

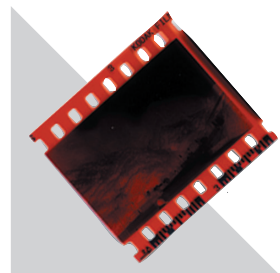


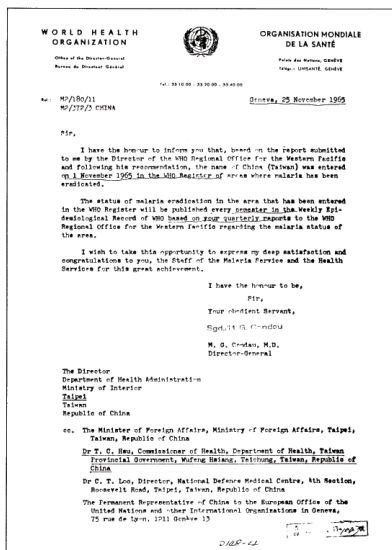
40

Chapter Two

Chapter Two

Overview of Malaria Eradication in Taiwan





WHO Certificate of Registration

On November 1, 1965, Taiwan was granted a WHO Certificate of Registration and officially declared a malaria-free zone. Prior to eradication, malaria had posed a threat to the lives of the people of Taiwan, especially in rural areas, where it was most serious, and, at the same time, it had been the biggest factor impeding economic development. When Japan occupied Taiwan in 1945, the number of war casualties was just over 600, with 164 people killed in fighting and 515 wounded. But another 4,624 Japanese died of illness in Taiwan, while 26,994 were ill. In most cases, the illness was malaria. Even the commander of the Japanese forces in Taiwan, Prince Kitasirakawa, died of falciparum malaria in Tainan. In 1911, a large-scale epidemic control program was implemented by the

Japanese, using Robert Koch's method. Antimalaria stations were set up all over the island to provide free and universal blood examination, and people who tested positive subsequently underwent compulsive treatment. To prevent infections, an enormous effort was made to eliminate mosquitoes in conjunction with land development and improvement of environmental health, and the use of bed nets was promoted among the public. As a result, a low infection rate of 2%-3% was achieved among the population under examination. Moreover, the mortality rate fell from 36 in every 10,000 in the years 1906 to 1909, to eight in every 10,000 in the 1930s. In 1942, however, during the latter stage of the World War II, there was a resurgence of the disease, killing 5,842 people, which translated to a mortality rate of 9.23 in every 10,000. The various reasons for this were that it was the time of the most fierce fighting during the war, that there was a shortage of medicine, and that the people living in the cities, especially in the north, were evacuated to the south.



Taking blood smears in the village
Source: Morishita, 1976

Chapter Two



Taiwan Provincial Malaria Research Institute (TAMRI)
Chapchou, Pingtung county (1948-1969)

In 1945, when Taiwan was restored to the Republic of China, some 1.2 million of Taiwan's population of six million suffered from malaria. In the foothills and mountainous areas, 40% of children suffered from spenomagly, an indication of the seriousness of the situation. After the war, when the Chinese national army came to Taiwan, there were numerous matters to attend to but the government was short of funds. Consequently, the public health work begun in the Japanese colonial

era to restore Taiwan's public health came to a complete and immediate halt. In order to rebuild the rural areas, the government, in accordance with an economic cooperation agreement between the Republic of China and the United States, established a Joint Commission for Rural Reconstruction (JCRR) in Nanjing on October 1, 1948, to assist with national reconstruction work. The JCRR, which had a team of outstanding domestic and overseas agricultural experts, provided abundant funding and made a tremendous effort in respect of rural revival in Taiwan in the short and medium terms. The malaria eradication process consisted of the following four stages: the preparatory phase, the attack phase, the consolidation phase, and the maintenance phase. The preparatory and attack phases coincided precisely with Taiwan's period of recovery after the war, when the economy of the entire nation depended mainly on agricultural activity. Industrialization was yet to begin. To eradicate malaria from the island, there was an urgent need for financial assistance from overseas.



