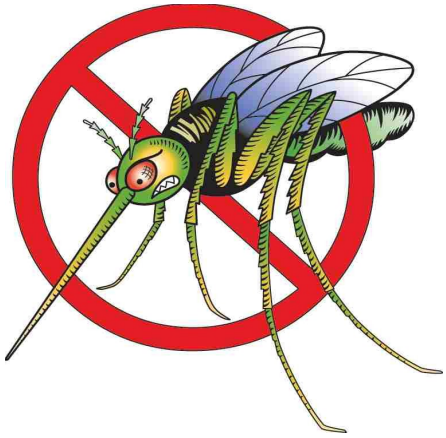
TRANSPARENCY AND ACCOUNTABILITY NETWORK



IMMC

INTEGRATED MOSQUITO AND MALARIA CONTROL

A comprehensive integrated mosquito and malaria control program to reduce the incidence of malaria, and other insect spread diseases.

BUSINESS PLAN
HISTORY OF PAST SUCCESS
CAUSE OF FAILURE IN PAST 3 DECADES

July 2006

DRAFT – FOR DISCUSSION ONLY

For more information contact:
Peter Burgess
Tr-Ac-Net Inc. in New York
212 772 6918
peterbnyc@gmail.com

INTEGRATED MOSQUITO AND MALARIA CONTROL CONTEXT

THIS DOCUMENT IS PART OF A SERIES THAT INCLUDES THE FOLLOWING:

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EXECUTIVE SUMMARY – LIBERIA
EXECUTIVE SUMMARY - REGIONAL

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IMMC – ORGANIZATION AND MANAGEMENT
(An Excel workbook/spreadsheet)
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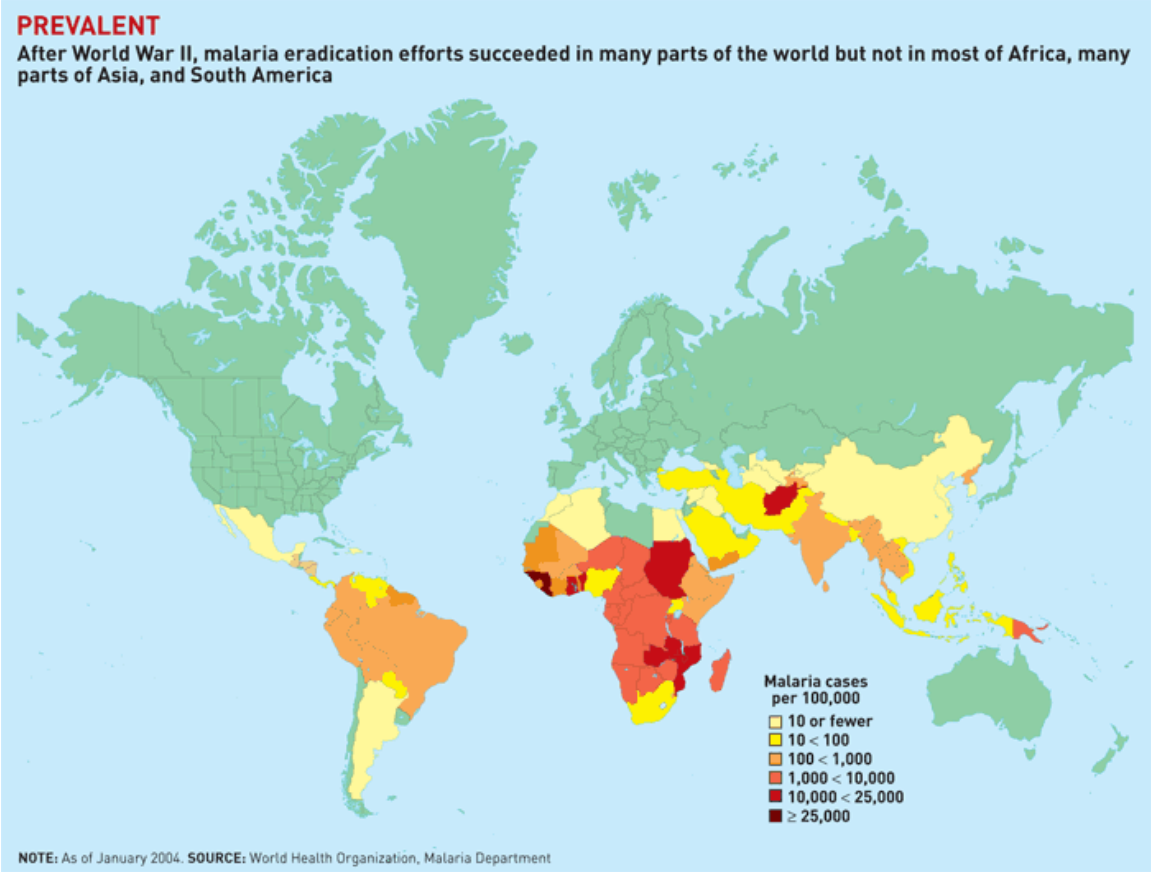
HISTORY OF SUCCESS IN REDUCING MALARIA
IT WAS POSSIBLE 50 YEARS AGO, WHY NOT NOW?

Global prevalence of malaria

The WHO map reproduced below shows the incidence of malaria around the world. This map is for 2004 ... a map for 1904 would have shown good parts of the USA, Mediteranean Europe, Japan and the north of Australia as malarial zones.



An estimated 500 million cases of acute malaria occur worldwide each year. As the map shows, most of these are in Sub-Saharan Africa (SSA) where there are around 450 million cases annually, resulting in at least 1 million deaths, primarily among infants and young children. Worldwide, up to 3,000 children die of malaria every day.

Malaria remains endemic in many tropical areas except places like the United States and Australia, where aggressive intervention has practically eliminated the mosquito vector from the environment and the malaria parasite from the human host.

 0356

Information from an Indian website: http://www.malariasite.com

History of Malaria Control

Malaria has caused unimaginable hardship to humanity as well as loss of millions of human life, from kings to commoners, from time immemorial. Many human settlements were decimated, civilizations declined, wars lost and advance of humanity halted due to malaria. Until 1897, when the mosquito vector was identified by Ronald Ross, people tried to protect themselves by various methods that they deemed fit.

The connection between malaria and swamps was known even in antiquity and the evil spirits or malaria gods were believed to live within the marshes.

The connection between malaria and mosquitoes was suspected from ancient times. One of the oldest scripts, written several thousand years ago in cuneiform script on clay tablets, attributed malaria to Nergal, the Babylonian god of destruction and pestilence, pictured as a double-winged, mosquito-like insect. A few centuries later, the natives told Philistines settling in Canaan, on the eastern shore of the Mediterranean, of the god Beelzebub, lord of the insects. The evil reputation of this deity increased through the ages until the early Jews named him "Prince of the Devils."

The ancient Hindus were also conscious of the mosquito's harmful potential. In 800 B.C. the Indian sage Dhanvantari wrote about the diseases caused by bites of the mosquitoes. *Susrutha Samhita* also mentions about a possible link between fevers and insects like mosquitoes.

Hippocrates, Greek Physician in 400 BC, attributed malaria to ingestion of stagnant water; also related the fever to the time of the year and to where the patients lived.

Use of mosquito nets has been dated to prehistroic times. It is said that Cleopatra, Queen of Egypt, also slept under a mosquito net.

So conscious were the ancient Romans of the association between mosquitoes and malaria that city officials would routinely prohibit human habitation in mosquito-infested districts. To protect themselves from the notorious Campagna mosquitoes, shepherds returning from a summer in the Apennines furnished their small cabins with a few sheep to satisfy the ravenous insects, thereby hoping to avoid malaria. The association with stagnant waters (breeding grounds for *Anopheles*) led the Romans to begin drainage programs, the first intervention against malaria. It is said that Emperor Nero drained the swamps near ancient Rome, in order to rid the city of malaria. By the Middle Ages, Kings and feudal lords feared marshes as breeding grounds of plagues and incurable fevers and a royal decree was passed in 11th century Valencia, sentencing any farmer to death who planted rice too close to villages and towns. In Britain, the 'Roman technology' of draining swamps protected some areas from malaria during this time. Italian physician Lancisi in 1717 had suggested a possible role for

mosquitoes in transmission of malaria and proposed the draining of marshes to eradicate malaria.

Malaria's decline in the United States and Europe in the late 1800s was due mainly to draining swamps and removing mill ponds. Draining swamps also exposed good agricultural land, enabling people to afford better houses and thus isolate the sick. Increasing livestock densities may have diverted biting from humans toward cattle, pigs, or horses. Improved housing, isolation of sick people in mosquito-proof areas, better access to health care and medication, and improved nutrition, sanitation, and hygiene all may have reduced transmission and/or mortality rates.

In 1882, Albert Freeman Africanus King (1841-1915), a US Physician, proposed a method to eradicate malaria from Washington, DC. He suggested to encircle the city with a wire screen as high as the Washington Monument. Although many people took this as a jest, his hypothesis to link mosquitoes with malaria transmission was proved five years later.

