

REVIEW

MALARIA AND ITS CONTROL IN THE PEOPLE'S REPUBLIC OF CHINA

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Abstract. Malaria is one of the major parasitic diseases in China. During the past 40 years, large scale malaria control activities were conducted in the country relying on primary health care nets and community participation. The control of malaria was implemented according to the principles of adopting integrated measures and repeated practices which are characterized by time- and locality-oriented approaches. As a result, remarkable success has been achieved. By the end of 1990, there were 117,000 malaria cases in China, with a morbidity of 0.0106%, which dropped by 95% in comparison with that in the 1950s. Most of the original hyper-endemic areas became meso- or hypo-endemic and for most of the previously meso- or hypo-endemic areas, the disease became sporadic. Malaria distribution and epidemic patterns also demonstrated great changes. The major experience comprises the integration of the malaria control program into the overall national health program, the mobilization of various sectors, including the community, the investigators and technical personnel in research institutions and control services to participate and cooperate in solving problems and difficulties encountered.

HISTORY OF MALARIA

Malaria is one of the major parasitic diseases left over by the old society. It has a long history and wide distribution in China. The earliest record of sickness bearing a resemblance to malaria can be found from the inscriptions on bones or tortoise shells and bronzewares in the Yin and Shang dynasties 3,500 years ago. The distribution of malaria symptoms can be traced back to "Huang Di Nei Jing", an ancient medical classic (Li, 1963; Ren *et al*, 1984). The disease has a detrimental effect on rural areas and a considerable number of persons succumbed to the disease before the founding of the People's Republic. For example, in Yun county, Yunnan Province, more than 30,000 fatalities due to malaria were recorded in 1933 (Huang and Lin, 1986). Another example occurred in the middle

and lower reaches of the Yangtze and Huaihe rivers: 60% out of a population of 28.5 million contracted malaria and numerous patients died during a flood season in 1931 (Zhang *et al*, 1988). According to incomplete statistics, the annual malaria cases numbered 3.5 million and the morbidity 6.46% in the 1950s, while the mortality rate was estimated to be about 1% before 1949 (Zhou, 1985). In the early 1950s, malaria was endemic in 1,829 counties/cities, which amounted to 70-80% of the total counties of the nation. Data collected in 1954 showed that malaria cases totaled 6.97 million (Taiwan Province not included, the same below), which accounted for 61.84% of the total recorded cases of acute infectious diseases, the morbidity being 1.2%. However, the actual situation was far more severe, because the primary health care system was not established and complete case reports were inaccessible at that time (Zhang *et al*, 1988).

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GEOGRAPHIC DISTRIBUTION

Malaria is widespread in China, and malaria

cases are more abundant in the rural than in the urban areas. The prevalence gradually decreases from south to north. South of 25° NL (Nanling mountain), are the hyper- or meso-endemic regions, where falciparum malaria is widely present. Meso- and hypo-endemic areas are between 25° and 33° NL (from Nanling to Qinling mountain and the Huaihe River), where vivax malaria is the predominant species, though falciparum infections also exist and focal outbreaks often occur. In the region north of 33° NL (north of Qinling mountain and the Huaihe River), malaria is of low endemicity, *Plasmodium vivax* being the only species; temporary epidemics are occasionally caused by imported falciparum malaria (Ren, 1984) (Fig 1).

MOSQUITO VECTORS

There are seven important malaria vectors distributed in different parts of China (Fig 2). *Anopheles minimus*, *An. jeyporiensis candidiensis* and *An. fluviatilis* mainly occur in areas south of 25° NL. *An. dirus* is one of the main vectors in Hainan Island. *An. sinensis* is the vector in the plains region located between 25–33° NL, while in the hilly districts, the vectors consist of *An. minimus*, *An. anthropophagus* or *An. jeyporiensis candidiensis*. In the region north of 33° NL, *An. sinensis* is the principal vector, while *An. messeae* serves as the carrier in Xinjiang Autonomous Region and the eastern part of Heilongjiang Province (Ren, 1984; Deng, 1980).