Dr. Shih Chu Hsu (center), Chief of Rural Health Division, JCRR, reviews the six - year malaria eradication program

Fortunately, with timely financial support from the Rockefeller Foundation and the Sino-American economic cooperation agreement, and subsequent financial, medical and technological support from international organizations, Taiwan's public health system was able to achieve an enviable record in epidemic control. In August 1946, after Dr. Robert Briggs Watson and Dr. Marshall C. Balfour visited Taiwan one after the other, a decision was made to establish the Malaria Research Center in Chaochou

Township, Pingtung County, with all funding and personnel supplied by the Rockefeller Foundation. Accordingly, in November that year, the Rockefeller Foundation's International Health Division, in collaboration with the government, set up the center in Chaochou. In mid-1947, two field research centers were established, one in Shuili of central Taiwan and the other in Keelung of northern Taiwan.



In December 1946, Dr. J. Harland Paul came to Taiwan to serve as director of the center. Dr. Watson took charge of testing new drugs for the treatment of malaria, such as



Collecting wiggler



DDT Spraying squad, 1952

chloroquine and proquanil (Paludrine). Dr. J. C. Carter was responsible for chemical and engineering-related methods to combat *Anopheles* mosquitoes. Mr. Zhou Qin-xian was charged with the task of collecting, identifying and dissecting malaria samples, and providing relevant training about them. Mr. Hsu Shih-chu of the JCRR assisted with surveys and education concerning malaria parasites, *Plasmodium (P.)*. In 1946 and 1947, the activities of these three research centers consisted primarily of studies of local epidemiological conditions, including analyses of available records on malaria from the Japanese colonial era, malariometric surveys of the population of local villages, and entomological observation of local anophelines. In 1948, research activity was expanded to include field experiments of newly available drugs, the use of DDT for indoor residual spraying and laticiding, and the installation of automatic flushing equipment to control stream-breeding mosquitoes. With the Rockefeller Foundation's support and the assistance of the personnel whom it assigned to Taiwan, the following measures formed the linchpin of Taiwan's malaria control program: I. Observation of malaria prevalence. II. Observation of *Anopheles* mosquitoes. III. Experimental malaria control.

Possible references for the epidemic control framework established with the support of the Rockefeller Foundation were as follows: (1) Drawing from the Japanese experience in adopting Robert Koch's prophylaxis strategy to carry out a trial in administering large doses of medication to patients with enlarged spleens and people whose blood had tested positive. About 1,600 people in the Peitou Community of Taipei had been selected as the subjects of this experiment. During the five-month period from July to November 1910, each subject had received one examination per month for malaria parasites and those tested positive had been treated with



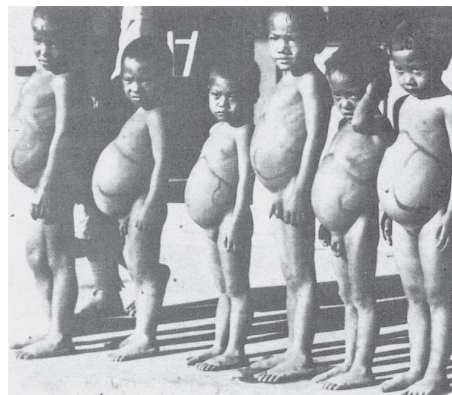
Oral administration of antimalaria drug



Paludrine is distributed to villagers in Sanhsing village, Chaochou township, 1947
Source: JCRR

Chapter Two

chloroquine, with very satisfactory results. Following that success, a large-scale malaria control campaign was initiated in 1911, beginning in the mountain regions, and gradually expanding over the whole of Taiwan, involving monthly blood examinations and vigorous treatment of malaria patients with antimalarial drugs. (2) In the 1940s, the effectiveness of DDT and other insecticides brought malaria control work worldwide into a new era. A description of the new program is as follows:



Children with enlarged spleens in mountain districts of Taiwan
Source: Morishita, 1976

Observation and research of malaria prevalence were concentrated in areas around the three research centers (which later became branch offices). These were to cover the following items:

I. Observation of malaria prevalence:

Scientific observation of people, times and places was performed so that an overall picture of the incidence of the disease could be ascertained. This work focused on the examination of infants, children under the age of 25 months, and elementary schoolchildren, as well as on analysis of available records from the Japanese colonial era. In-depth investigation was then carried out into the times, places, and localities of the incidences, so that objectives could be precisely set and an accurate assessment could be made of the

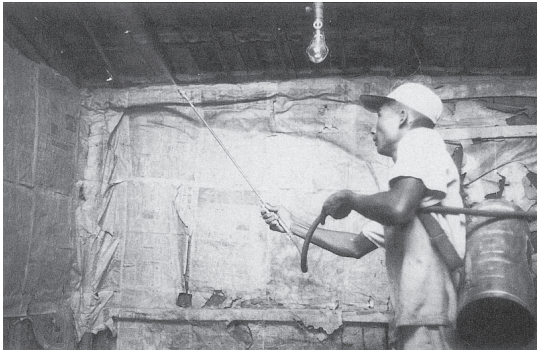


Monthly infant survey
Source: JCRR



Preparing blood smears

program's strengths in relation to those objectives, and that complete success could be achieved. Investigation was performed on the seasonal prevalence of malaria in the south, center and north of Taiwan. Overall, results of the above three investigations showed that there were two species of *Anopheles* mosquitoes that might have transmitted the disease, which were *An. sinensis* and *An. minimus*. But which one of the two had actually done so? Or had they both? It was necessary to rely on the observation of the mosquitoes to find an answer.



Intradomiciliary spraying with DDT



II. Observation of *Anopheles* mosquitoes:

With more than 12 anopheline species in Taiwan, it was important to identify the vector of transmission before the execution of control measures in order to gain control of the epidemic. Each different species of mosquito, however, varies considerably from each other in terms of its feeding and resting habits, and its associations with humans. The following sub-plans were carried out to address these areas of difficulty.

- (I) A study of seasonal breeding among *Anopheles* mosquitoes in southern Taiwan.
- (II) A study into natural infection of malaria parasites among *Anopheles* mosquitoes in Taiwan.

III. Experimental malaria control:

Field trials were conducted across Taiwan using various forms of experimental controlling methods, in order to identify the method of control most suited to the Taiwan region. This program proceeded as follows:

- (I) In southern Taiwan, chloroquinide and Paludrine were used as a suppressant and a therapeutic agent in field trials.
- (II) In central Taiwan, field trials were carried out using chloroquine.
- (III) Automatic flushing was initiated in streams to control malaria.
- (IV) Larviciding with insecticide.
- (V) DDT indoor residual spraying.

Following detailed evaluation of the outcomes of the research program, DDT indoor residual spraying became the main control strategy in subsequent operations. The reasoning was that the method effectively cut off the path of transmission as *An. minimus* would rest indoors or behind some sort of cover after a feed of blood. In addition, the method complied with the principle of cost-effectiveness.



Larviciding
Source: JCRR

Chapter Two



Spraying squad moving from one village to another, on foot

Following several years of hard work and field experiments, the spraying of DDT indoor residual spraying became Taiwan's primary method of malaria control. To completely eradicate the disease, large amounts of manpower were needed. Knowledge is power. Sound pre-operational training was not only an effective way of minimizing occupational losses; it also enabled experience to be passed down, and, all the more, raised malaria control activities to new heights. One of the most important

activities of the Rockefeller Foundation's Research Center, and the succeeding Taiwan Provincial Malaria Research Institute (TAMRI), was the training of malaria personnel. The Rockefeller Foundation's funding continued until 1949, but between 1949 and 1951, most of the experts conducting malaria control received Rockefeller Foundation bursaries. The three research centers also recruited technicians at their separate locations, and the TAMRI, with financial support from the JCRR, organized refresher training courses, providing in-service training for 200 public health workers and other specialists. It was with these various forms of assistance that the seeds of hope and success were planted for Taiwan's antimalaria work, enabling subsequent control and prevention work to proceed smoothly.