Ronald Ross's discovery of *Anopheles* mosquito as the vector for malaria in 1897 opened a new chapter in malaria control. With his brilliant research, he not only identified the habits and habitats of these mosquitoes but also proposed detailed plan of action to contain their breeding. Ronald Ross did not stop at writing about malaria control either. He stood at the vanguard of implementing his ideas till his end. Ross attempted to eradicate malaria from England by forming ‘mosquito brigades’ to eliminate mosquito larvae from stagnant pools and marshes. In 1899, he was sent to Freetown, the capital of Sierra Leone where he organised a sanitation drive, clearing the streets of tyres, bottles and empty cans and levelling roads so that rain water would not gather into puddles. But the Freetown malaria control programme did not yield desired results, probably because Ross had underestimated the number of breeding pools and the sheer number of vectors that he was trying to control. Ross had very limited funding and the best available technology was to pour oil on the numerous breeding sites around Freetown. As soon as the oil treatments stopped, breeding would begin again. Ross redoubled his efforts with increased funding from private sources and ensured the removal of all potential breeding sites, including rubbish, broken bottles and other potential water containers. Despite these concerted efforts, the programme was remembered more for its impact on the Freetown’s rubbish than with malaria control. J.W.W. Stephens and S.R. Christophers, who had worked with Ronald Ross in Freetown, organised a similar drive in Mian Mir in Lahore, India in 1901, without much success.

Italian physician Giovanni Battista Grassi, who demonstrated transmission of malaria from mosquitoes in man, did his own bit in controlling malaria. He warned against taking walks in the twilight, the prime mosquito feeding time. "Don't go out in the warm evenings," he announced, "unless you wear heavy cotton gloves and veils." Naturally he was laughed at. To prove his point, Grassi set up an experiment to prevent malaria in the most heavily diseased region in Italy, the railroad line that ran through the plain of Capaccio. With funds from the queen of Italy and authority from the railroad, Grassi installed fine mesh screens on the doors and windows of ten stationmasters' houses. One hundred twelve employees were paid to stay inside during the twilight. Another four hundred fifteen workers went out as usual. At the end of the summer, almost all the

unprotected developed malaria. But of the hundred and twelve protected individuals, only five got sick. "In the so much feared station of Albanella," wrote Grassi triumphantly, "from which for years so many coffins had been carried, one could live as healthily as in the healthiest spot in Italy!"

During the same period, Watson organised draining the salt marshes on the parts of the west coast of Malaya so as to make it habitable.

The sanitation drive suggested by Ronald Ross was successfully tried elsewhere. During the U.S. military occupation of Cuba, a campaign against yellow fever and malaria was commenced at Havana early in 1901. Under the leadership of the Assistant Surgeon General William Gorgas of the United States Army the anti mosquito measures produced very marked results. Pyrethrum, a natural insecticide derived from the chrysanthemum flower, was first used by William Gorgas in Cuba where it was burned inside sealed dwellings. Mosquitoes entirely disappeared from many parts of the city, and were decreased everywhere.

At the end of 1902, Prince Auguste d'Arenberg, President of the Suez Canal Company asked Ross to save Ismailia, the city that was built as a base for construction of the canal. It was gravely threatened by malaria for a long time. Ross led a sanitation drive so successful that by the following year, the city officials announced that they no longer needed mosquito nets and by 1904, a whole year had passed without a single reported case of malaria in Ismailia. Ross's drastic sanitary measures were even dubbed as "sanitary Bolshevism". Ross conducted similar campaigns in Greece, Mauritius, Spain and during World War I at various places on the battle front.

The experience of the US Army in Cuba was replicated during the construction of the Panama Canal between 1905-1910. The construction was made possible only after yellow fever and malaria, major causes of death and disease among workers in the area, were controlled. During the French reign between 1882 and 1888, an estimated 10000-20000 workers had died at the canal zone owing to these diseases. Therefore, before the construction could begin, Gorgas surveyed the area. Ronald Ross and William Crawford Gorgas worked together to eradicate malaria from Panama. In 1906, there were over 26,000 employees working on the Canal. Of these, over 21,000 were hospitalized for malaria at some time during their work. By 1912, there were over 50,000 employees, and the number of hospitalized workers had decreased to approximately 5,600. Through the leadership and efforts of William Crawford Gorgas, Joseph Augustin LePrince, and Samuel Taylor Darling, yellow fever was eliminated and malaria incidence markedly reduced through an integrated program of insect and malaria control. Drainage, brush and grass cutting, oiling and larviciding (when oiling was not sufficient) were all done. At the time, there were no commercial insecticides. Joseph Augustin LePrince, Chief Sanitary Inspector for the Canal Zone developed a larvacide mixture of carbolic acid, resin and caustic soda that was spread in great quantity. In addition, quinine was provided freely to all workers. Screening was provided to dwellings and attempts were made to kill the adult mosquitoes. Because the mosquitoes usually stayed in the tent or the house after feeding, collectors were hired to gather the adult mosquitoes that remained in the houses during the daytime.

In 1916, Dr. A.R. Campbell, a Bacteriologist at San Antonio, Texas constructed a bat house to colonize bats in order to destroy the malaria carrying mosquitoes.

The best method of malaria control was a topic of hot debate during this period. Battista Grassi, Italian parasitologist, suggested tighter netting. The renowned German microbiologist Robert Koch thought is possible to eradicate malaria by giving quinine as a prophylactic ("cinchonisation"). Ross did not agree with these views. SP James suggested that malaria will only disappear with improvements in housing and the separation of mosquitoes from humans. Thus malaria was considered to be a social disease and the remedy was to improve the economic life of the subjugated populations by good housing, good nutrition, good health and education services coupled with modern agricultural practices.

Economic betterment was advanced as the cause of the disappearance of malaria from northern Europe and England - where more than 10,000 cases had been admitted to London's St. Thomas's Hospital alone between 1860 and 1870, followed by a rapid decline to four or five cases each year by 1925. Malcolm Watson and LW Hackett of England and the Americans Fred Soper (See below) and Paul Russell supported Ronald Ross's emphasis on vector control. There was also another view that nothing should be done so as to allow immunity to develop, even at the cost of a few young lives.

Until 1944, when pesticide DDT was rediscovered as a new weapon against mosquito control, only quinine and insecticides pyrethrum and Paris green were available to help in malaria control efforts.

Paris Green (a mixture of diesel oil and copper acetoarsenite) was first used in malaria control in the 1920s in many countries like India, South Africa and Brazil.

In 1921-22, a fish called *Gambusia affinis* or mosquitofish was the released into water collections for its larvivorous habits and was found useful in the control of mosquitoes in California.

In 1933 Tennessee River valley authority and the Public Health Service played a vital role in the control operations of malaria in the area and by 1947, the disease was essentially eliminated. Mosquito breeding sites were reduced by controlling water levels and insecticide applications.

Another great success story in malaria control during this period was in Brazil. And the man who campaigned vigorously for the eradication of the mosquito from this part of the world was an unusual American named **Fred Soper**, who was born in Kansas in 1893 and was educated at Johns Hopkins School of Public Health. He was a man of legendary energy endowed with great common sense. When thousands of larvae of the malarial mosquito *A. gambiae* were discovered in 1930 along a river in Brazil, thousands of miles from their homeland in Africa, Soper recommended opening the dykes damming the tidal flats, given that salt water destroys the breeding areas. But the Government refused, and malaria began to spread infecting 100,000 people, and killing 20,000 in 1938. The Brazilian President, Getulio Vargas enlisted the services of Soper to eradicate the mosquito – a kind of ‘mission impossible’ and in 1939, the Malaria Service of Northeast Brazil was organized to combat the populations of *Anopheles gambiae*. Soper and his team of 40,000 workers fumigated houses and buildings with Pyrethrum and sprayed Paris Green on pools of water. In just 22 months, he

was able to eradicate the mosquito from an area of about 18,000 square miles in Brazil. Fred Soper's success was considered a great public health achievement in Brazil, and he was rewarded with medals and citations. This effort at species eradication was so successful that the mosquito is still absent from the area. This was before DDT was used in anti-malaria programmes.

The Centers for Disease Control (CDC) was organized in Atlanta, Georgia, on July 1, 1946. Office of Malaria Control in War Areas, an agency established in 1942 to limit the impact of malaria and other vector borne diseases (such as murine typhus) in the southeastern US during World War II was the predecessor of CDC. Dr. Justin M. Andrews, director of CDC from 1947 to 1951, was also the state malariologist for the state of Georgia. In the ensuing years, CDC oversaw the US national malaria eradication program and provided technical support to activities in the 13 states where malaria was still endemic. By 1951, malaria was considered eradicated from the United States. However, to the present day, malaria remains a major field of activities at CDC.

