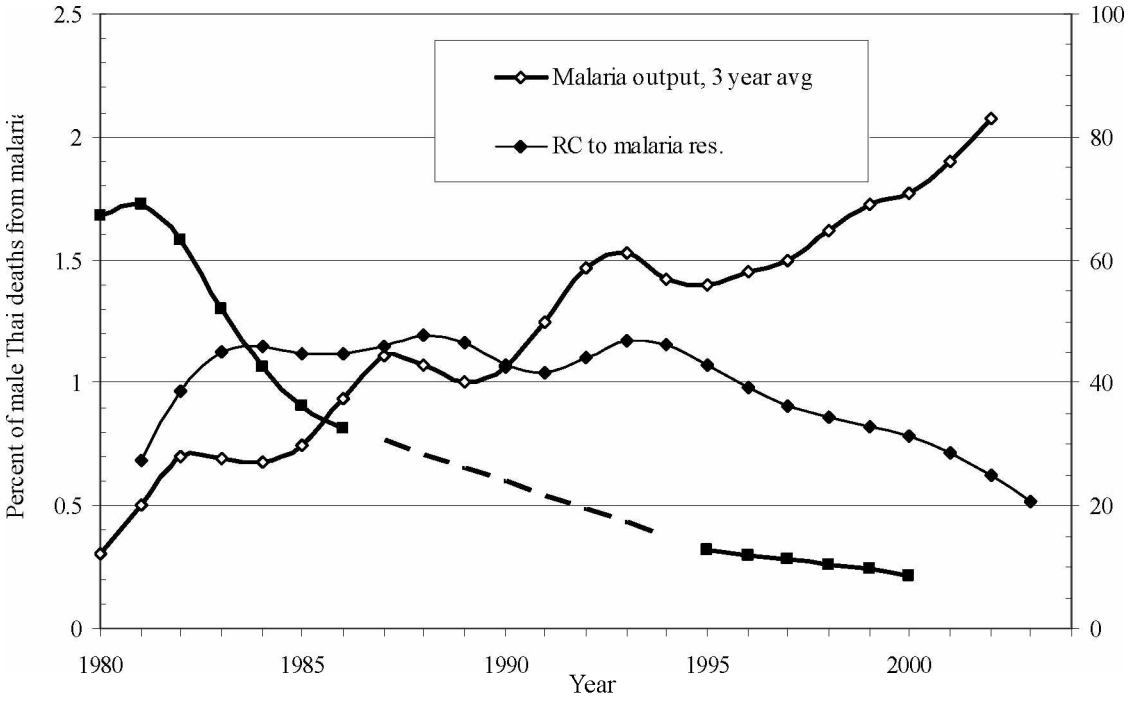
So the pattern of research interests can be seen to reflect the actual policies used to combat malaria in many of the countries affected.

Malaria research and deaths in Thailand

Thailand, together with other south-east Asian "tiger" countries, has been making a determined effort to modernise its economy through investment in science. This has borne fruit in the form of published scientific papers, whose numbers in the SCI have risen from fewer than 240 per year in the early 1980s to more than 1250 per year in the early 2000s. More than 60% of these papers are biomedical, and malaria research accounts for about one in eight of them. This compares with 1 in 250 biomedical papers worldwide, showing that Thailand's average relative commitment to malaria research is almost 36 times its "expected" value. It was even higher than this in the 1980s and early 1990s, during which time the Welcome Trust tropical medicine unit was developed under the direction of Professor Nick White FRS, who was a pioneer of and enthusiast for the new drug, artesunate (a qinghaosu derivative), one of the Artemesinins, which were subject to clinical trials and animal studies in China in the early 1980s and were tried out in Thailand from 1994 onwards (Marshall, 2000).

The death rate from malaria has dropped sharply, and does not seem to have suffered the recent rises that occurred in India as a result of heavy rain and a relaxation of controls. However, it is hard to be sure because the WHO data for deaths in Thailand (for which there is a long series available, from 1979 to 2000, with only a short break from 1988-1993), shown in Figure 7, are much lower than the WHO estimate for 2002, which is just under 4000 deaths, about 1.0% of all Thai deaths in that year. [This is an order of magnitude higher than the recorded number, which probably refers only to registered deaths.] The figure also shows the RC to malaria research and the annual number of malaria papers, which has continued to rise. One would hardly expect that research per se

would directly affect the death rate from malaria, but a national culture that places a high value on such research will also be favourable to well-chosen approaches to malaria control. Moreover, the prestige of the internationally-connected malaria research community is likely also to be influential in the securing of appropriate resources for control and treatment.



Malaria research in Thailand, numbers of papers per year (running three-year mean) and relative commitment to malaria research (running five-year mean), right scale; and percentage of male deaths from malaria (WHO country data), 1979-2000. Note: malaria death rates have also been estimated at ten times these values in WHO DALY country estimates for 2002.

There are several interesting lessons to be drawn from this survey. First, despite all the international pleading about the need to combat malaria, there is little evidence that malaria research has increased significantly in recent years, although there are some signs of a small upturn since 2002. Second, the vast majority (74% on a fractional count basis) of all malaria research is still being carried out in developed countries. To some extent this high figure is an artifact of the journal selection process of the SCI, but it still represents a large proportion of the international literature. Third, it is clear that the strategies adopted by countries for their malaria research do take some account of national needs, with African countries performing clinical work and developed nations (including China) more basic work. Fourth, the major burden of malaria is suffered by Africa, with over 90% of the DALYs attributable to malaria, yet it performs less than 10% of world malaria research.

The continents, with their burden of disease (Disability Adjusted Life Years, DALYs) from malaria and fractional counts of their malaria research papers, 1980-2004.

Table 10:

Continent	**DALYs**	**DALYs, %**	**Mal res paps**	**Mal res %**
Africa	31602	91.4	2276	9.6
Asia	2809	8.1	4035	17.0
Europe	3	0.0	7967	33.6
Latin America & Caribbean	141	0.4	989	4.2
North America	0	0.0	7135	30.1
Oceania	35	0.1	1293	5.5
World total	34590	100.0	23697	100.0

This stark imbalance, which echoes the "10/90" gap described by the Global Forum for Health Research, means that Africa is lacking both researchers and advocates for more resources to be used for the control of the disease.

Commitment of countries towards Malaria with high incidence of the disease profile from MEDLINE

Approximately 300-500 million people world wide are affected by malaria and between 1 and 1.5 million people die from it every year. Previously extremely widespread, the malaria is now mainly confined to Africa, Asia and Latin America. The problem of controlling malaria in these countries are aggravated by inadequate health infrastructures and poor socioeconomic conditions. The situation has become even more complex over the last few years with the increase in resistance to the drugs normally used to combat the parasite that causes the disease and insecticide resistance in vectors. Malaria is currently endemic in 91 countries with small pockets of transmission occurring in a further eight countries. *P. falciparum* is the predominant parasite. More than 120 million clinical cases and over 1 million deaths occur in the world each year.

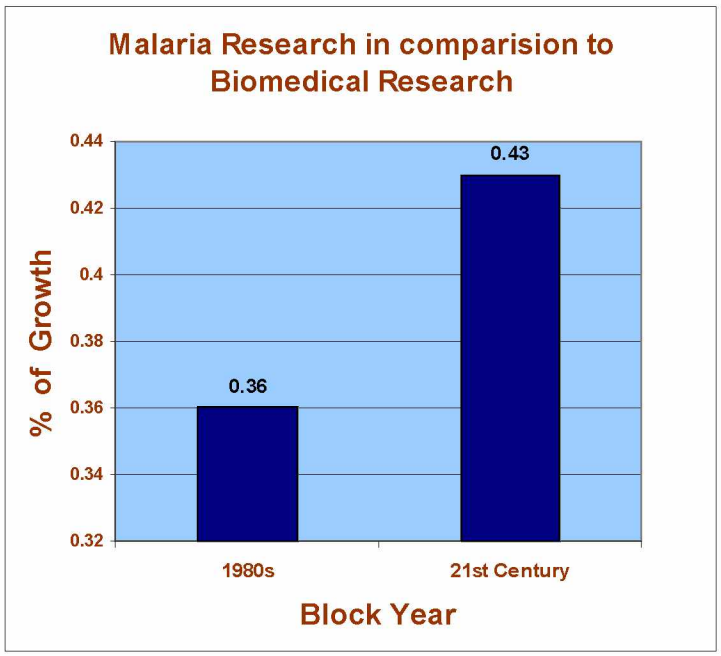
The distribution of malaria varies greatly from country to country and within the countries themselves. In 1990, 75% of all recorded cases outside of Africa were concentrated in nine countries: India ,Brazil ,Afghanistan ,Sri Lanka ,Thailand ,Indonesia ,Vietnam ,Cambodia and China .Malaria also occurs in portions of Iran and the Middle East. *P. falciparum* is common, as is *P. vivax*. *P. falciparum* infections unfortunately increased during 1990s in

India and Sri Lanka. Resistance in *P. falciparum* to multiple drugs is present in portions of Cambodia, Myanmar, Thailand, and Laos, and chloroquine resistance is widespread in Asia. *P. malariae* also occurs in this area.

For successful control of the disease it becomes necessary to take stock of the trend of Research being done in the area along with morbidity and mortality and DALYs due to malaria. With this aim the present analysis has been done on the basis of papers indexed in MEDLINE for a time period between 1980- 2005 with 5 years intervals , i.e. 1980, 1985, 1990, 1995, 2000 and 2005.
The data have been analysed only for selected countries having higher number of DALYs from developing world on particularly for control measures in terms of:
Drug resistance,
Drug development,
Control in general,
Research activities in front line areas such as :

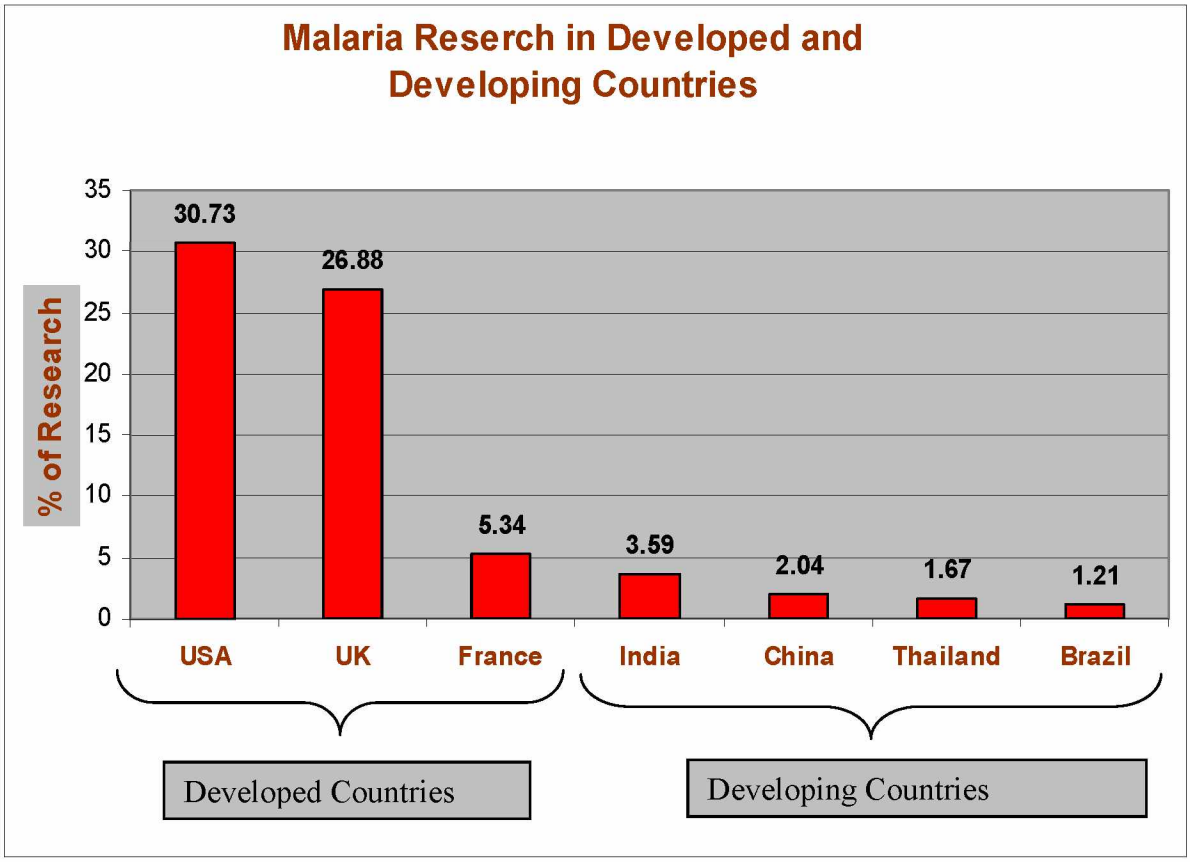
- Molecular biology,
- Immunological studies
- Vaccine development.