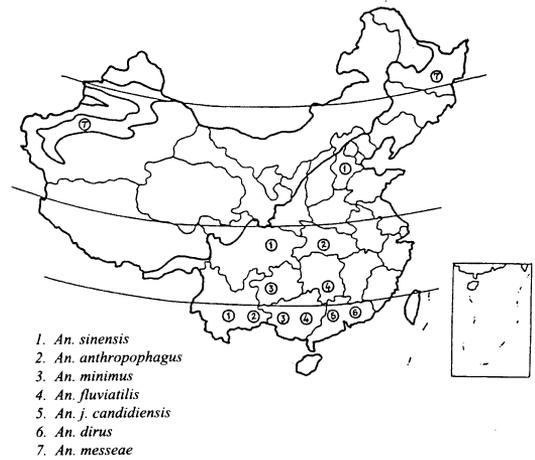


Fig 2 – The distribution of major vectors transmitting malaria in China

MALARIA CONTROL PROGRAM

The organization of malaria control

Since the founding of the People’s Republic, the Ministry of Public Health has paid emphatic attention to the pursuance of the policy of “prevention first” in health and sanitary services, and in this context antimalarial campaigns have been launched since 1950. Seeing the seriousness of malaria, the policy-makers gave priority to control of the disease in the context of public health and a nationwide control program was started in 1955. The leading groups for malaria control were set up at different levels. Research institutes and antimalaria stations were established correspondingly, as shown in Fig 3. Additionally, at the national level, the Departments of Agriculture, Water Conservancy, Communication, Commerce and Chemical Industry were incorporated in the fight against malaria.

Target and strategies

The target and strategies of antimalarial activities in China are “to persist in long-term struggle and repeated combat, so as to actively control prevalence, further lessen malaria hazard, and to attain finally the goal of eradication”. (Ministry of Public Health, 1983). In practical

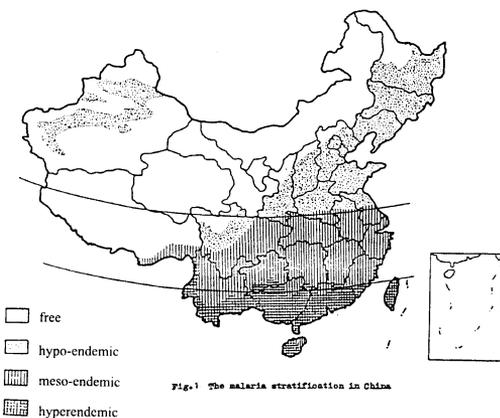


Fig.1 The malaria stratification in China

Fig 1 – The malaria stratification in China

MALARIA CONTROL IN PR CHINA

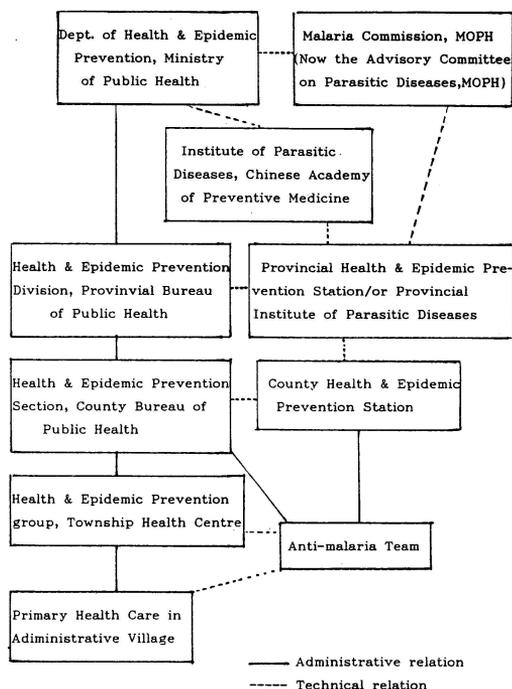


Fig 3 — Organs for malaria control in China

implementation of the strategies, integrated antimalarial measures were adopted.

Integrated antimalarial measures

China has a vast territory encompassing varied geographical features, economic status and living conditions, which have an impact on malaria prevalence. Naturally, different antimalarial measures are required for different endemic areas. The generally accepted concepts lead to the adoption of integrated antimalarial measures concentrated on diverse points according to different vectorial ecology and endemicity. In endemic areas where *An. sinensis* is the vector, integrated measures with emphasis on elimination of infection source and prevention of mosquito breeding are recommended, in which reduction of mosquito breeding sites in villages is involved. In endemic areas where the major vectors are *An. minimus* and *An. anthropophagus*, the principal measure is focused on the control of mosquito vectors and elimination of infection source. In endemic areas where the major vector is *An. dirus* the main measure is to change the ecological environment and so reduce mosquito

numbers in linkage with infection source control. In areas where the incidence has decreased to below 0.01%, malaria surveillance is justified as the predominant practice, which includes case detection, focus intervention, management of migrant populations as well as prompt incidence surveillance and vector monitoring (Department of Control of Endemic Diseases, 1988).