Up to 1950s, malaria control programmes in many countries involved treatment with quinine, personal protection with bednets and anti larval measures that included drainage, soil modification, proscription of urban agriculture (potatoes and other ridge-and-furrow type cultivation). The efforts were most often concentrated in urban areas. Some countries passed very strict, even draconian, legislations like the Mosquito Extermination Act for ensuring source reduction. These required all householders to prevent mosquito breeding sites by clearing all vegetation surrounding the house to a distance of ten metres in all directions. Any container that could possibly hold water and therefore provide a breeding site was to be removed from the household area. Regular inspections were made by the government health department in order to ensure that all households were complying with the legislation. Those households that did not comply were either subjected to a fine or the head of the household could be imprisoned. Such acts also required all mines, quarries, irrigation, water supply and other works to take specific measures to ensure that mosquito breeding sites were destroyed. With the availability of DDT in 1943, adult insecticidal operations were initiated by spraying and misting with adulticidal devices in tents and buildings, and by release from aircraft. By 1934-49, malaria was eradicated from Brazil and Egypt, largely due to extensive DDT spraying.

The WHO took up malaria eradication programme in 1955. In 1953, Brazilian malariologist Marcolino Candau, who campaigned on the promise of malaria eradication won the elections to the post of the director general of WHO defeating the psychiatrist Brock Chisholm. The Global Malaria Eradication Programme was launched in 1955 emphasising on vector control with DDT residual spraying and surveillance in all national programmes. The goal was to reduce infected vector populations feeding on humans sufficiently to interrupt parasite transmission. The programme imposed an uniform strategy for all countries and areas, ignoring the diversity of malaria and economy of nations, particularly the new governments then emerging from colonial rule. Sub-Saharan Africa was not included (or even ignored) due to its massive reservoir of malaria and insufficient infrastructure to support the programme. However, malaria was eradicated in nations with temperate climates and seasonal malaria transmission. The last indigenous case in England had been in the 1950s and in Holland in

1961. By 1969, many European countries namely Hungary, Bulgaria, Romania, Yugoslavia, Spain, Poland, Italy, Netherlands and Portugal managed to completely eradicate their endemic malaria. (In 1975, the World Health Organization declared that Europe was free of malaria). Some countries such as India and Sri Lanka had sharp reductions in the number of cases, followed by increases to substantial levels after efforts ceased. Other nations had negligible progress (such as Indonesia, Afghanistan, Haiti, and Nicaragua). Despite initial success in countries like India, by 1965, it started falling apart due to a number of factors: technical difficulties such as vector and parasite drug resistance, social and political factors preventing efficient application of control measures, wars and massive population movements, difficulties in obtaining sustained funding from donor countries, and lack of community participation that made the long-term maintenance of the effort untenable. The programme was criticized for being too inflexible like a military operation and received little support or even opposition from the local populations. By 1969 WHO admitted the failure of this campaign and the global eradication policy was abandoned. Several years later, the WHO's Malaria Eradication Division changed its name to the Division of Malaria and Other Parasitic Diseases.

Between 1969-1976, the World Health Organisation co-ordinated an intensive study of malaria in the Garki district of Northern Nigeria. Many problems that could have a bearing on malaria control, like high bite intensity, high proportion of vectors carrying the parasite, mosquitoes resting outdoors after blood meals instead of indoors on insecticide treated walls, were revealed by this study. It was concluded that the use of drugs and insecticides could markedly reduce the incidence of malaria in the short term but was not enough to break transmission and achieve long-term success.

From the early 1970's the malaria situation has slowly and progressively deteriorated. The concept of eradication was replaced with that of control as a part of primary health care. Reduced control measures between 1972 and 1976 due to financial constraints lead to a massive 2-3 fold increase in cases globally. Spraying never truly eradicated the mosquitoes anywhere, and the reduction in the more persistent *P.vivax* infections were much less than for *P.falciparum* - though the latter returned in much greater strength as control measures waned. The growing interchange of populations between malarious countries and malaria free countries is responsible for the continuous increase in the number of imported malaria cases in developed countries. Since 1976, several new pockets of malaria transmission have evolved.

Malaria control in the 1980s was neglected in many areas. The optimism of the eradication campaign was replaced by a belief that malaria could not be controlled. The systems set up for eradication, which were very centrally organised and directed were discredited, and support was withheld without offering alternative systems and strategies. Whilst it was said that malaria control should be integrated into the general health systems, instead of being a vertical programme, the means to do this were neglected. At the end of the 1980s and in the early 1990s the World Health Organisation (WHO) worked with all malarious countries to develop a global strategy for malaria control. This strategy was adopted by a Global Ministerial Conference on Malaria in Amsterdam in 1992. The strategy has four elements:

- To provide early diagnosis and prompt treatment
- To plan and implement selective and sustainable preventive measures, including vector control
- To detect early, contain or prevent epidemics
- To strengthen local capacities in basic and applied research.

The strategy was widely endorsed, and efforts to implement it have shaped the development of malaria control in most malarious countries. It has been adapted to the needs of different regions; in Africa, for instance, a Regional Malaria Control Strategy for 1996 to 2001 was developed by a Task Force for Malaria Control convened by the WHO African Regional Office (AFRO).

In 1998 Dr. Gro Harlem Brundtland, Director General, World Health Organization launched a Global Roll Back Malaria Initiative against malaria. The RBM Strategy included Early case detection and prompt treatment, Integrated vector management and Containment of focal epidemics. However, the programme is far from being successful.

Today, it's a much worse scenario. Thoughtless man-made irrigation schemes and dams provided new habitats for Anopheles, and resulted in 'man-made' malaria. The extension of urban areas lead to epidemics in the peripheries of the growing cities. Mass migrations of non-immune populations into endemic areas for political reasons has further complicated matters. More than 300 million cases with 2 million deaths, multi-insecticide and multi-drug resistance, non-use of DDT, non-availability of cheap and effective chemo-therapeutics and prophylactics, steady-state, benign holoendemic malaria replaced by unstable hyperendemicity, functional immunity impaired by the ad hoc chemotherapy distributed from the primary health centres - It is déjà vu all over again. New technology promises to bring the always-in-the-pipeline vaccine and the more flashy bed nets dipped in permethrin. The super-sensitive, single-minded Ross went to his grave still holding the firm conviction that malaria could be eradicated if only weak-willed governments would commit themselves to exploit his discovery and attack the anopheline in their watery lairs.

Use of Insecticides: As early as 1825 Michael Faraday reported to the Royal Society of London the formation of benzene hexachloride. However, it had to wait for more than 115 years to become useful as a pesticide. Similarly, Dichlorodiphenyltrichloroethane (DDT) was first synthesized in 1874 by a Viennese pharmacist, Othmar Zeidler, but he did not investigate the properties of the new substance. The use of chemicals to control troublesome insects so as to save food crops started by mid 19th century. Paris green was used as an insecticide in 1867. Production of pyrethrum, which is a natural insecticide derived from the chrysanthemum flower, started in the US by 1870. In 1882, Petroleum was first recommended in the US for insect bites and stings. By 1897 oil of citronella was used as insect repellent. Pyrethrum was first used by William Gorgas in Cuba where it was burned inside sealed dwellings. In around 1910, the German scientist G. Giemsa was experimenting with different ways of using pyrethrum and developed a way of spraying pyrethrum on walls with a spray pump. This method took over two decades to catch on, and it was used with great success in South Africa for the control of malaria on sugar estates. In 1920 Oil-soaked sawdust was first recommended for mosquito control and Paris green was considered as the a mosquito larvicide. Paris Green was first used in malaria

control in the 1920s. It was used in countries like India, South Africa and Brazil.

In 1924, Paris green dust was applied to swamps in Louisiana for control of Anopheles mosquitoes. In 1942, many chemicals were tested for control of insect-borne disease among Armed Forces. By 1947, more than 13,000 such chemicals had been tested and classified, but the glory went to DDT, resynthesised by Paul Muller in 1939 [See below] In 1943, Van Linden gave the name lindane to the pesticide made with the active isomers of the benzene hexachloride mixture.