Observations and Results



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 (5.344%) among developed and India (3.59%), China (2.04%), Thailand (1.67%) and Brazil (1.21%) from developing nations.

Country-wise data

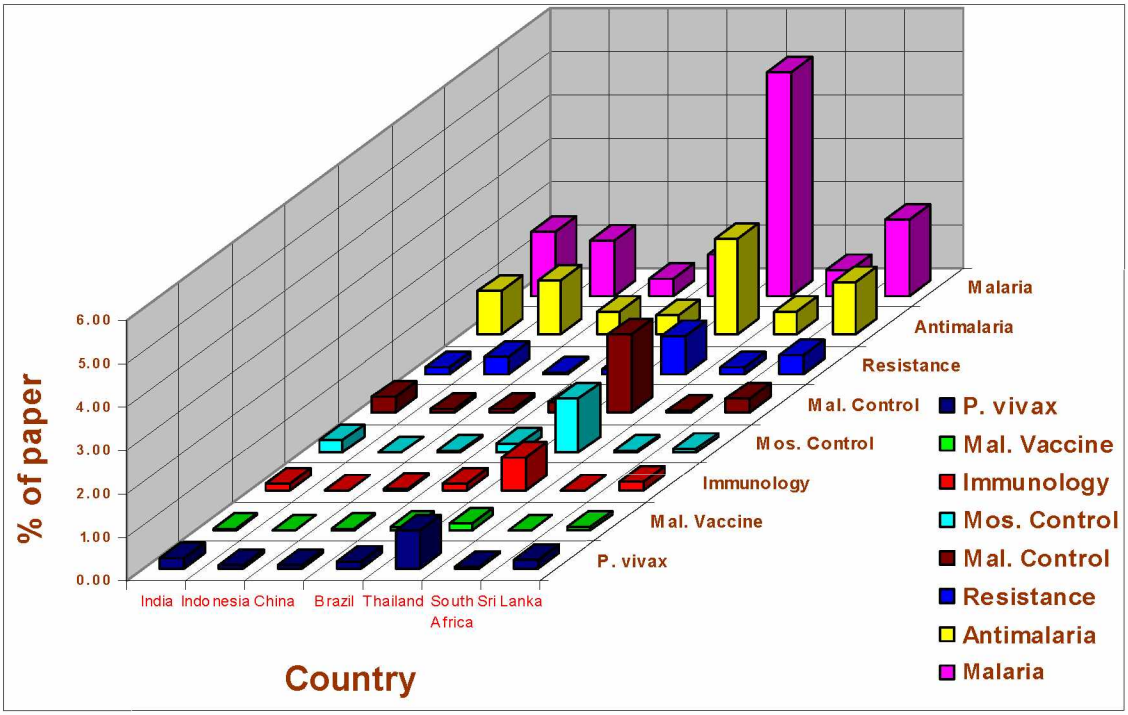


Overall, the research is fairly basic (mean RL = 2.6 based on journals, RL = 2.7 based on individual title words), at least compared with research on some other diseases such as

cancer where there is more focus on patient treatment and clinical trials. In Thailand, (WHO statistics over two periods, 1979-1987 and 1994-2000) the percentage of males dying from malaria has gone down dramatically from a peak of 1.7% in 1981 to about 0.2% in 2000. At the same time there has been a big increase in the amount of malaria research, both absolutely and expressed as a percentage of Thai biomedical output representing a positive co-relation with research on malaria and its impact on malaria control. Apart from Thailand other countries from this part of the world having big leaps were India (0.78%-1980 to 1.38% -2005), China (0.29%-1980 to 0.82%-1995) and Brazil (0.34%-1980 to 1.42% -2000).

Further data was analyzed on the basis of selected 17 subject areas. Some of them concern drugs, mosquito control, drug development, antimalarials, drug resistance and immunological studies including vaccine and ACT. The other approaches of interest were genetics, molecular and immunological studies. What is perhaps more interesting is the variation between countries in the subjects on which they concentrate,

RC for the selected subject areas from developing countries

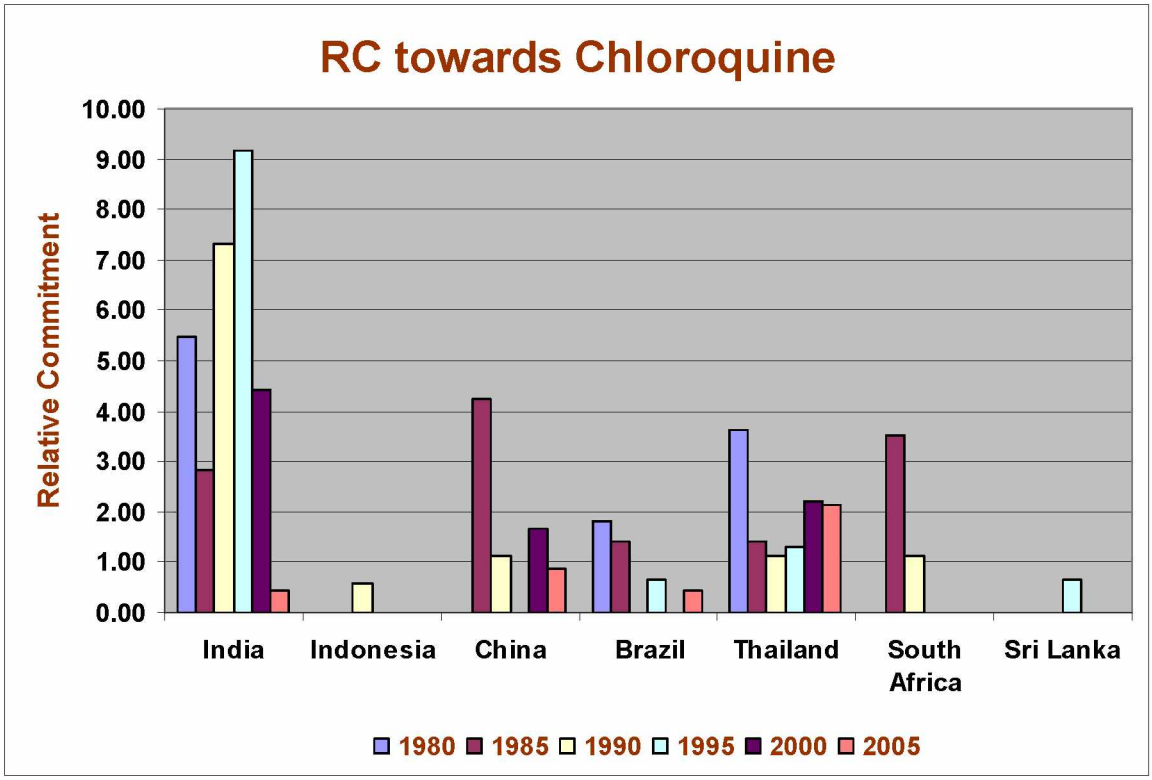


The year-wise data on drugs indicates work on chloroquine has decreased because of many resistant strains of malaria. The trend of research activities related to drugs in the field of malaria for the years 1980-2005 revealed India was having maximum (29.58%) papers related to Chloroquine followed by Thailand for Mefloquine (19.30%) , Pyremethamine (17.82%) and Chlroquine (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%).

The trend of research activities related to drugs in the field of malaria for the years 1980-2005 is as follows :

India	29.58%	Chloroquine
	11.72%	Pyremethamine
Thailand	19.30%	Mefloquine
	17.82%	Pyremethamine
	11.84%	Chloroquine
China	7.87%	Chloroquine
Brazil	5.45%	Mefloquine



Results for India indicates that most effort , during earlier years was on research related to 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 . A Study of malaria trends in India revealed that initially DDT spraying wiped out the disease and cases declined from 75 million and 0.8 millions deaths to about 100,000 and no death by 1964. Research on malaria was stopped and even the famous *Indian Journal of Malariology* was terminated which was revived later during 1980s.

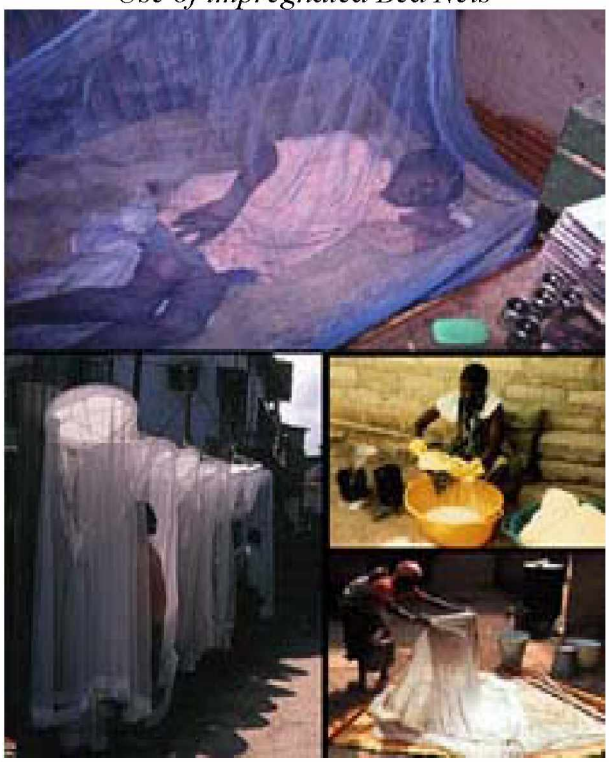
Fumigation in the surrounding

Spraying a house interior

But malaria resurged back in 1970s and reached to peak of 6.5 million cases in 1976s then government implemented Modified plan of Operation including research priorities. Analysis of malaria situation revealed that malaria was never eradicated but had only declined to low levels. Now, the malaria cases are more or less at the same level (approximately 2 million) because of newer integrated strategies of control measures as revealed by research papers and RC's.

Later 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

Use of impregnated Bed Nets



Community participation for source reduction of mosquito breeding

Fish culture in ponds

Growing of eucalyptus in marshy areas

Use of guppies to control mosquito larvae

Analytical evaluation of Malaria Research Papers in MEDLINE & SCI during the period of 1986-90 & 2001-05

Vector-borne infectious diseases such as Malaria, Filariasis, Dengue, Japanese Encephalitis, Yellow Fever, Kala-azar and Chikungunya contribute to a large proportion of health problems in many countries. The global scientific community is constantly engaged in devising new tools and implementing new strategies to overcome the menace of vector-borne diseases. Amongst all these diseases Malaria continues to pose serious public health threat in different countries. Over 70% of the population is at risk of being infected with malaria. The disease has continued to be the leading cause of morbidity and mortality in the developing countries. To combat the disease research on vaccines, drug development, environmentally safe insecticides, alternative approaches to vector control are needed.

This chapter addresses the challenge of reducing the global malaria burden through studying the coverage of papers dealing on the topic from two very important International databases namely SCI & MEDLINE for the two-time period 1986-90 & 2001-05 with a gap of 10 years. Total coverage of malaria papers during 1986-90, by MEDLINE was 5888 while SCI covered 3967 papers. During 2001-05 the coverage by MEDLINE leaped many folds (12,491). In SCI also number of papers covered is more that is 10123. This trend shows that MEDLINE is the world's most comprehensive source of life sciences and biomedical bibliographic information database.