It was also because of the success of the experiments with insecticides between 1946 and 1949, that the idea for malaria control in Taiwan gradually took shape. The basic strategy behind the control measures was gradually developed on the basis of the available manpower, financial resources and epidemiological priorities. On October 17, 1951, representatives of the National Health Administration (NHA), the Provincial Health Administration (PHA), the TAMRI, the International Cooperation Administration, the Council for United States Aid (CUSA), the JCRR, and the WHO, held a meeting, at which an island-wide malaria control program was proposed. In November that year, the government signed an agreement with the WHO to undertake a four-year joint malaria control program, whose objective was to eradicate malaria completely in Taiwan. In accordance with this agreement, the WHO assigned an international malaria team, comprising one malariologist, an entomologist and a sanitary engineer, to take part in the program. It also provided US\$34,000 to buy four years' worth of essential laboratory equipment and supplementary items



Warning sign on the doorway of a house sprayed with DDT, bearing the messages:
Center column: "Do not wipe off DDT deposit."
Right column: "Spraying once a year is an effective way to avoid malaria infection for one year."
Left column: "Controlling malaria with DDT is for you, for me and for everybody."
Lower portion: Inspection certificate specifying the spraying date and the responsible spraying squad.



Warning sign on doorway reminding residents:
 "Do not wipe off DDT deposits."

The four-year island-wide malaria control program received technical cooperation from the WHO, as well as financial assistance from the JCRR, the United States Mutual Security Agency (MSA) and the CUSA. The assistance provided by these overseas organizations was fundamental, and it was only because Taiwan received these urgently needed insecticides and equipment that the island-wide control program was able to begin. In November 1952,

the Malaria Advisory Committee was established, with delegates from each of the above-mentioned organizations. The committee met once or twice a year, to discuss the progress of the malaria control program, work plans, coordination of malaria control activities with the military, quantification of insecticide needs, spraying equipment and budgets.



Chapter Two

In 1954, while the spraying operation was still in progress, the original strategy underwent extensive revision, with the island-wide spraying extended for a further two years to cover 1956 and 1957. The area sprayed in 1956 covered the whole of Taiwan, with the exception of the centers of big cities, where there was no existing threat of malaria endemicity. In January 1955, Taiwan requested an extension of financial support from the United State's Foreign Operations Administration (FOA) and the CUSA, in order to purchase DDT and spraying equipment. The proposal was approved by both organizations and the necessary funds were forthcoming. Accordingly, between 1953 and 1957, spraying was adopted as a control activity at different times, depending on the level of prevalence at various locations arounds the island.

From 1952 to 1957, the funds for the eradication program were distributed as follows: the TAMRI's budget was used not only for DDT spraying, but also for general administrative tasks, research, epidemiological evaluations of the control program, as well as assorted expenses associated with visits from international guests and organizations. The funds from the MSA, the CUSA, and the JCRR were spent on insecticides, spraying equipment, and vehicles. Costs of locally purchased items were usually defrayed from funds provided in New Taiwan dollars by the TAMRI and the PHA; imported items were ordered directly by the organizations providing financial support. The WHO funds were mainly used for the salaries and per diem of the international malaria team, as well as a small number of laboratory and field equipment, and supply depots.

For the island-wide malaria control program to be carried out effectively, apart from the active cooperation of residents, an integrated and comprehensive preparatory plan, the injection of new technology, and the timely provision of goods and materials were particularly necessary. But the truth was that all this required high levels of financial support. The undertaking of the preparatory phase and the attack phase took place at the time of Taiwan's recovery following World War II, when the people were mostly honest and simple agricultural folks. The public health infrastructures bequeathed from the Japanese colonial era, the assistance provided by the Rockefeller Foundation in laying the foundations for island-wide malaria control, as well as the Sino-American agreement on economic cooperation and continual assistance from international organizations, apparently all contrived to bestow fortune upon the residents of Taiwan, with the most practical form of encouragement being the nation's official designation as a malaria-free zone.