Although DDT was first synthesized in 1874 by a Viennese pharmacist, Othmar Zeidler, he did not investigate the properties of the new substance but simply published his synthesis. Then in 1939 in Switzerland, Paul Müller of the Geigy Company, resynthesized this compound and discovered its insecticidal properties. The Geigy Company began to market the substance in 1940-41 as a 5% dust called Gesarol spray insecticide and a 3% dust called Neocid dust insecticide. The now universally used name, DDT, was first applied by the British Ministry of Supply in 1943. DDT was first added to U.S. Army supply lists in May 1943. Gahan and colleagues, in August 1943, made the first practical tests of DDT as a residual insecticide against adult vector mosquitoes.The first field test in which residual DDT was applied to the interior surfaces of all habitations and outbuildings of a community to test its effect on *Anopheles* vectors and malaria incidence was begun in Italy in the spring of 1944. This experiment was carried out in the town of Castel Volturno at the mouth of the Volturno River, north of Naples, by the Malaria Control Demonstration Unit of the Malaria Control Branch of the Public Health Sub-Commission, Allied Control Commission, Italy. Spraying began on 17 May 1944, and this experiment, together with a second one started later in the Tiber Delta area, lasted 2 years. The war needs and experiments greatly accelerated its acceptance and use and led to the discovery and application of similar insecticides such as benzene hexachloride and dieldrin. However, by 1949 mosquitoes resistant to DDT and other new insecticides were found. In 1962, Rachel Carson published *Silent Spring.* In it, she discussed the decline in certain regions of the United States of the America robin, due to its consumption of earthworms that were laden with the DDT used in massive amounts to combat Dutch elm disease. Carson's book stimulated widespread public concern about DDT and other pesticides. Through a series of legal hearings in the United States instigated by lawyers and scientists working with the Environmental Defense Fund, DDT was eventually banned or severely restricted in most states. In 1972, the U.S. Environmental Protection Agency banned all DDT uses except those essential to public health. Similar bans were instituted by Sweden in 1969 and later in most of the developed countries. But DDT is still being used in some developing countries to control malaria, but the debate is continuing.

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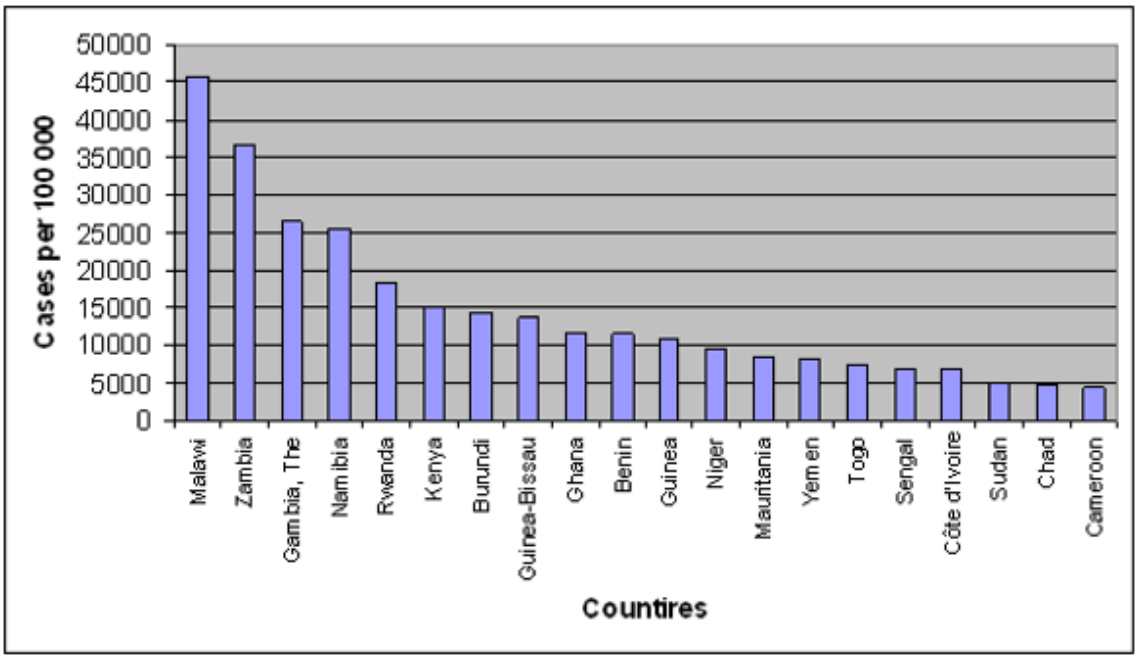
HISTORY OF SUCCESS IN REDUCING MALARIA
PROGRESS – BY REGION AND COUNTRY BY COUNTRY

Africa and Middle East

The following table was prepared by the Africa Fighting Malaria group based on 1997 data. A report prepared in 2006 by the World Economic Forum and Harvard University added in Botswana at 25,000 cases per 100,000, and information from MARA shows Liberia at more than 25,000 cases per 100,000.



Africa – some success

The mosquito and malaria prevalence was reduced in many corporate locations in Africa, but because the interventions were not extended widely into the surrounding communities, the total impact on the local population was small. Substantial reduction in the malaria case load can be achieved in Africa when there are appropriate IMMC interventions, as for example in Liberia, Zambia, Equatorial Guinea, Mozambique, etc.

Egypt

As far back as 1902, Egypt's eradication program resulted in an 89% decrease in hospital cases.

At the end of 1902, Prince Auguste d'Arenberg, President of the Suez Canal Company asked Ross to save Ismailia, the city that was built as a base for construction of the canal. It was gravely threatened by malaria for a long time. Ross led a sanitation drive so successful that by the following year, the city officials announced that they no longer needed mosquito nets and by 1904, a whole year had passed without a single reported case of malaria in Ismailia. Ross's drastic sanitary measures were even dubbed as "sanitary Bolshevism".

Ross conducted similar campaigns in Greece, Mauritius, Spain and during World War I at various places on the battle front.

Nigeria

Between 1969-1976, the World Health Organisation co-ordinated an intensive study of malaria in the Garki district of Northern Nigeria. Many problems that could have a bearing on malaria control, like high bite intensity, high proportion of vectors carrying the parasite, mosquitoes resting outdoors after blood meals instead of indoors on insecticide treated walls, were revealed by this study. It was concluded that the use of drugs and insecticides could markedly reduce the incidence of malaria in the short term but was not enough to break transmission and achieve long-term success.

Sierra Leone

The following about Ross in 1899

Ronald Ross's discovery of *Anopheles* mosquito as the vector for malaria in 1897 opened a new chapter in malaria control. With his brilliant research, he not only identified the habits and habitats of these mosquitoes but also proposed detailed plan of action to contain their breeding. Ronald Ross did not stop at writing about malaria control either. He stood at the vanguard of implementing his ideas till his end. Ross attempted to eradicate malaria from England by forming 'mosquito brigades' to eliminate mosquito larvae from stagnant pools and marshes. In 1899, he was sent to Freetown, the capital of Sierra Leone where he organised a sanitation drive, clearing the streets of tyres, bottles and empty cans and levelling roads so that rain water would not gather into puddles. But the Freetown malaria control programme did not yield desired results, probably because Ross had underestimated the number of breeding pools and the sheer number of vectors that he was trying to control. Ross had very limited funding and the best available technology was to pour oil on the numerous breeding sites around Freetown. As soon as the oil treatments stopped, breeding would begin again. Ross redoubled his efforts with increased funding from private sources and ensured the removal of all potential breeding sites, including rubbish, broken bottles and other potential water containers. Despite these concerted efforts, the programme was remembered more for its impact on the Freetown's rubbish than with malaria control. J.W.W. Stephens and S.R. Christophers, who had worked with Ronald Ross in Freetown, organised a similar drive in Mian Mir in Lahore, India in 1901, without much success.

South Africa

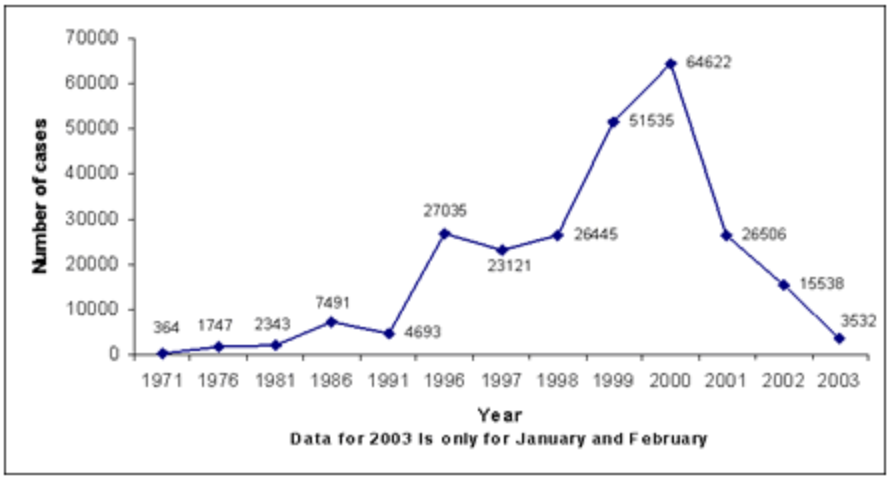
Paris Green (a mixture of diesel oil and copper acetoarsenite) was first used in malaria control in the 1920s in many countries like India, South Africa and Brazil.

Parts of South Africa have endemic malaria. This was brought under control using IRS and DDT, but when DDT uses was terminated malaria cases increased dramatically. They have been brought under control again by using IRS and DDT again.