Significance of malaria as a health problem is increasing, as approximately 300-500 million people worldwide are affected and between 1 and 1.5 million die from it every year. Previously extremely widespread, the malaria is now mainly confined to Africa, Asia and Latin America. Though geographical area affected by malaria has reduced considerably over the past years, but control of the disease is becoming more difficult and gains are being eroded.

Problem of controlling malaria is associated with inadequate health infrastructures, deteriorating social and economic conditions, global climate change and mass movement of refugees. The situation has become more complex due to emergence of multi drug resistant strains of parasite. In view of the importance of malaria research in the field of human health and well being it becomes important to map out the research activities of Indian Scientists. Since research publications are one of the major outputs of any research activity, which can be quantified also.

After collection of data from two sources like MEDLINE and SCI, we made a comparative study between the MEDLINE and SCI data on malaria, the total papers in the years (1986-1990) and (2001-2005), and top five countries from developed (USA, UK, France, Germany and Israel) and developing countries (India, Thailand, South Africa, China and Malaysia).

For making a comparison calculations were made about the Relative commitment (RC) of Developed and Developing countries from MEDLINE and comparisons were made with the trend of SCI. Also the different year groups were compared with each other.

The top ten Journals which covers maximum papers during the chosen time period were identified.

Results

Total coverage of malaria papers during 1986-90, by MEDLINE was 5888 while SCI covered 3967 papers. During 2001-05 the coverage by MEDLINE leaped many folds (12,491). In SCI also number of papers covered is more that is 10123.

Figure 1.A

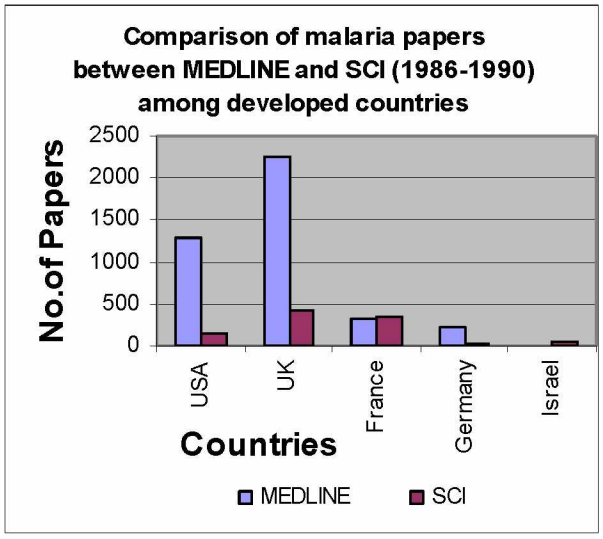


Figure 1.B

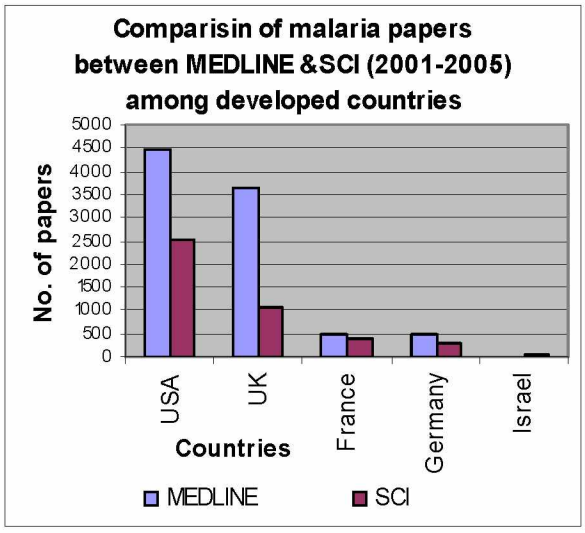


Figure 1.C

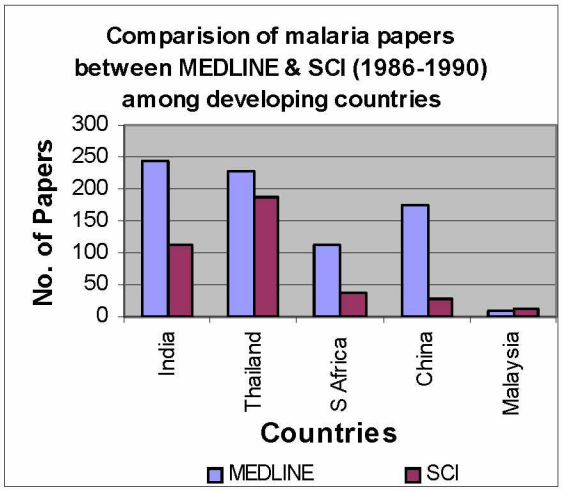
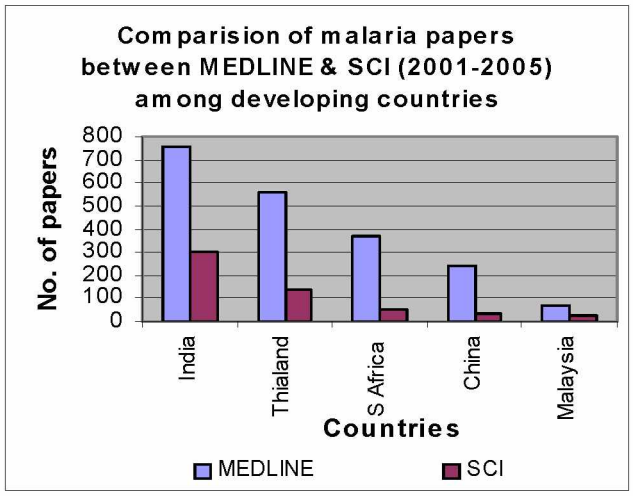


Figure 1.D



Comparison between MEDLINE and SCI data shows that MEDLINE covers comparatively more papers in the field of malaria as that of SCI.

Among the developed countries USA covers maximum papers in the recent as well as in previous years followed by UK, France, Germany and Israel.

Among the developing countries India is more actively participating in malaria research in the recent years and previous years also (Figure 1.A,B,C,D).

Analyzing the data of MEDLINE brings out

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 (Figure 2.A,B).
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 (Figure 2.C,D)..

Figure 2.A

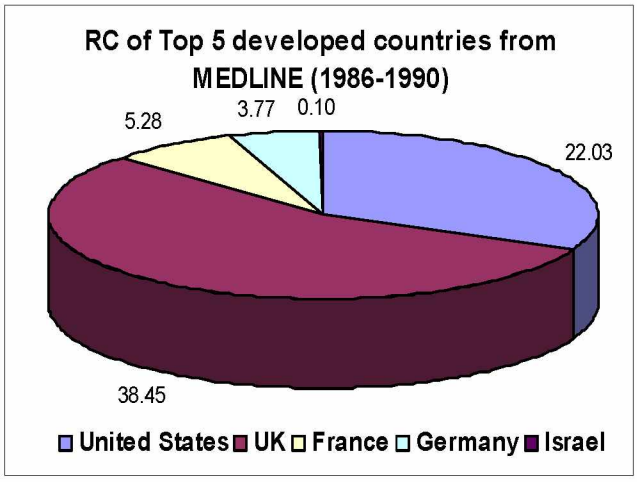


Figure 2.B

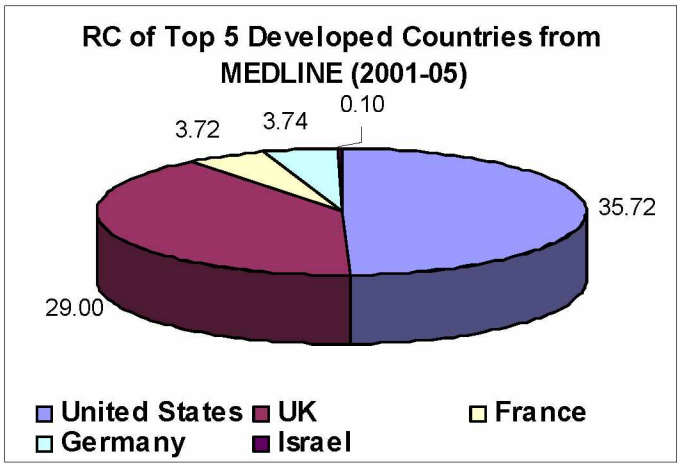


Figure 2.C

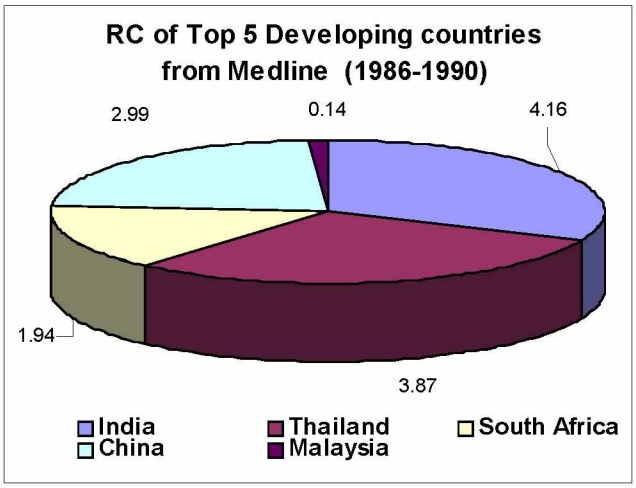
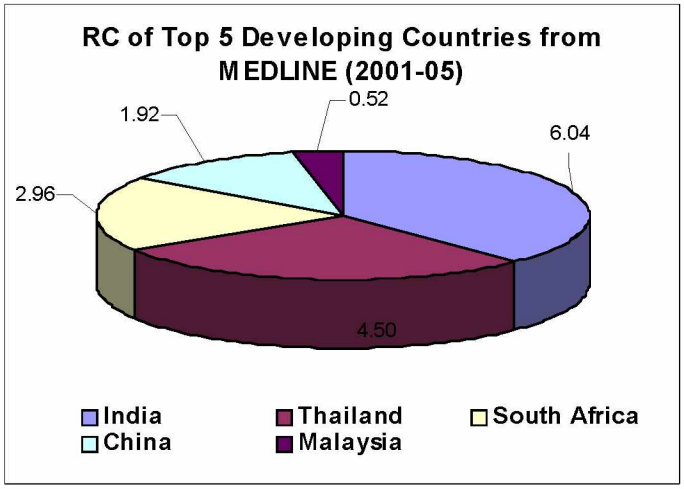


Figure 2.D



Further studying the trend of journals enlisted in both the databases it was found 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).

Table 11:

SCI 2001-05-Journals	Total Papers	Percentage coverage		Medline 2001-05 Journals	Total Papers	Percetage coverage
Am J Trop Med Hyg	261	4.74		*Am J Trop Med Hyg*	426	3.41
Mol Biochem Parasitol	149	2.70		*Mol Biochem Parasitol*	259	2.07
Trends Parasitol	133	2.41		*Trop Med Int Health*	220	1.76
Trop Med Int Health	127	2.31		*Trans R Soc Trop Med Hyg*	215	1.72
Trans Roy Soc Trop Med Hyg	111	2.01		*Trends Parasitol*	193	1.54
Infect Immun	109	1.98		*Infect Immun*	177	1.42
Lancet	99	1.80		*J Biol Chem*	176	1.41
Ann Trop Med Parasitol	90	1.63		*Lancet*	174	1.39
J Biol Chem	90	1.63		*J Am Mosq Control Assoc*	143	1.14
J Med Entomol	86	1.56		*Ann Trop Med Parasitol*	142	1.14

Through the data we can find that 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. With regard to countries of journals the scenario was that the journals covered in SCI are more from the developed countries with USA standing in top followed by UK, Germany, Netherlands, France and so on (In recent years UK is in top followed by USA (2001-2005. While in MEDLINE journals from the developing countries like India, China, Brazil, Thailand are being covered. From the journal analysis it is concluded that in the recent years *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).

Malaria Research from India on the basis of Indian Science Abstracts and Papers collected from most active Institutes in the field

Vector borne diseases and particularly the malaria have been a serious problem in India for centuries. Details of this can be found even in the ancient Indian medical literature like the 'Charaka Samhita' and Sushrut Samhita. The economic loss due to malaria was estimated to be arround Rs. 10,000 million per year in 1935. The annual incidence of malaria was estimated at around 75 million cases with about 0.8 million deaths.