ESSENTIAL ACTIVITIES IN MALARIA CONTROL

The malaria control activities after the founding of the People's Republic of China might be roughly divided into three periods.

First period (1949–1955). This was the preparatory period. Malaria control organizations at the central, provincial and county levels were established and technical personnel trained. Investigations on malaria were carried out in different regions of the country. Therapeutic studies and small-scale field control measures were adopted. Major activities of malaria control were focused on treatment of severe cases in hyper-endemic areas, key construction regions and among border defense forces (Huang and Lin, 1986).

Second period (1956–1977). The control project was incorporated into the national health program and large-scale malaria control activities was conducted in the country. Article 28 of the "National Program for Agricultural Development (Draft)" promulgated in late 1955, under the heading "Strive to eradicate the most deleterious infectious diseases", indicated that malaria was one of the target diseases to be eradicated wherever possible. Article 28 earmarked the commencement of programmed control of malaria in China, as part of a general mobilization for disease control. In 1956–1957, surveys of malaria were made in 17 provinces/autonomous regions/municipalities. The incidence of malaria was reduced following the implementation of extensive disease control strategies which included blood examination, case treatment, anti-relapse therapy and mosquito prevention and diminution. The incidence of malaria in 1958 accounted for 57.35% of that in 1956 (Zhang *et al*, 1988).

In this second period, serious epidemics of malaria occurred twice in China. In 1960, a prevailing epidemic, with vivax malaria as the predominant species, occurred in the northern part of China including the Huanghai and Jiangnan plains, ensuing from serious natural disasters. The number of cases increased from 1.58 million in 1959 to 10 million in 1960. The number of cases reported from Hebei, Shandong, Henan, Jiangsu and Anhui Provinces was 9.53 million. The second widespread epidemic of malaria was noted in 1970 due to the disbandment of antimalaria organizations during the upheaval of the "Cultural Revolution". The number of cases rapidly increased to more than 24 million in 1970. The important experience gained from the control of these two epidemics of malaria was that the consolidation of malaria control was a long-term undertaking (Zhang *et al*, 1988).

Third period (from 1978 on). This has involved consolidation of acquired knowledge and intensification of malaria surveillance. Previous experience in malaria control was used to solidify the antimalarial strategies, malaria control being implemented according to the principles of integrated measures and repeated practices, which is characterized by time- and locality-oriented approaches and is in line with the "law for control of infectious diseases in the People's Republic of China". Since 1978, a total of 282,000 health workers were trained in epidemiology, entomology, parasitology and malaria control. Relying on primary health care nets and community participation, about 503 million people in 18 provinces/autonomous regions/municipalities were under malaria surveillance. By means of the collaborative efforts of the masses and professional organizations for antimalarial activities, and by strengthening health centers at the grass-roots level with qualified staff, as well as implementing integrated antimalarial measures, malaria prevalence was under control in most of the endemic areas (Tang, 1990).

Microscopic examination of febrile patients was carried out widely in the endemic areas. Totally, 17,834 stations were established in different localities with a coverage of 502 million population. In 1989, 18,532,000 blood

slides were examined by microscopy. Parasitemia cases amounted to 61.1% of total reported cases, the remainder being diagnosed clinically. The establishment of microscopical stations plays an important role in case detection, case treatment, malaria situation analysis and prediction, and epidemic prevention (Advisory Committee on Parasitic Diseases, 1990).

FEATURES OF MALARIA CONTROL IN CHINA

Community participation

One of the outstanding features of malaria control in China is community participation. Several ten thousand administrators, health workers, and village doctors participate in the organization and propagation of antimalarial measures among the masses. Data collected from years 1979 to 1989 demonstrated that 14.58 million cases were cured, 187 million persons were treated during the quiescent phase of transmission, 343 million persons received prophylactic drugs during transmission seasons, and residual spraying of insecticides or application of immersed bednets covered areas with 163 million residents. The accomplishment of such arduous tasks has been realized with the active participation of the communities.