South Africa – KwaZulu-Natal

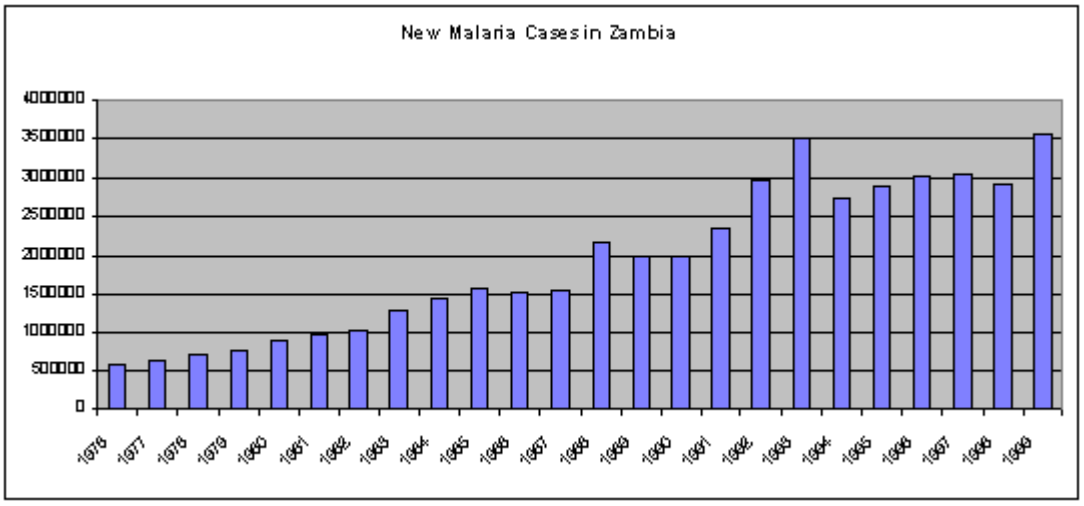
Recent progress in Southern Africa in mosquito / malaria control using a comprehensive approach is encouraging. In KwaZulu-Natal, insecticide use to kill

mosquitoes and treatment of the infection taken together gave favorable results and the experience has been expanded in the region successfully. It is recognised that long term results are going to be achieved by regional programs that go beyond small area interventions. The following graph shows the increase and subsequent decline. (Please note the data for 2003 is not consistent with the rest of the data points)

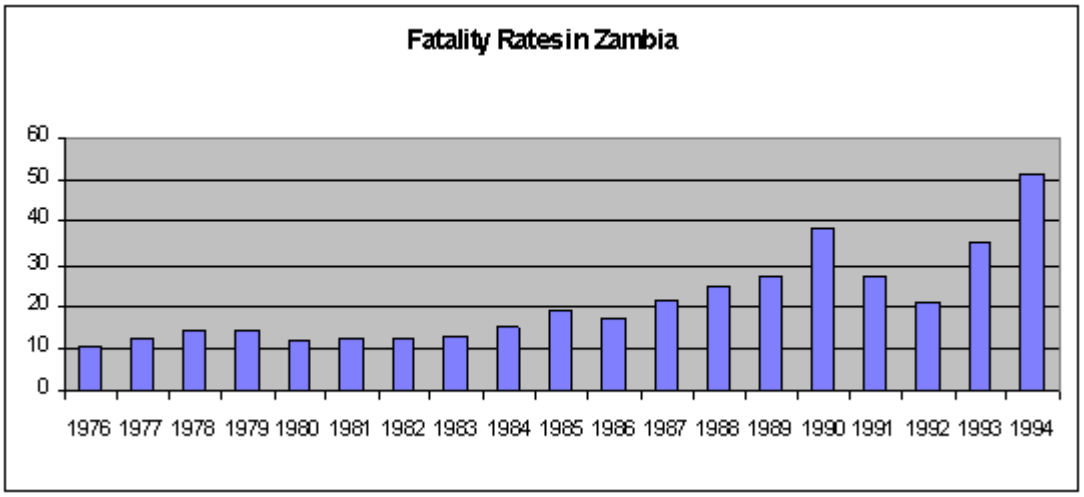


Zambia

In the rich "north" malaria has a negligible case load, but in Zambia the new reported cases increased from just over 500,000 in 1976 to more than 3.5 million in 1999. With a population of 10 million, this is equivalent to about 35,000 cases per 100,000 (CHECK)



The number of deaths has also increased from 1976 to recent times. The rate in 1994 was more than 50 deaths per 100,000 people, about 50,000 in a population of around 10 million.



Since around 2,000 the Zambian leadership has taken malaria seriously and various public health initiatives have reduced the deaths from around 50,000 to around 30,000 a year. An international assistance initiative called the Malaria Control and Evaluation Partnership in Africa (MACEPA) has been assisting Zambia since 2005 and there is continuing success.

Why was Africa not a success?

The quick answer is because no resources were ever allocated to IMMC interventions in Africa. All rich countries became malaria free more than 50 years ago. Both Europe and North America had malaria up until the immediate post-WWII years. The major campaigns organized by UNICEF and WHO reached most parts of the world, but NOT Africa.

Recent interventions for Africa related to malaria have been single component strategies and usually not at a scale that can have a significant impact. Use of best practice for IRS using DDT has been constrained by donor countries citing environmental concerns that are essentially baseless. Distriubution of bednets has been a preferred intervention, though it seems that this cannot have much community wide impact.

Europe

For centuries, much of Europe suffered from malaria, but malaria receded as the habitat for mosquito breeding became constrained with the spread of modern agriculture and better drainage. Malaria was eventually eradicated in Europe.

Malaria's decline in the United States and Europe in the late 1800s was due mainly to draining swamps and removing mill ponds. Draining swamps also exposed good agricultural land, enabling people to afford better houses and thus isolate the sick. Increasing livestock densities may have diverted biting from humans toward cattle, pigs, or horses. Improved housing, isolation of sick people in mosquito-proof areas, better access to health care and medication, and improved nutrition, sanitation, and hygiene all may have reduced transmission and/or mortality rates.

However, malaria was eradicated in nations with temperate climates and seasonal malaria transmission. The last indigenous case in England had been in

the 1950s and in Holland in 1961. By 1969, many European countries namely Hungary, Bulgaria, Romania, Yugoslavia, Spain, Poland, Italy, Netherlands and Portugal managed to completely eradicate their endemic malaria. (In 1975, the World Health Organization declared that Europe was free of malaria).

Mediteranean Europe

But it remained a problem in the Mediteranean countries until after WWII. Greece and Italy, including famously, Sardinia, reduced malaria almost completely in the post war years.

Italy

The now universally used name, DDT, was first applied by the British Ministry of Supply in 1943. DDT was first added to U.S. Army supply lists in May 1943. Gahan and colleagues, in August 1943, made the first practical tests of DDT as a residual insecticide against adult vector mosquitoes.The first field test in which residual DDT was applied to the interior surfaces of all habitations and outbuildings of a community to test its effect on *Anopheles* vectors and malaria incidence was begun in Italy in the spring of 1944. This experiment was carried out in the town of Castel Volturno at the mouth of the Volturno River, north of Naples, by the Malaria Control Demonstration Unit of the Malaria Control Branch of the Public Health Sub-Commission, Allied Control Commission, Italy. Spraying began on 17 May 1944, and this experiment, together with a second one started later in the Tiber Delta area, lasted 2 years. The war needs and experiments greatly accelerated its acceptance and use and led to the discovery and application of similar insecticides such as benzene hexachloride and dieldrin. However, by 1949 mosquitoes resistant to DDT and other new insecticides were found.

Sardinia

In Sardinia, very heavy use of DDT was effective in eliminating mosquitoes and malaria, but there was a concern that heavy DDT use would have lasting health consequences for the human population. Surprisingly, 50 years later, this has not materialized as expected.

Central and South America

In the past, control of malaria was achieved in parts of South and Central America, as well as in parts of Africa and Asia.

Brazil

Paris Green (a mixture of diesel oil and copper acetoarsenite) was first used in malaria control in the 1920s in many countries like India, South Africa and Brazil.

Another great success story in malaria control during this period (1930s) was in Brazil. And the man who campaigned vigorously for the eradication of the mosquito from this part of the world was an unusual American named **Fred Soper**, who was born in Kansas in 1893 and was educated at Johns Hopkins School of Public Health. He was a man of legendary energy endowed with great common sense. When thousands of larvae of the malarial mosquito *A. gambiae* were discovered in 1930 along a river in Brazil, thousands of miles from their

homeland in Africa, Soper recommended opening the dykes damming the tidal flats, given that salt water destroys the breeding areas. But the Government refused, and malaria began to spread infecting 100,000 people, and killing 20,000 in 1938. The Brazilian President, Getulio Vargas enlisted the services of Soper to eradicate the mosquito – a kind of 'mission impossible' and in 1939, the Malaria Service of Northeast Brazil was organized to combat the populations of *Anopheles gambiae*. Soper and his team of 40,000 workers fumigated houses and buildings with Pyrethrum and sprayed Paris Green on pools of water. In just 22 months, he was able to eradicate the mosquito from an area of about 18,000 square miles in Brazil. Fred Soper's success was considered a great public health achievement in Brazil, and he was rewarded with medals and citations. This effort at species eradication was so successful that the mosquito is still absent from the area. This was before DDT was used in anti-malaria programmes.