National Malaria Control Programme launched in 1953 later converted to NMEP in 1958. The programme proved highly successful and the disease incidence came down drastically. The incidence dropped further to all time low figure of 0.1 million cases with no deaths in 1965.

But the programme suffered repeated set-backs due to technical, operational and administrative reasons coupled with drug & insecticide resistance resulting to increase in total number of cases and touching a high time figure of 6.5 million cases in 1976. Which however, was brought under control after the implementation of Modified Plan of Operation.

Malaria has now staged a dramatic comeback in India after its near eradication in the early and mid sixties. With this backdrop research institutes were setup during the period of 1970-80, targeted towards the control & management of vectors and vector borne diseases like malaria, filariasis and Japanese encephalitis along with concentrated focus on Vector and Malaria control.

The main objectives of these institutes are to further scholarly research in applied related fields with the goal of enhancing aims and to disseminate these findings to academics, policy makers and practitioners.

Publication Analysis of some of the Top Indian Institutes active in the field of Malaria and Vector studies

Now more than two decades have passed and to evaluate the work being carried out it is necessary to have a stock checking. What we really want to know is to find out the strong areas and gaps if any to devise new strategies.

Publication and citation analyses are standard tools for research evaluation. However, some methodological problems remain unresolved, but none the less scientometrics has made us aware that science is amenable to measurement, however imperfect the representation may be, the relations between qualitative and quantitative approaches can be reformulated: qualitative descriptions and insights inform the measurements as hypotheses and heuristics, while the measurements can be updated and refined by taking interaction terms into account.

Qualitative approaches inform the model from different perspectives, and the results of the quantitative analysis can again be provided with meaning from the various perspectives.
Regular evaluation exercises form an important part of the Institutional efforts towards achieving excellence in research. To that end, the ICMR has set-up a Scientometrics Unit in the head quarter's Office in 1986 in the Division of Publication & Information . The primary mandate of this Unit had been to collect, analyze and evaluate the quantifiable research output of the ICMR (research papers in journals).

The study is based on initial bibliometric & citation analysis along with mapping of research papers from Indian Science Abstracts and some of the institutes of India active in the field of vector and vector borne diseases e.g., Malaria, Filariasis, Japanese encephalitis, Epidemiology and Control of disease, Vectors *etc.* on the basis of papers appearing in research journals from 1977-2004.

Current global picture of malaria indicates it is a public health problem is prevalent in more than 90 countries. In India, the burden of malaria has deteriorated in past few years. Role of Indian scientist working in this field can be traced out by publications from research journals. Papers related to malaria were collected from Indian Science Abstracts as it covers almost all research journals published in India and is the only Indian abstracting service. The study was carried out for a period of 30 years with interval of 10 years. This data was collected for the years 1970, 1980, 1990 and 2000. The data was analysed to map out the trend of research, most active institutes and prolific journals for Malaria. Maximum papers appeared during the year of 2000, some of the most active institutes were National Institute of Malaria Research (NIMR-ICMR), Central Drug Research Institute, (CSIR), International Center for Genetic Engineering & Biotechnology and National Vector Borne Diseases Control Programme(NVBDCP). It was interesting to see that with the development of new technologies in medical sciences, there was a tremendous increase in work related to Molecular biology, Immunology, Proteomics, Vaccine development and Antimalarial compounds. Though in some areas like Malaria in children and Malaria during pregnancy there were smaller number of papers. Before 1980's papers were mostly focused on Plasmodium parasite and vector control. Apart from increase in number of papers in modern biology after 1980's, there were few other upcoming areas also exploratory. The study is still going on, these are part of initial findings.

If we look at Indian scenario, it was believed that use of DDT during 60's completely eradicated malaria but in the next decade the disease further re-emerged with a widespread areas. During eighties, the disease further aggravated with a focal out breaks during nineties, and situation of mortality was highest during 1995.

Problem of controlling malaria is associated with inadequate health infrastructures, deteriorating social and economic conditions, global climate change and mass movement of refugees. The situation has become more complex due to emergence of multi drug resistant strains of parasite.

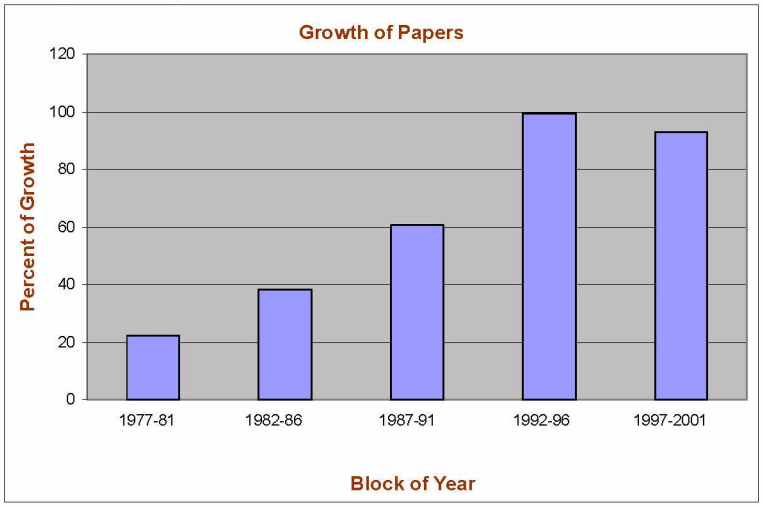
Indian Science Abstracts covers approximately all Indian journals and is the only abstracting service in India. To screen out the papers related to malaria research few keywords were

selected. These keywords were Malaria, Plasmodium, Vivax, Falciparum, Anopheles, Mosquito Control, Antimalaria, Outbreak of Malaria, Economic loss due to malaria. Some related keywords like Malaria in Pregnancy, Drug resistance, Remote sensing, Vaccine development and Vector control were also included for the search. Data of last 30 years at an interval of 10 years *i.e.* 1970, 1980, 1990 & 2000 were collected from Indian Science Abstracts and analysed for different parameters like Subject wise analysis, Trend of contribution of active Institutes and preference of Journal for publishing papers. Initially the data was collected in text format and then converted to MS-Excel worksheet for analysis.

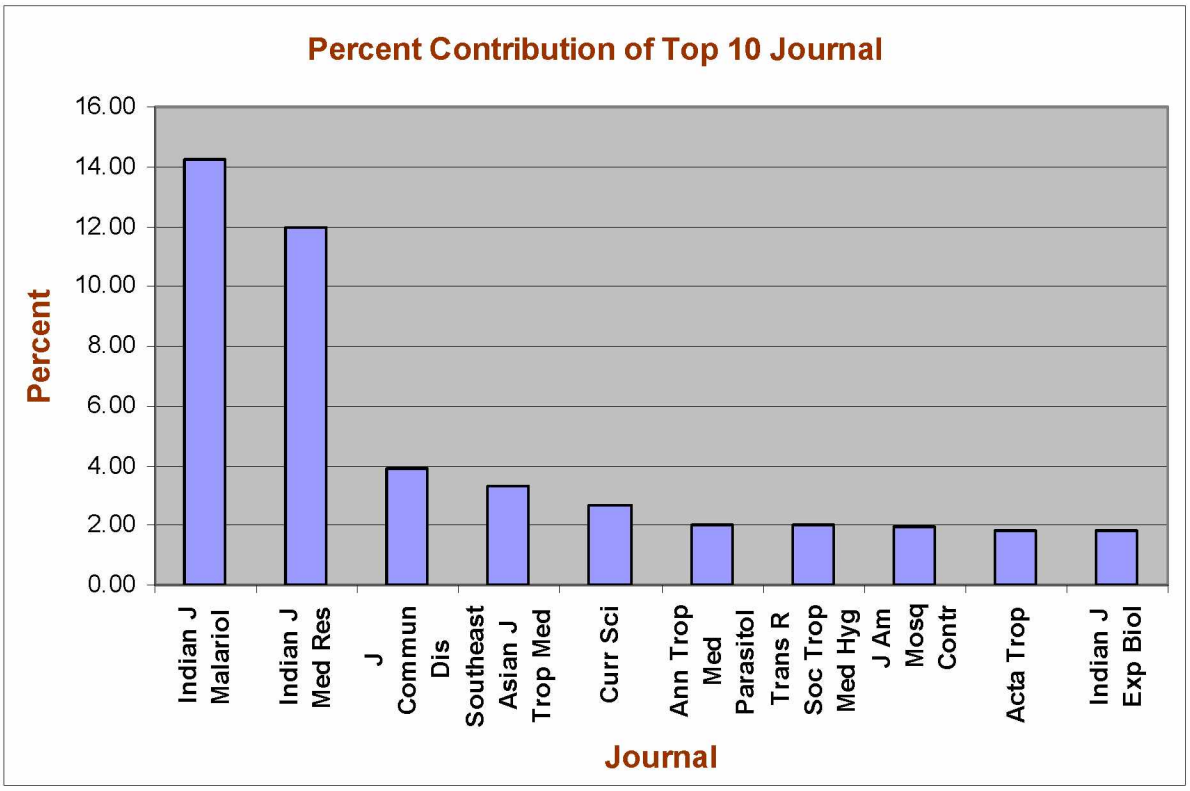
We performed a bibliometric study of the scientific publications resulting from the institutes and applied the principal bibliometric indicators: Price's and Bradford's laws on the increase or dispersion of scientific literature, the participation index (PaI) of Institutes, and the productivity index (PI) of authors. By means of visual mapping, documents were grouped according to the keywords from the title field of the bibliography. For this we used software developed by Loet Leydesdorff .

The data related to citations has been collected from Science Citation Index in ten years blocks. A total of 1796 journal papers published between 1977 and 2004 have been collected from the net for analysis and Total 340 papers from ISA. Both the data sets were analysed separately.

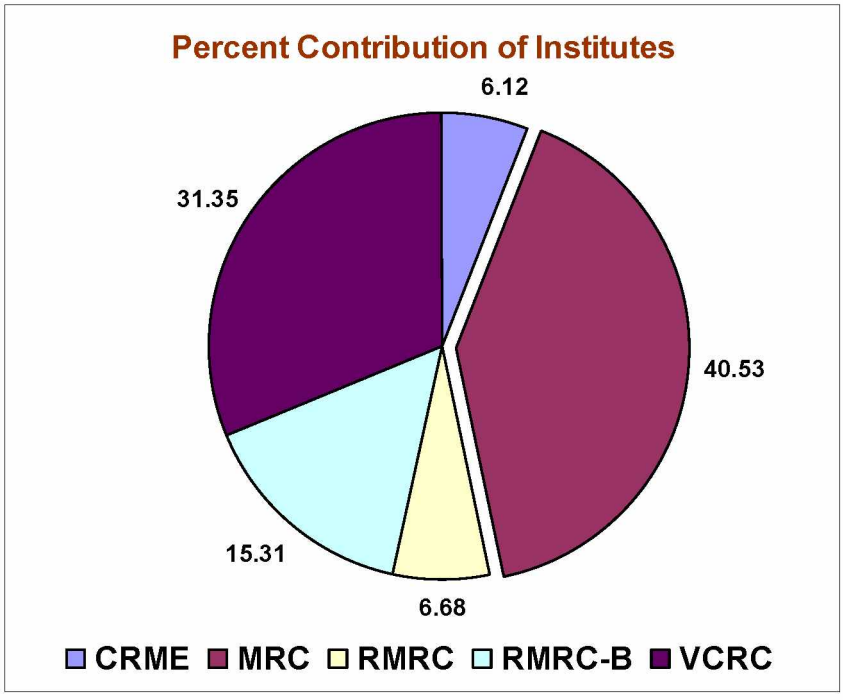
Data Set of Publications from Indian Institutes in the field:
Our results show fulfillment of Price's law as the papers grow exponentially (r=0.946 vs. r =0.937, after linear adjustment).