First training course for County Malaria Supervisors, 1947

Based on the views of veterans and experts in the health circles , other factors leading to the success of malaria eradication in Taiwan could be summed up as follows:

- I. Lien Jih-chin believes that credit must first be given to the Japanese for laying sound foundations in malaria research and malaria control during their colonial rule of Taiwan. Next, however, came the Rockefeller Foundation, which, in the early days following Taiwan's reversion to the sovereignty of the Republic of China, provided the most valuable technical and financial support, and trained the main force of local malaria personnel. In addition, foreign aids from other organizations, such as the WHO, the JCRR, the CUSA and the MSA, were also a tremendous help.
- II. Yan Chun-huei argues that once the malaria program was set in motion, the organization for central planning, TAMRI, had decentralized the implementation of the program by delegating the responsibilities to local health services, and with the military being fully mobilized to provide assistance, Taiwan was therefore able to – with minimum cost but maximum effect – reduce the number of malaria cases island-wide, from tens of thousands to zero in indigenous transmission, in just about ten years (Li Shu-juan, *et al.*, 2001)
- III. Professor Xie Xian-chen's research report, published in ***Malaria in Taiwan: Past and Present*** (June 1990), argues that the reasons for the success of the Malaria Eradication Program in Taiwan can be put down to the favorable conditions that prevailed in Taiwan before the program was carried out, and they are as follows:
 - (I) The people of Taiwan were already well acquainted with malaria;
 - (II) Basic knowledge of malaria epidemiology in Taiwan had already been established;
 - (III) Health and medical systems already existed in the Taiwan region



Chapter Two

- (IV) Taiwan had already accumulated a reserve of important personnel, such as malariologists, entomologists, sanitary engineers (1947 to 1952), and during that period, 13 young experts who had graduated from National Taiwan University (NTU) joined the force of malaria eradication work, so the main malaria control cadre broke down as follows: Liang Kuang-Chi and Chen Xi-Zhou from the NTU Hospital Medical Department's eighth graduating class (1945); Chen Zheng-De from the NTU College of Medicine's first graduating class (1947); Chen Xian and Xie Xian-Chen from the second graduating class (1948); Zeng Bo-cun, Chuang Cheng-hua, Wu Yao-jin, Chen Wan-yi and Huang Qian-dao from the third graduating class; Peng Rui-yan from the Medical Technology Department's ninth graduating class (1944); Chou Lian-pin from the eleventh graduating class (1945); and Liu Su-yong from the Zoology Department of the College of Science's second graduating class (1950).
 - (V) A malaria control experimentation plan had been carried out previously (1947-1952).
 - (VI) A sound household registration system was already in place.
 - (VII) The transportation system was well developed.
 - (VIII) The assistance of international health organizations (such as the WHO, the UNICEF, the health division of the CUSA, the health division of the JCRR, and the Rockefeller Foundation).
 - (IX) Before the success of malaria eradication, Taiwan's main *Anopheles* mosquitoes had not developed immunity to insecticides.
 - (X) Prior to the success of malaria eradication, Taiwan's malaria parasites had not developed immunity to chloroquine, an advantage that Taiwan enjoyed over other countries (according to the United States' *Morbidity and Mortality Weekly Report (MMWR)*, 34 (1985), Report No. 186, chart 415).
 - (XI) There was sound cooperation between all levels of government, and full cooperation from the military, in malaria control work.
 - (XII) During the period of eradication, levels of socio-economic standards in Taiwan had begun to rise.
- IV.** Hu Hui-de argues that the most important achievement of the investigation and research projects carried out during the preparatory phase was the determination of the primary vector of malaria infection as *An. minimus* and the knowledge gained of its behavior, as it was on the basis of these achievements that the large-scale control program was able to get underway during the attack phase in 1952. The strategy focused on the two weak points in the mosquito's path of transmission, namely that the malaria parasite must grow for more than ten days within the mosquito's body before acquiring the ability to spread infection, and that *An. minimus* was disposed to rest indoors or under some other cover after feeding on blood. Within a few hours of coming into contact with insecticide, the mosquito would die from the toxicity. Therefore, if all resting places of mosquitoes could, without exception, be thoroughly sprayed with DDT with residual effect, the transmission of malaria could be gradually eliminated, if not immediately interrupted.