Panama Canal

For many years, efforts to build the Panama Canal failed because workers succumbed to malaria. But in the early 1900s the Panama Canal was constructed and the impact of malaria on workers was controlled. Quinine was used as a medicine, and major efforts were made to reduce the mosquito population and its proximity to people.

The experience of the US Army in Cuba was replicated during the construction of the Panama Canal between 1905-1910. The construction was made possible only after yellow fever and malaria, major causes of death and disease among workers in the area, were controlled. During the French reign between 1882 and 1888, an estimated 10000-20000 workers had died at the canal zone owing to these diseases. Therefore, before the construction could begin, Gorgas surveyed the area. Ronald Ross and William Crawford Gorgas worked together to eradicate malaria from Panama. In 1906, there were over 26,000 employees working on the Canal. Of these, over 21,000 were hospitalized for malaria at some time during their work. By 1912, there were over 50,000 employees, and the number of hospitalized workers had decreased to approximately 5,600. Through the leadership and efforts of William Crawford Gorgas, Joseph Augustin LePrince, and Samuel Taylor Darling, yellow fever was eliminated and malaria incidence markedly reduced through an integrated program of insect and malaria control. Drainage, brush and grass cutting, oiling and larviciding (when oiling was not sufficient) were all done. At the time, there were no commercial insecticides. Joseph Augustin LePrince, Chief Sanitary Inspector for the Canal Zone developed a larvacide mixture of carbolic acid, resin and caustic soda that was spread in great quantity. In addition, quinine was provided freely to all workers. Screening was provided to dwellings and attempts were made to kill the adult mosquitoes. Because the mosquitoes usually stayed in the tent or the house after feeding, collectors were hired to gather the adult mosquitoes that remained in the houses during the daytime.

Caribbean

In the Caribbean, for centuries malaria killed more people, especially Europeans, than were killed in military conflict. During the 1940s and 1950s malaria was effectively eradicated in the Caribbean, except in Haiti. This is a difference in governance capability rather than a difference in science.

Cuba

Around 1900.

The sanitation drive suggested by Ronald Ross was successfully tried elsewhere. During the U.S. military occupation of Cuba, a campaign against yellow fever and malaria was commenced at Havana early in 1901. Under the leadership of the Assistant Surgeon General William Gorgas of the United States Army the anti mosquito measures produced very marked results. Pyrethrum, a natural insecticide derived from the chrysanthemum flower, was first used by William Gorgas in Cuba where it was burned inside sealed dwellings. Mosquitoes entirely disappeared from many parts of the city, and were decreased everywhere.

South Asia, South-East Asia and Oceana

India

Paris Green (a mixture of diesel oil and copper acetoarsenite) was first used in malaria control in the 1920s in many countries like India, South Africa and Brazil.

Programs to reduce the prevalence of malaria in India were largely successful in the 1950s and 1960s. Millions of cases a year were reduced to tens of thousands. The programs appear to be less successful now, in part because of reduced interventions, partly increased resistance and probably greater travel between areas, especially into neighboring countries such as Bangladesh.

Some countries such as India and Sri Lanka had sharp reductions in the number of cases, followed by increases to substantial levels after efforts ceased. Other nations had negligible progress (such as Indonesia, Afghanistan, Haiti, and Nicaragua). Despite initial success in countries like India, by 1965, it started falling apart due to a number of factors: technical difficulties such as vector and parasite drug resistance, social and political factors preventing efficient application of control measures, wars and massive population movements, difficulties in obtaining sustained funding from donor countries, and lack of community participation that made the long-term maintenance of the effort untenable. The (WHO) programme was criticized for being too inflexible like a military operation and received little support or even opposition from the local populations.

Sri Lanka

The malaria prevalence reduction programs in Sri Lanka were very successful in the 1950s and 1960s, but malaria has come back as continuing intervention was eliminated, and little attention was paid to the continuing science. It is now apparent that resistance is an important factor in Sri Lanka, both for the mosquito against pesticides and the malaria parasite against low cost drug therapy.

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Malaya

Around 1900

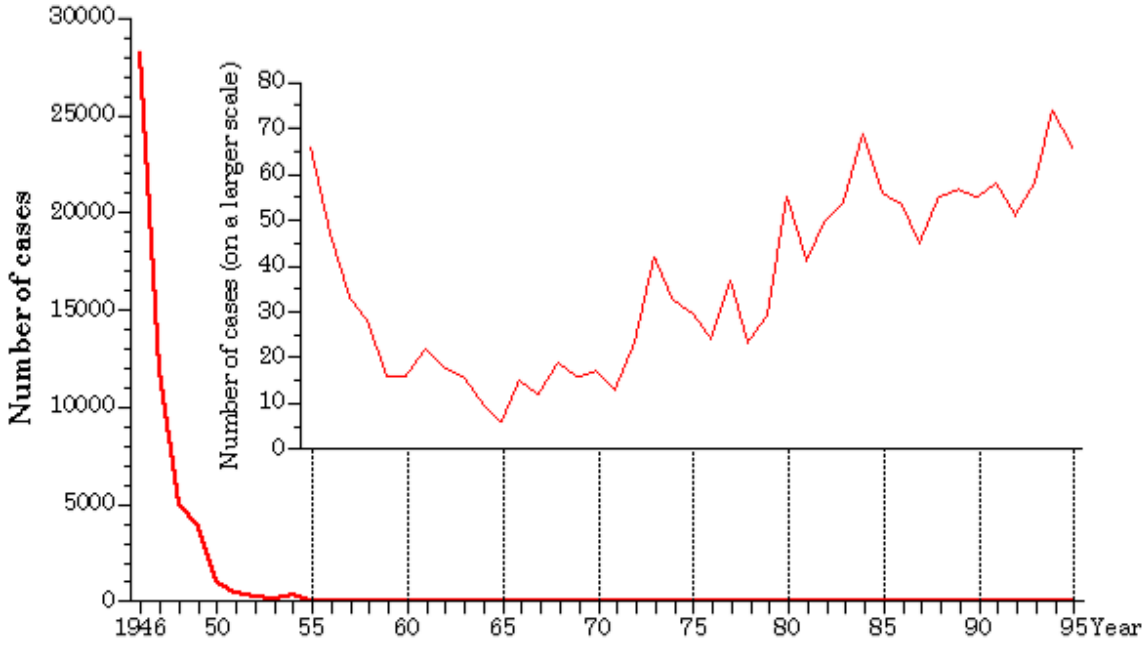
During the same period, Watson organised draining the salt marshes on the parts of the west coast of Malaya so as to make it habitable.

Japan

Japan had endemic malaria until after WWII. A major campaign in the years following the war reduced malaria to a negligible problem and malaria has remained under control until now. The follow graph shows the success very clearly. Fifty years later the number of reported cases is under 100. In the years prior to the 1946 to 1950 campaign cases had been in excess of 25,000.

Figure 1. Reported cases of malaria in Japan, 1946-1995

Statistics on Communicable Diseases in Japan (Ministry of Health and Welfare)



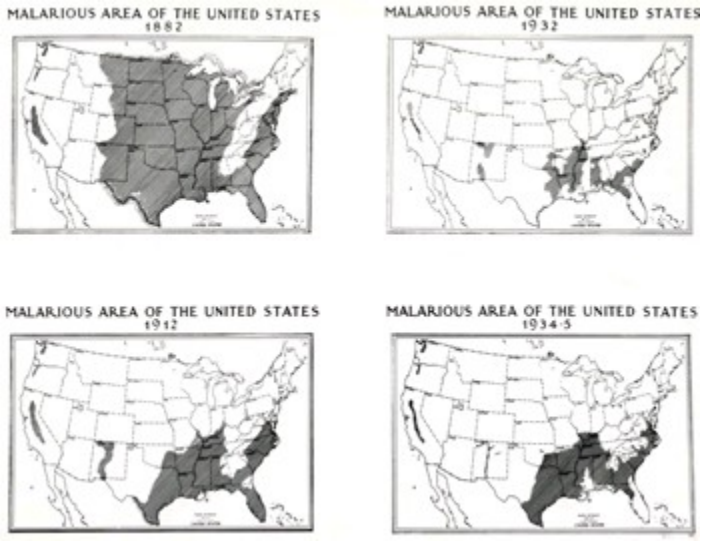
Australia

The Northern Territory of Australia had endemic malaria, but this was reduced by intensive mosquito and malaria control. The last reported case of local malaria transmission was in 1962. They continue a strong mosquito and malaria control program because of the continuing possibility that imported cases of malaria could easily become epidemic because of the high efficiency of the vector.