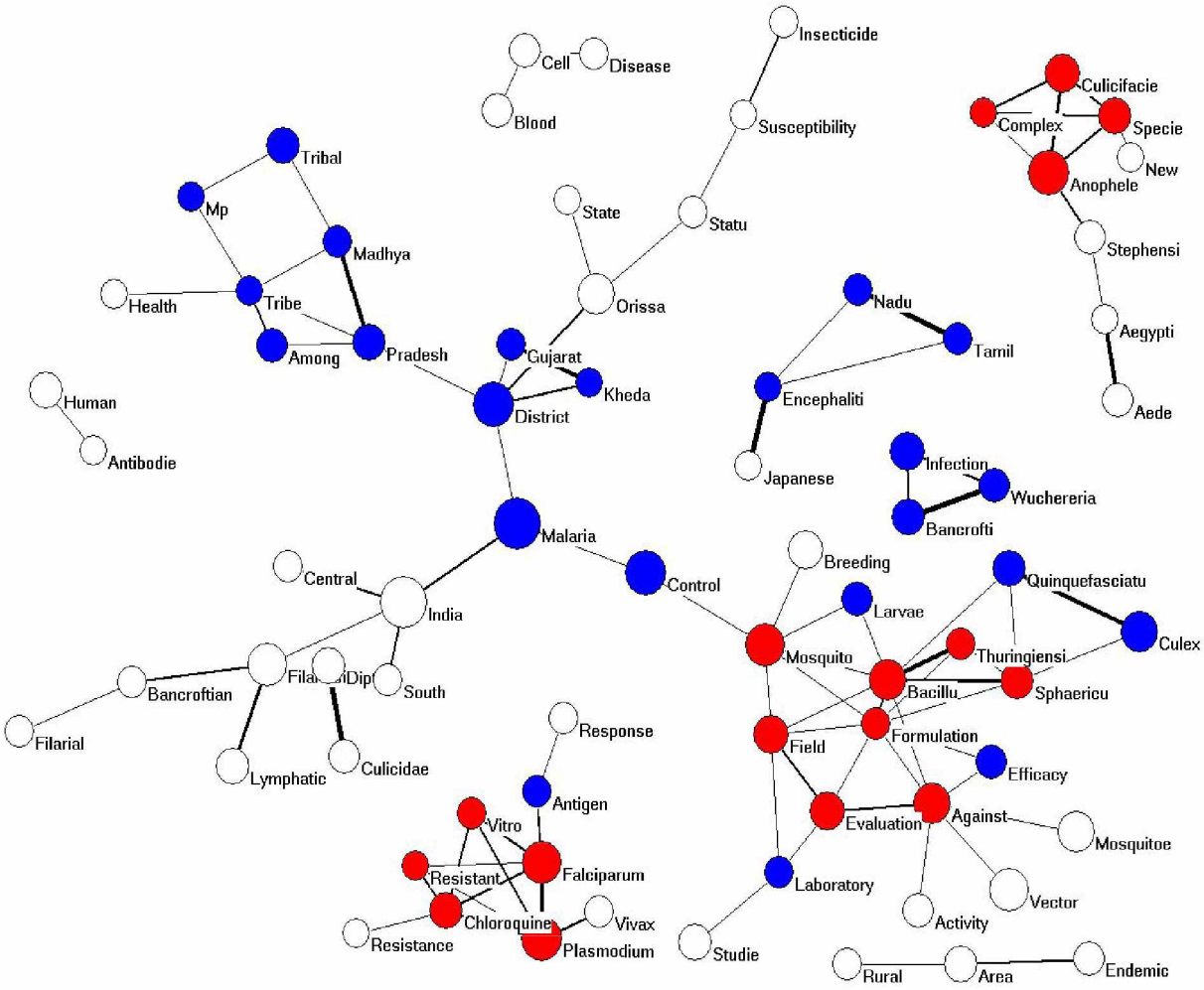
The journal most commonly used were *Indian J Malariol* and *Indian J Med Res* (Bradford's first zone).



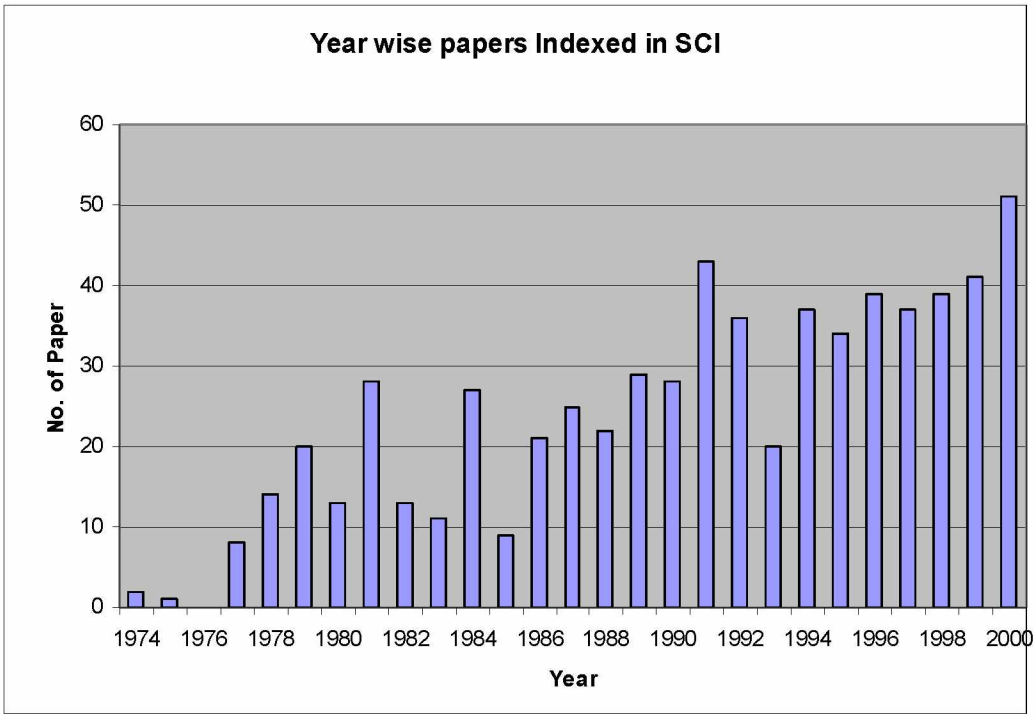
The National Institute of Malaria Research (Formerly, Malaria Research Center) of ICMR, was the most productive institution (PaI=40.53).



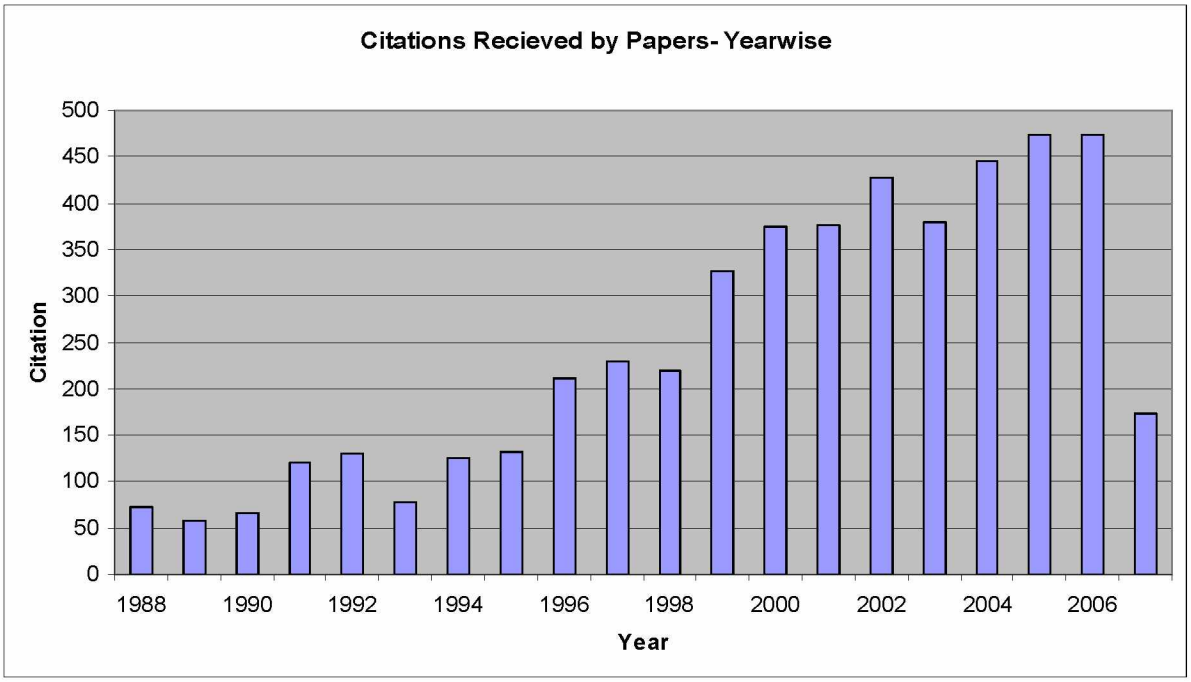
The Papers were distributed in five main clusters:
1-Mosquito bio-ecology & control measures;
2-Geographical distribution of disease through out the country;
3-Studies related to drugs for the control of the disease;
4-Studies related to Vectors of the disease and;
5 - Studies related to resistance to Insecticides.



For qualitative analysis, trend of papers appearing in JCR journals along with Impact Factors have been analyzed. The citation pattern indicated an increasing trend over the years.



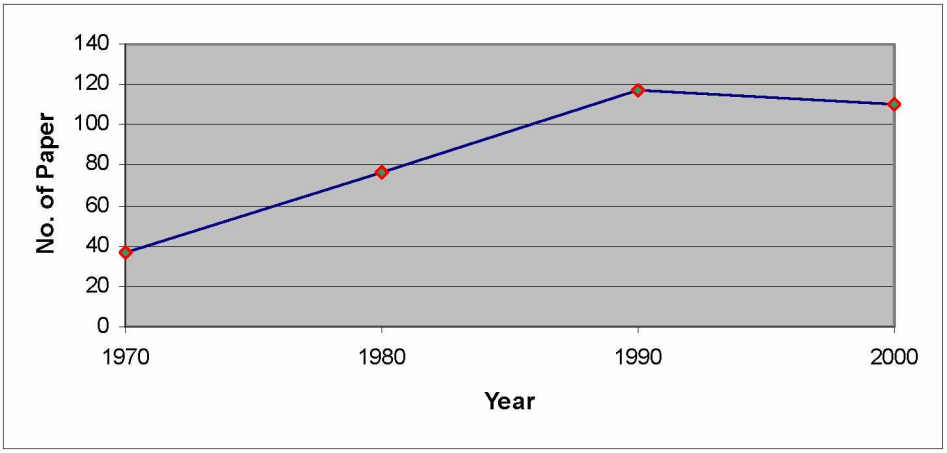
Total Papers Indexed	658
Total Citation Received	4882
Average Citation/Paper	7.42



Observations and Result from ISA:

There were a total of 340 published papers by Indian Scientist in different Journals on malaria research during 1970, 1980, 1990 & 2000. As the graph indicates only approx 11% papers published during 1970 with a significant increase during 1980 (22%) and 1990 (34.4%). During the year of 2000 the number of publications remained more or less same (32%).

No. of malaria papers in last 30 years



It is evident from the data that over the years, many new areas gained importance. Modern developments in medical science paved way for a new spectrum of research fields during 1990 & 2000. During 1970, the papers were more on clinical aspect with a slant to vector studies. During 1980 no. of papers increased particularly in the field of Vector & Vector Control, as well as few modern front line areas like Cerebral Malaria or *P. falciparum*, Insecticides, new emerging field like Immunological based studies on *P. falciparum* & *P. vivax*. During 1990 also, there was significant increase in no. of papers with a share from the field of Antimalarials compounds/drugs.

There was also increase in the no. of papers related to *P. falciparum* and Immunological studies. Regarding *P. falciparum*, most of the papers were on Chloroquine sensitivity of *P. falciparum*. During 2000 the trend was almost like the past years *i.e.* 1990. Most of the papers were on Antimalarial compounds/drugs and studies of *falciparum* along with few areas related to Immunological aspects.