Malaria intersectoral linkage

Owing to the rapid transmission of malaria, especially in densely populated areas, it is difficult to consolidate the results of malaria control in a certain area. The provincial and regional intersectoral linkage, collaboration and coordination on a large scale in the active implementation of malaria control can improve the results of malaria control. In 1973, after a large outbreak occurred in the central provinces of Jiangsu, Shandong, Henan, Anhui and Hebei, malaria intersectoral linkage between the 5 provinces was formed under the auspices of the Ministry of Public Health. The linkage has significantly improved the antimalarial campaigns. In 1973, the case numbers reported from the five provinces were 12.987 million, which amounted to 86.0% of the total reported cases in the whole country (Department of Health and Epidemic Prevention, 1984). In 1989, the case

number was reduced to 0.056 million, accounting for 40.8% of that in the whole nation. The scope of malaria intersectoral linkage was expanded in these past ten years. In 1989, 14 provinces and autonomous regions established malaria intersectoral linkage at provincial/autonomous region or prefectural levels (Advisory Committee on Parasitic Diseases, 1990).

MALARIA RESEARCH

Scientific research on malaria is pursued in accordance with the principles of integration of laboratory and field studies, plus combination of pilot trials and extensive investigations as well. Applied research is especially encouraged so as to serve directly the disease control program. Investigations on epidemic characteristics and precipitating factors *Plasmodium* species, and fauna preference, ecology and transmission roles of mosquito species provided a scientific base for stratification of endemic areas and plotting of control strategies. In order to guide antimalarial campaigns, various pilot areas were selected for testing antimalarial measures. The valuable exper-

ience derived from these studies was used to modulate the overall malaria control work in the country.

Success occurred in drug research and large-scale synthesis, comprising chloguanide, cyclochlorguanide, chloroquine, pyrimethamine, primaquine, as well as drugs for treatment of falciparum malaria with chloroquine-resistance ie qinhaosu derivatives, pyronaridine and piperazine. In relation to these latter new antimalarials, Chinese scientists carried out systematic pharmacological, toxicological and clinical research. Rational treatment regimens were developed (Zhang, 1988).

Further understanding of the types of *P. vivax* isolates in China and their biological characteristics were acquired. Following the success in *in vitro* cultivation of *P. falciparum*, Chinese researchers have made some advances in shorter term cultivation of *Plasmodium vivax*. In recent years, drug-coated plates made in China were used to investigate the degree of chloroquine-resistance of *P. falciparum* and to survey other antimalarials. The investigations attained a fundamental understanding of distri-

Table 1

Some features related to malaria transmission in China.

Region	Transmission period	Species of <i>Plasmodium</i>	Vectors
South of 25° NL	9-12 months	<i>P. vivax</i>	<i>An. minimus*</i> , <i>An. dirus**</i>
	6-8 months	<i>P. falciparum*</i>	<i>An. j. candiagensis</i>
		<i>P. malariae</i>	<i>An. sinensis</i>
25-33° NL	6-8 months	<i>P. vivax*</i>	<i>An. sinensis*</i>
		<i>P. falciparum</i>	<i>An. anthropophagus**</i>
		<i>P. malariae</i>	<i>An. j. candiagensis</i>
North of 33° NL	3-6 months	<i>P. vivax</i>	<i>An. sinensis*</i> <i>An. messeae**</i>
North-west of 33° NL	Non-endemic area		

* major species

** major species in some localities

bution of drug-resistant *P. falciparum* in the country (Liu *et al*, 1986).

Other studies identified *An. anthropophagus* as the major vector for transmission of malaria in the region from 22° NL to 33° NL in China. Its efficiency in transmitting malaria was revealed to be about 20 times that of *An. sinensis*. Residual spraying and immersion of bed-nets provided effective measures against the vector (Liu *et al*, 1990). The sensitivity of major vectors to important insecticides was tested. *Bacillus calmette* 187, a biological product, was developed against mosquitos and has been assayed in pilot field studies. Experience was accumulated to control the rice-field breeding species of mosquito vectors by combined methods of agricultural production, soil-moistened irrigation and water drainage at regular intervals. Looking ahead, advances in biology, immunology, seroepidemiology and genetic engineering are expected to facilitate further improvement of antimalarial activities.