United States of America

Malaria's decline in the United States and Europe in the late 1800s was due mainly to draining swamps and removing mill ponds. Draining swamps also exposed good agricultural land, enabling people to afford better houses and thus isolate the sick. Increasing livestock densities may have diverted biting from humans toward cattle, pigs, or horses. Improved housing, isolation of sick people in mosquito-proof areas, better access to health care and medication, and improved nutrition, sanitation, and hygiene all may have reduced transmission and/or mortality rates.

Prior to WWII, the USA experience malaria seasonally in many parts of the country, especially, but not only in the Southern States. In the period 1946 to 1951 an agency of the US Government had a public health mandate to eradicate malaria and used mosquito control as a key intervention. This agency of the US Government is now the well respected Center for Disease Control (CDC). The following maps show malaria prevalent areas of the USA from 1882 to 1935. The only cases in the USA post 1950 are cases related to visits overseas and travellers coming to the USA.



The Centers for Disease Control (CDC) was organized in Atlanta, Georgia, on July 1, 1946. Office of Malaria Control in War Areas, an agency established in 1942 to limit the impact of malaria and other vector borne diseases (such as murine typhus) in the southeastern US during World War II was the predecessor of CDC. Dr. Justin M. Andrews, director of CDC from 1947 to 1951, was also the state malariologist for the state of Georgia. In the ensuing years, CDC oversaw the US national malaria eradication program and provided technical support to activities in the 13 states where malaria was still endemic. By 1951, malaria was considered eradicated from the United States. However, to the present day, malaria remains a major field of activities at CDC.

USA – California

As early as 1910, California had reduced the incidence of malaria by between

80% and 90%. School absences were cut in half and medical treatment needs very much reduced. Epidemics of insect borne disease such as encephalitis, malaria and yellow fever were brought under control in most of the USA decades ago, in the first half of the last century. The Mosquito Abatement Act was passed in 1915 in California and the California Mosquito Association was created in 1930. Between 1914 and 1928, the U. S. Public Health Service reported mosquito abatement programs in no less than seventeen different states. By 1935 the American Mosquito Association was formed, and it soon boasted one hundred member countries.

In 1921-22, a fish called *Gambusia affinis* or mosquitofish was the released into water collections for its larvivorous habits and was found useful in the control of mosquitoes in California.

Tennessee River Valley

In 1933 Tennessee River valley authority and the Public Health Service played a vital role in the control operations of malaria in the area and by 1947, the disease was essentially eliminated. Mosquito breeding sites were reduced by controlling water levels and insecticide applications.

USA – Louisiana

In 1924, Paris green dust was applied to swamps in Louisiana for control of Anopheles mosquitoes.

USA - Minnesota

For many years, the State of Minnesota, faced with thousands of square miles of seasonally standing water and ideal mosquito breeding grounds, employs abatement and control practices that are environmentally safe and cost effective. The per capita expenditures are consistently under one dollar annually. The over-riding philosophy driving the program for decades was that, so long as public funded costs are lower than total private costs related to control, treatment, and administration, it is good public policy to conduct the program. Over the years, success rates of 87% and more in controlling the mosquito population have been the norm.

USA - Florida

Without comprehensive control programs insect borne disease would be a major problem in the United States. The State of Florida has a comprehensive program and, even though it is tropical with a lot of standing water, malaria is not any more an endemic problem. Some of the US interventions have been strengthened because of fear that the mosquito will serve as a vector to carry the West Nile virus which has appeared in recent years in parts of the USA. In the spring of 2005, the New York City health department treated many thousands of storm sewer drains with larvacide tablets to counter a potential mosquito population explosion.

USA – Gulf Coast (post Katrina and Rita hurricanes)

The programs to ensure that the mosquito population is kept under control are ongoing in the USA.. In the aftermath of Hurricanes Katrina and Rita along the Gulf Coast in the United States, the authorities arranged for many hundreds of square miles of land to be sprayed with a very low concentration of insecticide to counter a potential explosion in the insect population, including mosquitoes.

HISTORY OF VARIOUS INTERVENTIONS

Sanitation and cleaning up the environment

Sanitation and cleaning up the environment had a big role in cleaning up a lot of health problems during the 19th century.

Chemical interventions

As early as 1825 Michael Faraday reported to the Royal Society of London the formation of benzene hexachloride. However, it had to wait for more than 115 years to become useful as a pesticide. Similarly, Dichlorodiphenyltrichloroethane (DDT) was first synthesized in 1874 by a Viennese pharmacist, Othmar Zeidler, but he did not investigate the properties of the new substance. The use of chemicals to control troublesome insects so as to save food crops started by mid 19th century. Paris green was used as an insecticide in 1867. Production of pyrethrum, which is a natural insecticide derived from the chrysanthemum flower, started in the US by 1870. In 1882, Petroleum was first recommended in the US for insect bites and stings. By 1897 oil of citronella was used as insect repellent. Pyrethrum was first used by William Gorgas in Cuba where it was burned inside sealed dwellings. In around 1910, the German scientist G. Giemsa was experimenting with different ways of using pyrethrum and developed a way of spraying pyrethrum on walls with a spray pump. This method took over two decades to catch on, and it was used with great success in South Africa for the control of malaria on sugar estates. In 1920 Oil-soaked sawdust was first recommended for mosquito control and Paris green was considered as the a mosquito larvicide. Paris Green was first used in malaria control in the 1920s. It was used in countries like India, South Africa and Brazil.

Chemical interventions

Until 1944, when pesticide DDT was rediscovered as a new weapon against mosquito control, only quinine and insecticides pyrethrum and Paris green were available to help in malaria control efforts.

Paris Green (a mixture of diesel oil and copper acetoarsenite) was first used in malaria control in the 1920s in many countries like India, South Africa and Brazil.

In 1924, Paris green dust was applied to swamps in Louisiana for control of Anopheles mosquitoes.

In 1942, many chemicals were tested for control of insect-borne disease among Armed Forces. By 1947, more than 13,000 such chemicals had been tested and classified, but the glory went to DDT, resynthesised by Paul Muller in 1939 [See below] In 1943, Van Linden gave the name lindane to the pesticide made with the active isomers of the benzene hexachloride mixture.

In 1921-22, a fish called *Gambusia affinis* or mosquitofish was the released into water collections for its larvivorous habits and was found useful in the control of mosquitoes in California.

Although DDT was first synthesized in 1874 by a Viennese pharmacist, Othmar Zeidler, he did not investigate the properties of the new substance but simply

published his synthesis. Then in 1939 in Switzerland, Paul Müller of the Geigy Company, resynthesized this compound and discovered its insecticidal properties. The Geigy Company began to market the substance in 1940-41 as a 5% dust called Gesarol spray insecticide and a 3% dust called Neocid dust insecticide. The now universally used name, DDT, was first applied by the British Ministry of Supply in 1943. DDT was first added to U.S. Army supply lists in May 1943. Gahan and colleagues, in August 1943, made the first practical tests of DDT as a residual insecticide against adult vector mosquitoes. The first field test in which residual DDT was applied to the interior surfaces of all habitations and outbuildings of a community to test its effect on *Anopheles* vectors and malaria incidence was begun in Italy in the spring of 1944. This experiment was carried out in the town of Castel Volturno at the mouth of the Volturno River, north of Naples, by the Malaria Control Demonstration Unit of the Malaria Control Branch of the Public Health Sub-Commission, Allied Control Commission, Italy. Spraying began on 17 May 1944, and this experiment, together with a second one started later in the Tiber Delta area, lasted 2 years. The war needs and experiments greatly accelerated its acceptance and use and led to the discovery and application of similar insecticides such as benzene hexachloride and dieldrin. However, by 1949 mosquitoes resistant to DDT and other new insecticides were found.

In 1962, Rachel Carson published *Silent Spring.* In it, she discussed the decline in certain regions of the United States of the America robin, due to its consumption of earthworms that were laden with the DDT used in massive amounts to combat Dutch elm disease. Carson's book stimulated widespread public concern about DDT and other pesticides.

Through a series of legal hearings in the United States instigated by lawyers and scientists working with the Environmental Defense Fund, DDT was eventually banned or severely restricted in most states. In 1972, the U.S. Environmental Protection Agency banned all DDT uses except those essential to public health. Similar bans were instituted by Sweden in 1969 and later in most of the developed countries.

But DDT is still being used in some developing countries to control malaria, but the debate is continuing.

House spraying

in 1939, the Malaria Service of Northeast Brazil was organized to combat the populations of *Anopheles gambiae.* Soper and his team of 40,000 workers fumigated houses and buildings with Pyrethrum and sprayed Paris Green on pools of water. In just 22 months, he was able to eradicate the mosquito from an area of about 18,000 square miles in Brazil. Fred Soper's success was considered a great public health achievement in Brazil, and he was rewarded with medals and citations. This effort at species eradication was so successful that the mosquito is still absent from the area. This was before DDT was used in anti-malaria programmes.