Incidence of malaria in India

Year	Total cases	*P. falciparum*	Deaths
1976	6.47 million	0.75 million	59
1984	2.18 million	0.65 million	247
1985	1.86 million	0.54 million	213
1986	1.79 million	0.64 million	323
1987	1.66 million	0.62 million	188
1988	1.85 million	0.68 million	209

1989	2.05 million	0.76 million	268
1990	2.02 million	0.75 million	353
1991	2.12 million	0.92 million	421
1992	2.13 million	0.88 million	422
1993	2.21 million	0.85 million	354
1994	2.51 million	0.99 million	1122
1995	2.93 million	1.14 million	1151
1996	3.04 million	1.18 million	1010
1997	2.57 million	0.99 million	874
1998	2.09 million	0.91 million	648

We can see from Ref: the table, which is showing incidence of malaria in India, which indicates increase in no. of falciparum cases both in terms of morbidity and mortality, from 1984 onwards with maximum during 1995 which may be one of the reason for emphasis on increased number of research activities depicted by no. of papers.

In order to analyze the trend of research in sub fields of subject areas, ten sub fields were screened out *i.e.* Cerebral malaria, Vector & Vector control, Clinical malaria parasite, Field research, Antimalarial drugs/compounds, Insecticides, Malaria in children, Malaria in Pregnancy, Chloroquine. The percentage contribution of paper published in each sub field for all the years. Fig. 2 indicates a significant increase in papers related to Malarial parasite, Vector & Vector control with each successive decade. Sub field like Antimalarial drugs/compounds, which came into existence in 1980, also presented a significant increase. Few sub field like Malaria in children and Malaria in pregnancy remain important one although with less number of papers.

Percentage of malaria papers in each sub field during 1970, 1980, 1990 & 2000

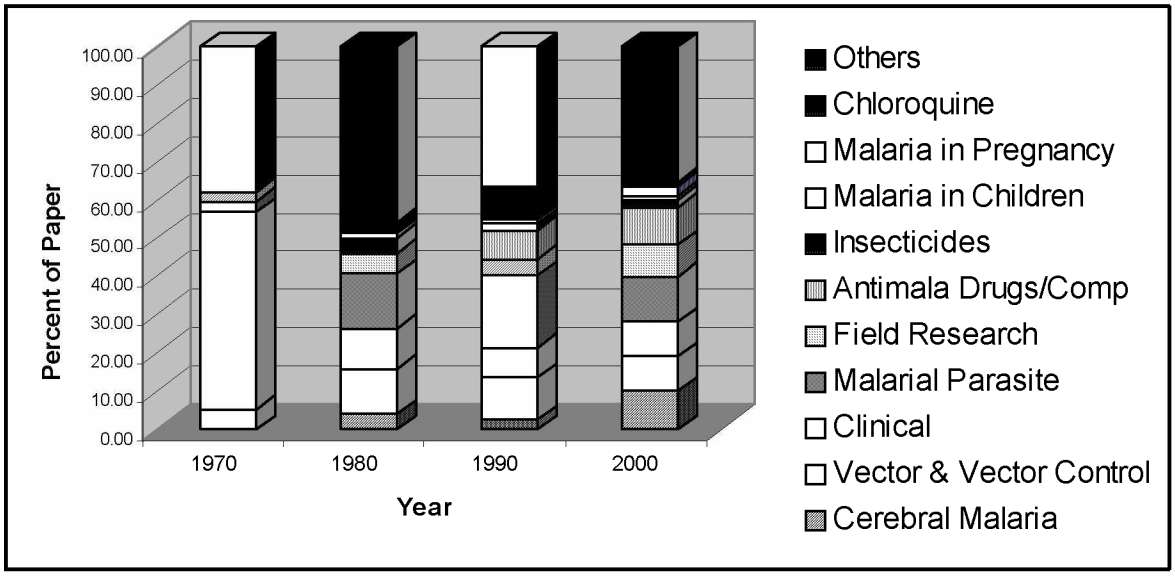
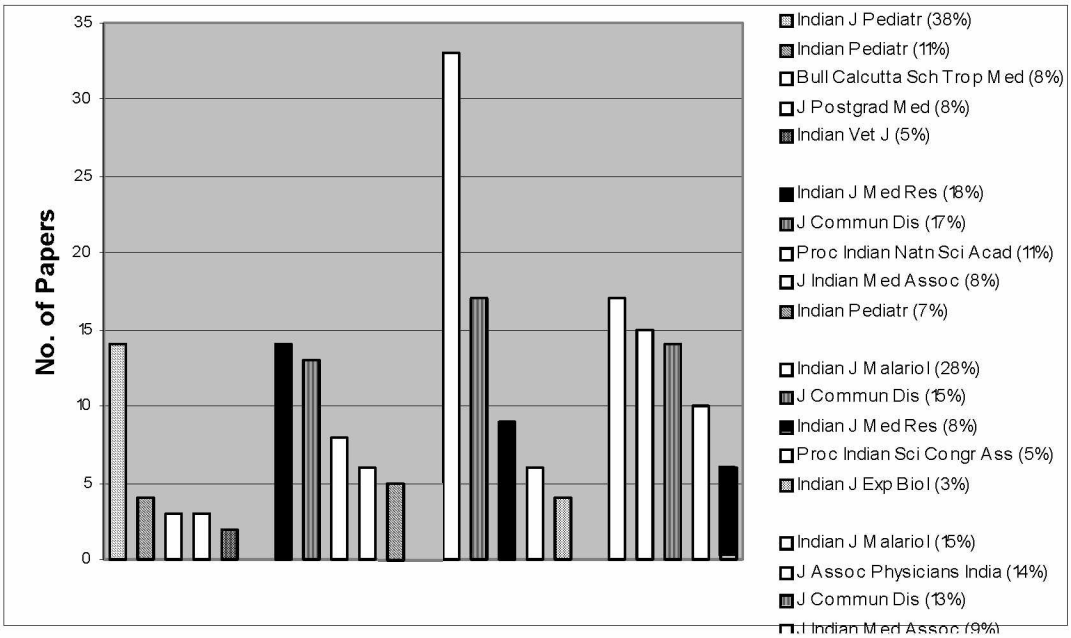


Figure shows the comparative contribution of top five journals during respective year i.e.1970, 1980, 1990 & 2000, *Indian J Malariology* (now known as J Vector Borne Dis) has

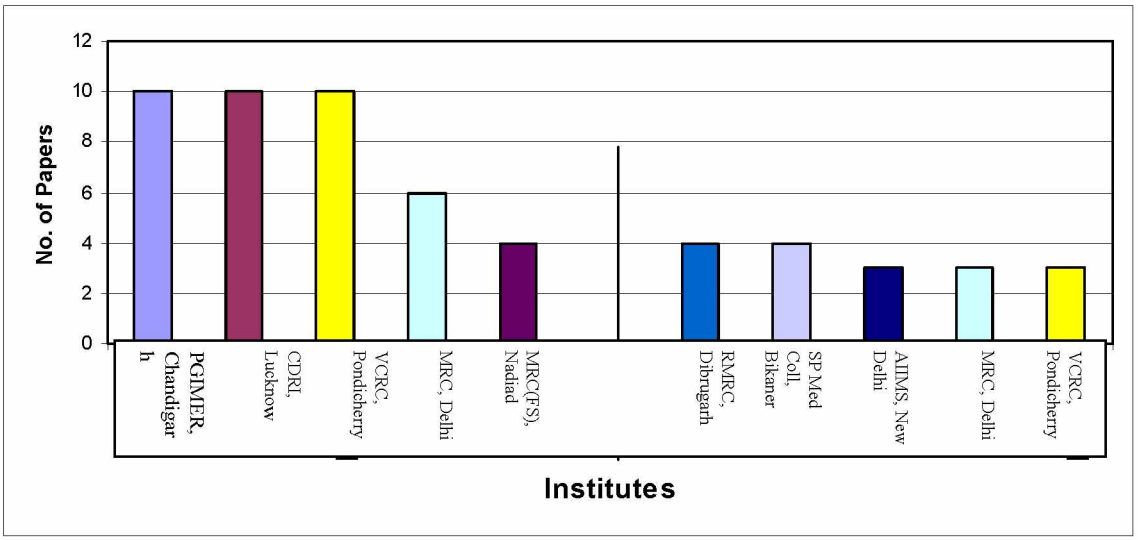
the highest contribution in 1990 & 2000 as it was terminated before 1970 and again revived in 1981. *J Commun Dis* was the most persistent journal during 1980, 1990 & 2000.

Top five journals in malaria of last three decades



The data relating to contribution of various Institutes and Universities, indicates about the most active institution for malaria research during 1990 & 2000. They were mostly various field stations of Malaria Research Centre (renamed now National Institute of Malaria research), PGIMER, Central Drug Research Institute and Vector Control Research Centre. Malaria Research Centre and Vector Control Research Centre both of the institutes belong to Indian Council of Medical Research, the apex body of medical research in India.

Active Institutes involved in malaria research during 1990 & 2000

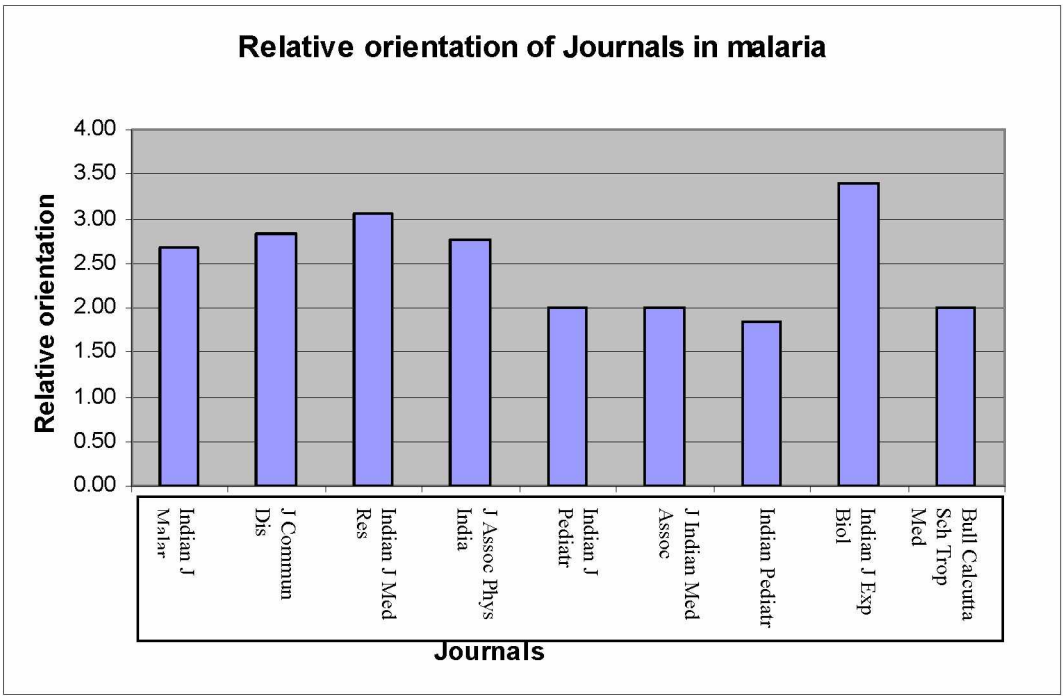


Relative orientation of malaria paper during 1970, 1980, 1990 & 2000 (with following weightage Epidemiology = 1, Clinical = 2, Malaria parasite = 3, Control of malaria = 4)

Year	Relative orientation of paper
1970	2.13
1980	2.90
1990	3.00
2000	2.90

Table represents the relative orientation of research in four sub fields during 1970(2.13), 1980(2.90), 1990(3.00) and 2000(2.90). For analysis purposes, four sub fields *i.e.* epidemiology, clinical studies, malarial parasite and control of malaria have been assigned a weightage of 1, 2, 3 and 4 respectively. Relative orientation of research for each decade was calculated. The relative orientation of research for the journals was also computed in the similar way.

Relative orientation of journals regarding malaria (with following weightage Epidemiology = 1, Clinical = 2, Malaria parasite = 3, Control of malaria = 4)



The Indian scenario of the last three decades reveals that there has been increase in both number of papers as well as the research level with new emerging areas. With each passing decade, various research institutes came into existence and new developed techniques and tools were used. The orientation of the research, which was more clinical in 1970, turned into basic research with emphasis on detailed studies of malaria parasites using molecular biology and immunological techniques and control measures. The cerebral malaria being the fatal one became the prime concern. With emergence of developed techniques in immunology, molecular biology and drug designing gave a new direction regarding control of malaria. As these findings are based on initial study of an ongoing research, there will be much more detailed in-depth studies when compared with other Asian and African countries.

Text Data Mining Analysis & Output of the fifty years Research Database

Spreadsheets applications allow data to be stored with low development overheads, but also with low data quality. Reporting on data from such sources is difficult using traditional techniques. Therefore we have used text data mining techniques to analyze 50 years of global data related to research papers on Malaria stored as free text in a spreadsheet application. The goal was to map the data of potential researchers with the different research areas, identifying potential countries involved in subject specific research area, getting into the spatial and temporal aspect of the data.

Data preparation steps required to transform the data into a format appropriate for text data mining. The data is then mined by calculating term weights to which clustering techniques are applied. Clustering identified some groups that contained relatively homogeneous types of jobs. Training a classification model to learn the cluster groups allowed those jobs to be identified in unseen data.

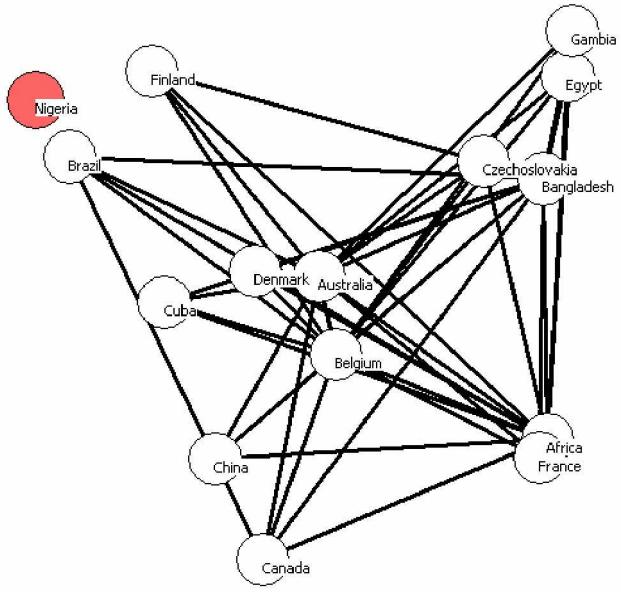
With some manual analysis to code a target variable for a subset of the data, classification models were trained to predict the target variable based on text features. This was achieved with a moderate level of accuracy. BibTechMon was used for the analysis, a software developed by a group of scientist at Vienna, Austria.

Result

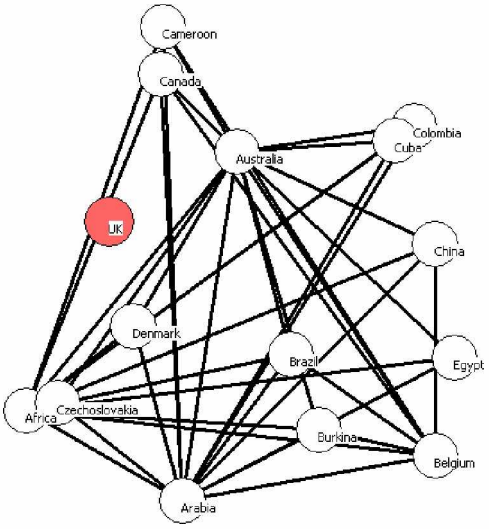
Here the line between the nodes shows the common title of the research papers published by the countries involved. The circle size of the node indicates the frequency and the orange color circle is having the highest frequency.

Figure:

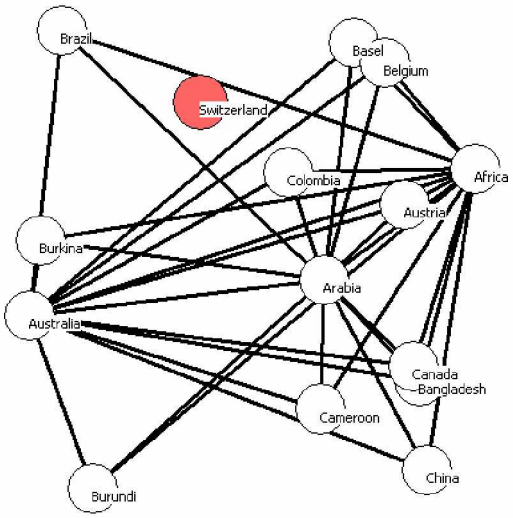
Most Frequent Countries Publishing Articles Between Year 1981 - 85



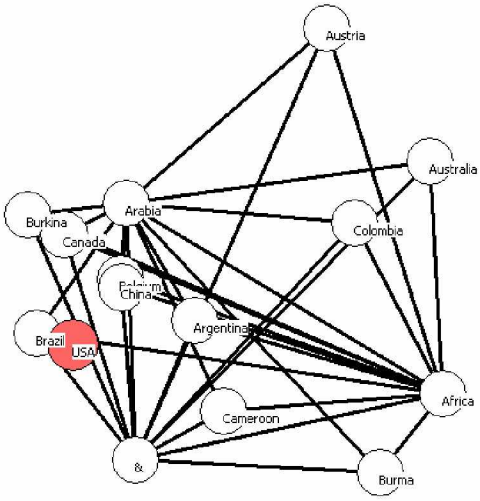
Most Frequent Countries Publishing Articles Between Year 1986 - 90



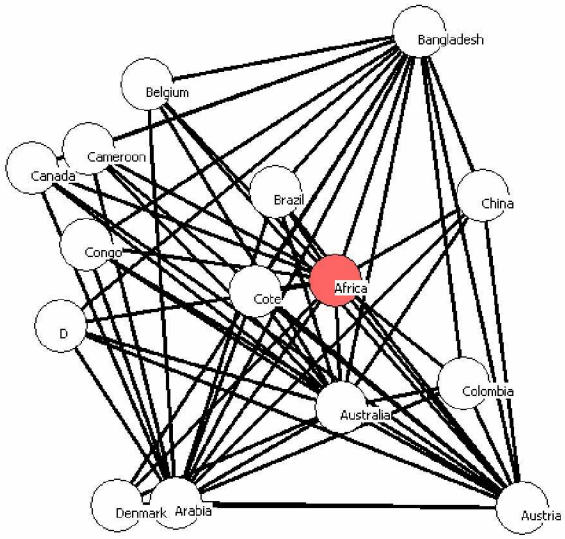
Most Frequent Countries Publishing Articles Between Year 1991 - 95



Most Frequent Countries Publishing Articles Between Year 1996 - 2000

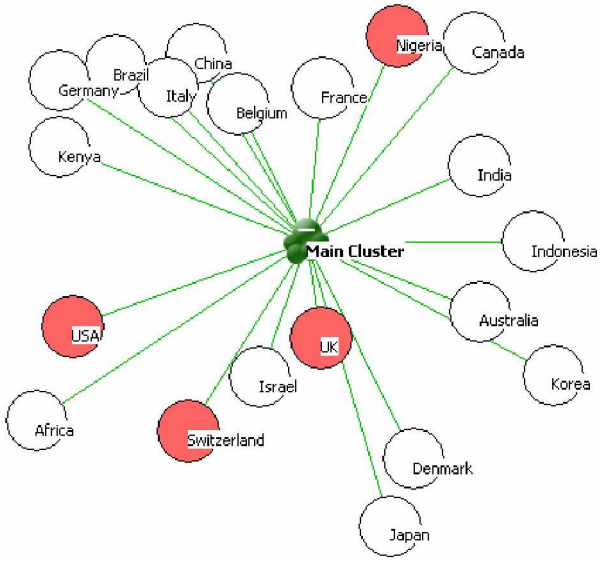


Most Frequent Countries Publishing Articles Between Year 2001 - 05

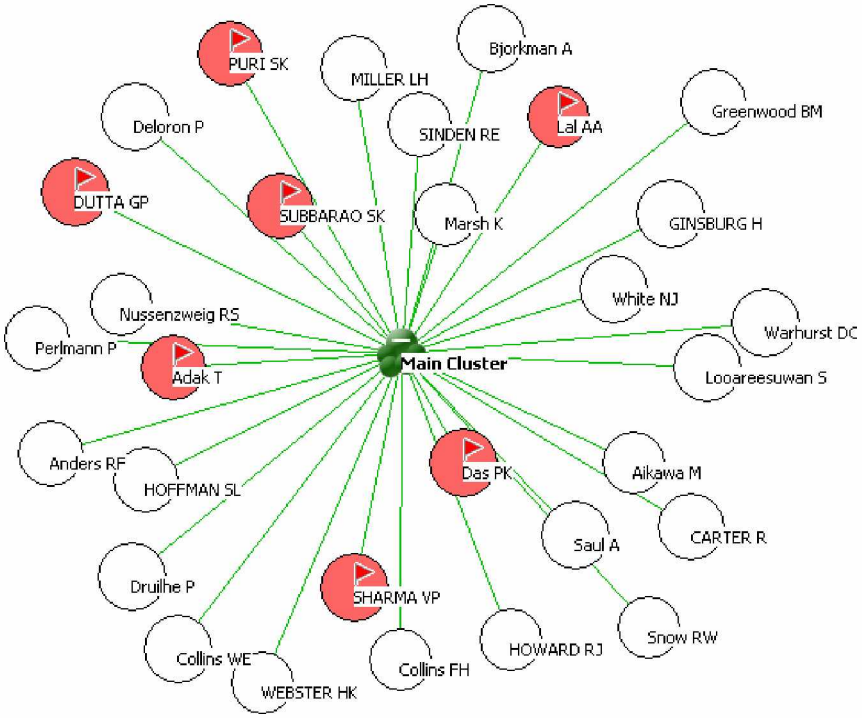


Following Figure is the result of the analysis which shows the most prominent countries (in terms of frequencies) in publishing papers and articles.

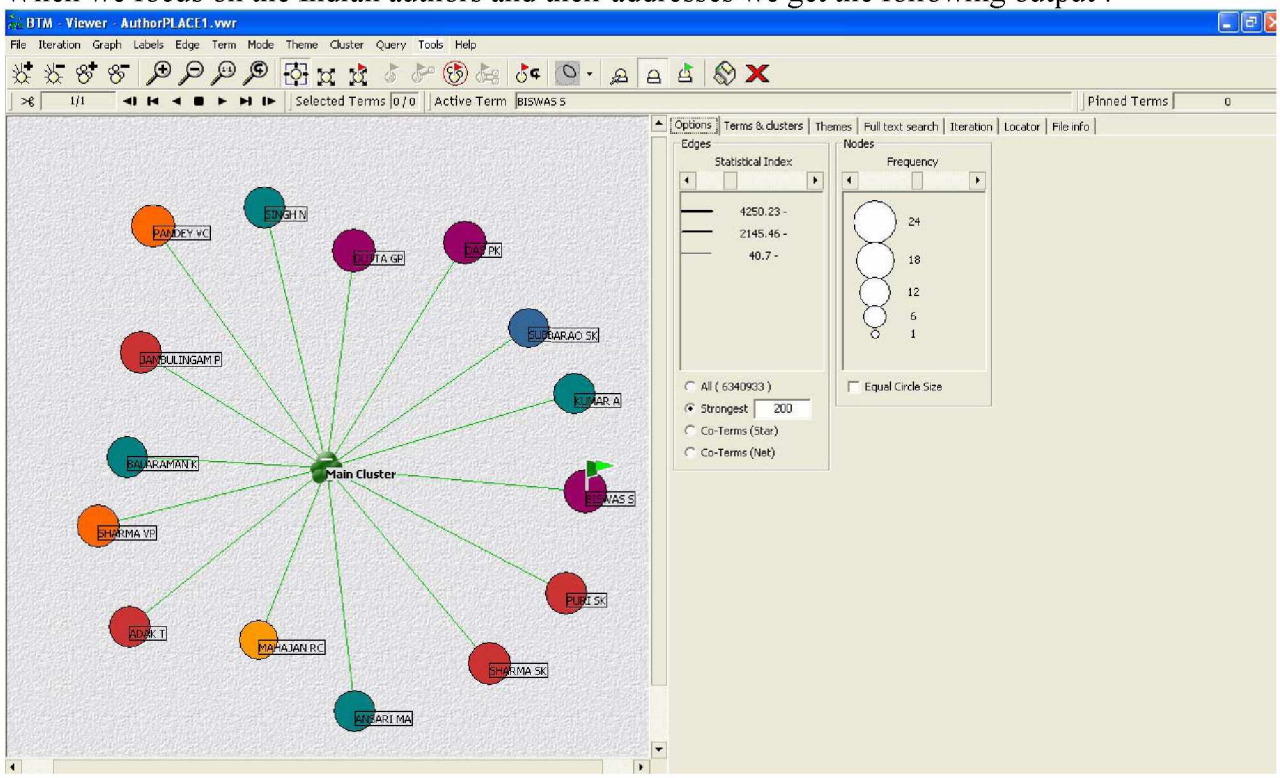
Most Frequent Countries Publishing Articles Between Year 1981 - 2005