Early control programs

Up to 1950s, malaria control programmes in many countries involved treatment with quinine, personal protection with bednets and anti larval measures that included drainage, soil modification, proscription of urban agriculture (potatoes

and other ridge-and-furrow type cultivation). The efforts were most often concentrated in urban areas. Some countries passed very strict, even draconian, legislations like the Mosquito Extermination Act (Ed. Note: probably in India) for ensuring source reduction. These required all householders to prevent mosquito breeding sites by clearing all vegetation surrounding the house to a distance of ten metres in all directions. Any container that could possibly hold water and therefore provide a breeding site was to be removed from the household area. Regular inspections were made by the government health department in order to ensure that all households were complying with the legislation. Those households that did not comply were either subjected to a fine or the head of the household could be imprisoned. Such acts also required all mines, quarries, irrigation, water supply and other works to take specific measures to ensure that mosquito breeding sites were destroyed. With the availability of DDT in 1943, adult insecticidal operations were initiated by spraying and misting with adulticidal devices in tents and buildings, and by release from aircraft. By 1934-49, malaria was eradicated from Brazil and Egypt, largely due to extensive DDT spraying.

History of WHO

The WHO took up malaria eradication programme in 1955. In 1953, Brazilian malariologist Marcolino Candau, who campaigned on the promise of malaria eradication won the elections to the post of the director general of WHO defeating the psychiatrist Brock Chisholm. The Global Malaria Eradication Programme was launched in 1955 emphasising on vector control with DDT residual spraying and surveillance in all national programmes. The goal was to reduce infected vector populations feeding on humans sufficiently to interrupt parasite transmission.

The programme imposed an uniform strategy for all countries and areas, ignoring the diversity of malaria and economy of nations, particularly the new governments then emerging from colonial rule. Sub-Saharan Africa was not included (or even ignored) due to its massive reservoir of malaria and insufficient infrastructure to support the programme.

However, malaria was eradicated in nations with temperate climates and seasonal malaria transmission. The last indigenous case in England had been in the 1950s and in Holland in 1961. By 1969, many European countries namely Hungary, Bulgaria, Romania, Yugoslavia, Spain, Poland, Italy, Netherlands and Portugal managed to completely eradicate their endemic malaria. (In 1975, the World Health Organization declared that Europe was free of malaria).

Some countries such as India and Sri Lanka had sharp reductions in the number of cases, followed by increases to substantial levels after efforts ceased. Other nations had negligible progress (such as Indonesia, Afghanistan, Haiti, and Nicaragua). Despite initial success in countries like India, by 1965, it started falling apart due to a number of factors: technical difficulties such as vector and parasite drug resistance, social and political factors preventing efficient application of control measures, wars and massive population movements, difficulties in obtaining sustained funding from donor countries, and lack of community participation that made the long-term maintenance of the effort untenable. The programme was criticized for being too inflexible like a military operation and received little support or even opposition from the local

populations.

By 1969 WHO admitted the failure of this campaign and the global eradication policy was abandoned. Several years later, the WHO's Malaria Eradication Division changed its name to the Division of Malaria and Other Parasitic Diseases.

The 1970s

From the early 1970's the malaria situation has slowly and progressively deteriorated. The concept of eradication was replaced with that of control as a part of primary health care. Reduced control measures between 1972 and 1976 due to financial constraints lead to a massive 2-3 fold increase in cases globally. Spraying never truly eradicated the mosquitoes anywhere, and the reduction in the more persistent *P.vivax* infections were much less than for *P.falciparum* - though the latter returned in much greater strength as control measures waned. The growing interchange of populations between malarious countries and malaria free countries is responsible for the continuous increase in the number of imported malaria cases in developed countries. Since 1976, several new pockets of malaria transmission have evolved.

The 1980s

Malaria control in the 1980s was neglected in many areas. The optimism of the eradication campaign was replaced by a belief that malaria could not be controlled. The systems set up for eradication, which were very centrally organised and directed were discredited, and support was withheld without offering alternative systems and strategies. Whilst it was said that malaria control should be integrated into the general health systems, instead of being a vertical programme, the means to do this were neglected.

End 1980s and 1990s

At the end of the 1980s and in the early 1990s the World Health Organisation (WHO) worked with all malarious countries to develop a global strategy for malaria control. This strategy was adopted by a Global Ministerial Conference on Malaria in Amsterdam in 1992. The strategy has four elements:

- To provide early diagnosis and prompt treatment
- To plan and implement selective and sustainable preventive measures, including vector control
- To detect early, contain or prevent epidemics
- To strengthen local capacities in basic and applied research.

The strategy was widely endorsed, and efforts to implement it have shaped the development of malaria control in most malarious countries. It has been adapted to the needs of different regions; in Africa, for instance, a Regional Malaria Control Strategy for 1996 to 2001 was developed by a Task Force for Malaria Control convened by the WHO African Regional Office (AFRO).

In 1998 Dr. Gro Harlem Brundtland, Director General, World Health Organization launched a Global Roll Back Malaria Initiative against malaria. The RBM Strategy included: (1) Early case detection and prompt treatment, (2) Integrated vector management and (3) Containment of focal epidemics. However, the programme is far from being successful.

Today – man-made malaria

Today, it's a much worse scenario.

- Thoughtless man-made irrigation schemes and dams provided new habitats for Anopheles, and resulted in 'man-made' malaria.
- The extension of urban areas lead to epidemics in the peripheries of the growing cities.
- Mass migrations of non-immune populations into endemic areas for political reasons has further complicated matters.
- More than 300 million cases with 2 million deaths,
- multi-insecticide and multi-drug resistance,
- non-use of DDT,
- non-availability of cheap and effective chemo-therapeutics and prophylactics,
- steady-state, benign holoendemic malaria replaced by unstable hyperendemicity,
- functional immunity impaired by the ad hoc chemotherapy distributed from the primary health centres

It is déjà vu all over again.

- New technology promises to bring the always-in-the-pipeline vaccine and the more flashy bed nets dipped in permethrin.

The super-sensitive, single-minded Ross went to his grave still holding the firm conviction that malaria could be eradicated if only weak-willed governments would commit themselves to exploit his discovery and attack the anopheline in their watery lairs.

APPENDIX 2

HISTORY OF SUCCESS IN REDUCING MALARIA
IT WAS POSSIBLE 50 YEARS AGO. WHY NOT NOW?

Panama Canal

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USA

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Europe

Much of Europe suffered from malaria, but malaria receded as the habitat for mosquito breeding became constrained with modern agriculture and better drainage. But it remained a problem in the Mediteranean countries until after WWII. Greece and Italy, including famously, Sardinia, reduced malaria almost completely in the post war years. In Sardinia, very heavy use of DDT was effective in eliminating mosquitoes and malaria, but there was a concern that heavy DDT use would have lasting health consequences for the human population. Surprisingly, 50 years later, this has not materialized as expected.

Japan

Japan had endemic malaria until after WWII. A major campaign in the years following the war reduced malaria to a negligible problem and malaria has remained under control until now.

Australia

The Northern Territory of Australia had endemic malaria, but this was reduced by intensive mosquito and malaria control. The last reported case of local malaria transmission was in 1962. They continue a strong mosquito and malaria control program because of the continuing possibility that imported cases of malaria could easily become epidemic because of the high efficiency of the vector.

Caribbean

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South Africa

Parts of South Africa have endemic malaria. This was brought under control using IRS and DDT, but when DDT uses was terminated malaria cases

increased dramatically. They have been brought under control again by using IRS and DDT again.

India

Programs to reduce the prevalence of malaria in India were largely successful in the 1950s and 1960s. Millions of cases a year were reduced to tens of thousands. The programs appear to be less successful now, in part because of reduced interventions, partly increased resistance and probably greater travel between areas, especially into neighboring countries such as Bangladesh.

Sri Lanka

The malaria prevalence reduction programs in Sri Lanka were very successful in the 1950s and 1960s, but malaria has come back as continuing intervention was eliminated, and little attention was paid to the continuing science. It is now apparent that resistance is an important factor in Sri Lanka, both for the mosquito against pesticides and the malaria parasite against low cost drug therapy.

Africa

The mosquito and malaria prevalence was reduced in many corporate locations in Africa, but because the interventions were not extended widely into the surrounding communities, the total impact on the local population was small. Substantial reduction in the malaria case load can be achieved in Africa when there are appropriate IMMC interventions, as for example in Liberia, Zambia, Equatorial Guinea, Mozambique, etc.

Why was Africa not a success?

The quick answer is because no resources were ever allocated to IMMC interventions in Africa. All rich countries became malaria free more than 50 years ago. Both Europe and North America had malaria up until the immediate post-WWII years. The major campaigns organized by UNICEF and WHO reached most parts of the world, but NOT Africa.

Recent interventions for Africa related to malaria have been single component strategies and usually not at a scale that can have a significant impact. Use of best practice for IRS using DDT has been constrained by donor countries citing environmental concerns that are essentially baseless. Distriubution of bednets has been a preferred intervention, though it seems that this cannot have much community wide impact.