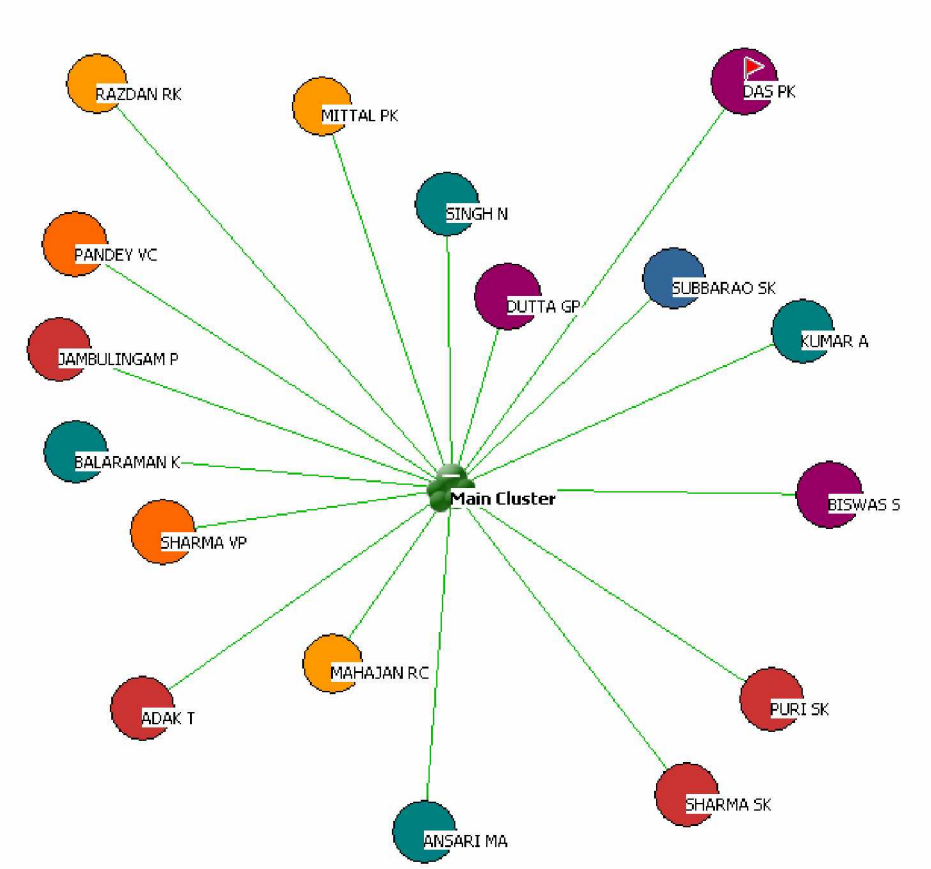
Most Prominent Authors from 1981 - 2005 (Indian Authors are in Orange Color)



When we focus on the Indian authors and their addresses we get the following output :



Some more clear view is as follows:



Top 17 Indian authors with their frequencies

When we match their addresses out of the analyzed data we get the following output.

Top 17 Indian Authors and their addresses

Authors	Address
BISWAS S	MALARIA RESEARCH CENTRE (ICMR), 22 SHAM NATH MARG, DELHI-110 054, INDIA.
DUTTA GP	CENTRAL DRUG RESEARCH INSTITUTE, LUCKNOW, INDIA.
PANDEY VC	CENT DRUG RES INST,DIV BIOCHEM,LUCKNOW 226001,UTTAR
SHARMA VP	ICMR, MALARIA RES CTR, 22 SHAM NATH MARG, DELHI 110054, INDIA
ADAK T	MALARIA RESEARCH CENTRE (ICMR), 2 NANAK ENCLAVE (RADIO COLONY), DELHI-110 009, INDIA.
JAMBULINGAM P	VECTOR CONTROL RES CTR, MED COMPLEX, ICMR, PONDICHERRY 605006, INDIA
SINGH N; PURI SK	DIVISION OF MICROBIOLOGY, CENTRAL DRUG RESEARCH INSTITUTE, LUCKNOW
SHARMA SK	MALARIA RES CTR FIELD STN, SECTOR 5, ROURKELA 769002, ORISSA, INDIA
ANSARI MA	MALARIA RES CTR, 20 MADHUBAN,VIKAS MARG, DELHI 110092, INDIA
BALARAMAN K	VECTOR CONTROL RESEARCH CENTRE. MEDICAL COMPLEX, INDIRA NAGAR, PONDICHERRY ' 605-006, INDIA.
KUMAR A	ICMR, MALARIA RES CTR, FIELD STN, DIRECTORATE HLTH SERV BLDG, PANAJI 403001, GOA, INDIA
SINGH N	ICMR. FIELD STN. MALARIA RES CTR. MED COLL BLDG, JABALPUR 482003, MP, INDIA
SUBBARAO SK	DEPTT. OF MICROBIOLOGY, ALL INDIA INSTITUTE OF MEDICAL SCIENCES, ANSARI NAGAR, NEW DELHI, INDIA.
MAHAJAN RC	POSTGRAD INST MED EDUC & RES, DEPT PARASITOL, CHANDIGARH 160012, INDIA
MITTAL PK	DEPARTMENT OF ZOOLOGY, PANJAB UNIVERSITY, CHANDIGARH - 160014, INDIA.
DAS PK	INDIAN COUNCIL MED RES, VECTOR CONTROL RES CTR, PONDICHERRY 605006, INDIA
RAZDAN RK	ICMR, MALARIA RES CTR, 20,MADHUBAN, DELHI 110092, INDIA

The case study provided a number of insights on how to use text data mining techniques on low quality data sets often found in spreadsheet applications and small databases.

• Formatting the data for text mining required appending many columns into a single text column. Semi-structured data values could be transformed by including a token (QUAN here), e.g. the column name, to identify the column. This ensured the context of the value was not lost when combined with other free text columns.
• Determining text mining stop words and common phrases replacements is an iterative process. Clusters needed to be recomputed until all of the top terms were relevant to the data mining goal and the clusters matched expectations.
• Classification models were able to learn both the cluster labels and a binary target variable using information derived from free text fields. This was achieved with moderate levels of accuracy relative to the application. To train the classification models required manual classification of a subset of the data to create the target variable. This activity would best be performed by subject matter experts.
•When trained to learn the cluster labels a decision tree using text terms as inputs failed to learn the mapping. The problem search space was too large for the decision tree to learn one term at a time.
• When learning a binary target variable the decision tree trained using text terms as inputs marginally outperformed a neural network trained components. The reduction to a single binary output variable simplified the problem search space allowing the decision tree to learn the mapping successfully. The process of dimension reduction, while simplifying the classification task, smooths detail in the inputs reducing the accuracy of the neural network. This case study demonstrates that applying text data mining techniques in low quality data situations is viable provided the value of the data justifies the effort required applying text data mining.

Salient Findings and Conclusions of the Study

1. The total numbers of papers published during 1955-2005 is 122055. During 1996-2005 the number of papers 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).
2. The distribution of the research levels of the malaria papers, with papers in three other biomedical sub-fields – AIDS, cancer and respiratory medicine indicates the malaria papers are the most basic of the four. 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
3. 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.
4. 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, with annual growth rate of (-)14.39 to (+)15.12.
5. India has nearly 442 high productive institutions in the field of Malaria Research, publishing a total of 5669 papers. The top 10 Institutes contributed approximately 55% papers with an average of 285.8 paper per Institute.
6. The apex institutions in the field of malaria research for India are; NIMR, CDRI, VCRC, ICGEB, RMRC-Bhubaneswar, AIIMS, PGIMER, IISc, and Ispat Gen. Hospital. Universities are lagging behind in the field of Malaria Research. Hence initiatives could be planned to carry out the research activities in Academic Institutions & Universities, as a large number of researchers are available there.
7. Analysis indicates, an increase in the relative effort devoted to modern research in the field of control measures and understanding of vectors, parasite & antimalarials *eg* Artemesinin (ACT), Genome or Gene Studies, Malaria Vaccine, *P. falciparum* and Mosquito or Vector Control. Vaccines research has shown an increase during 1986-95, and has remained at about 22% of the total world average
8. In the field of parasite biology most of the efforts are concentrated on *P. falciparum* whereas the papers on *P. vivax* have shown only a marginal increase.Report of *P. knowlesi*, the monkey malaria of South-east Asia made new developments. Use of Rapid diagnostic kits were adopted for research areas in later years.
9. The Indian scenario of the last three decades reveals that there has been increase in both number of papers as well as the research level with new emerging areas. With each passing decade, various research institutes came into existence and new developed techniques and tools were used. The orientation of the research, which was

more clinical in 1970, turned into basic research with emphasis on detailed studies of malaria parasites using molecular biology and immunological techniques and control measures. The cerebral malaria being the fatal one became the prime concern.

10. Results for India indicates that most effort , during earlier years was on research related to 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, Mosquito control *etc* but does very little work on Mefloquine. Among the productivity of developing countries as compared to world average India has shown its strong commitment towards Artemesinin (ACT), Drug resistance, Malaria in pregnancy and Malaria in children.

11. Both the number of journals and the number of articles grew exponentially. The most important observation is that the number of least productive journal has been 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

12. A comparison of the databases (SCI, MEDLINE,TDB) indicates, for Malaria Papers TDB is the most comprehensive source of information, particularly for developing and less developed countries. Where as MEDLINE is the world's most comprehensive source of life sciences and biomedical bibliographic information.
13. The journals covered in SCI are more from the developed countries with USA standing at the top followed by UK, Germany, Netherlands, France *etc*. While in MEDLINE, journals from the developing countries like India, China, Brazil, Thailand are having better percentage share.

Recommendation of Chairperson Project Review Committee

Malaria is a vector borne disease of prime public health importance resulting in around 1.7 million cases and about 1000 deaths annually in India. Owing to changing ecological conditions, socioeconomics, developmental activities and life style in addition to development of resistance in parasite and vectors, there are still various outstanding issues for research. Though there are lot journals reporting research activities undertaken in the field of malaria, the information is scattered and not affordable for everybody. The need for a comprehensive data base was always felt.

By documenting the published papers of last 50 years screened from global secondary services, ICMR has done a commendable job. The documentation has gone through exhaustive search, collation after removal of redundancy and making it user friendly.,This database would serve as a guiding principle for young researchers to have readily available exhaustive review of malaria research which will help in identification of thrust areas of research. Even the database indicates as to which journals are most read by the malariologists all over the world and the scientists will be able to orient their research activities accordingly. Country wise information on specific research areas vis a vis global contribution will also be helpful in emulating the countries which have elicited success stories of malaria control The database will also be very useful for academicians, public health workers and operational researchers in shaping the future course of planning in undertaking research for malaria control.

I congratulate both the authors and ICMR for their remarkable contribution for bringing out such a long awaited database in the field of malaria.

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Delhi - 110 054

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