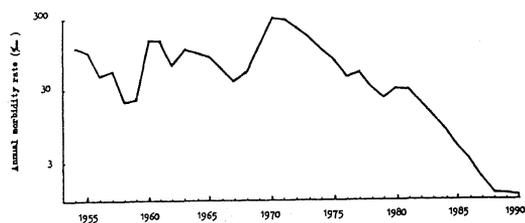


Fig 4 – The morbidity of malaria in 1954 – 1990, China

PRESENT STATUS OF MALARIA

As a result of active implementation of malaria control measures for more than 40 years, considerable success has been achieved. Areas of endemicity have been diminished, malaria hazards dramatically lessened and the morbidity rate markedly decreased (Fig 4) specially in the 1980s (Malaria Commission, 1986; Wang and Qian, 1988) although the total numbers of fatal cases have remained roughly the same (Table 2).

Table 2

Incidence of malaria in China (1980-1990).

Year	No. of cases	Incidence %	Lethal cases	Mortality per hundred thousand
1980	3,300,349	0.33783	64	0.00649
1981	3,059,635	0.30713	70	0.00653
1982	2,041,359	0.20340	61	0.00601
1983	1,377,647	0.13560	40	0.00390
1984	903,802	0.08770	32	0.00312
1985	563,400	0.05493	44	0.00424
1986	363,651	0.03475	48	0.00459
1987	210,614	0.01984	38	0.00358
1988	134,156	0.01244	53	0.00491
1989	137,540	0.01256	60	0.00547
1990	117,359	0.01056	35	0.00315

MALARIA CONTROL IN PR CHINA

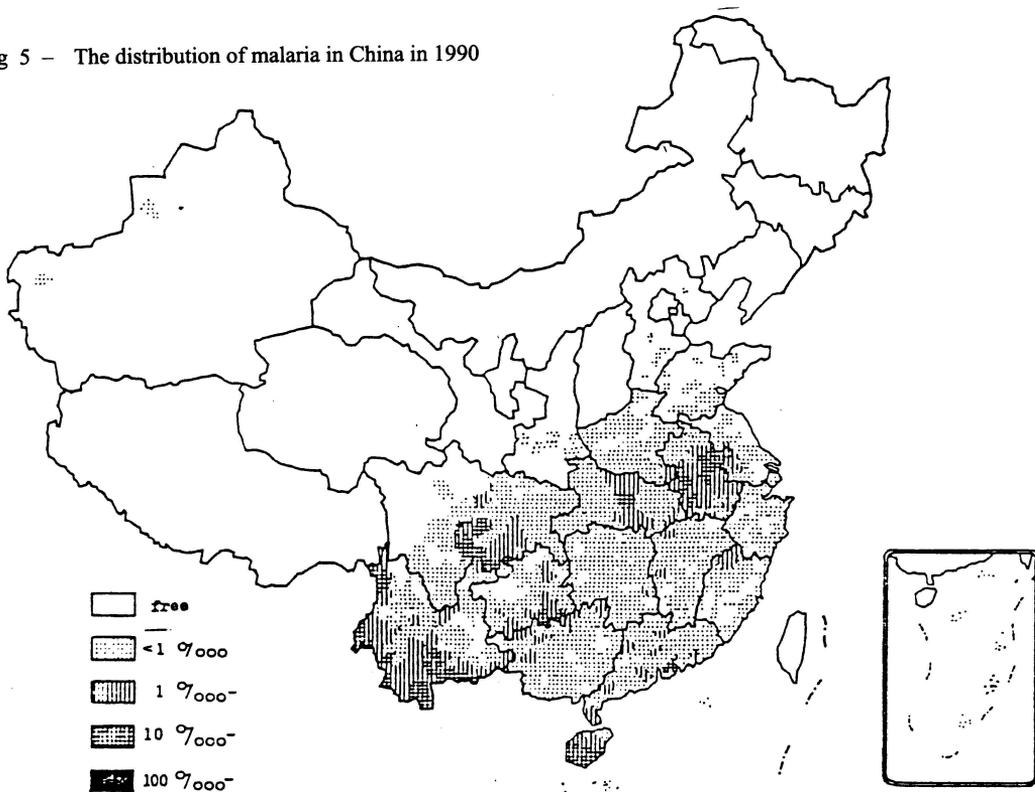
Data collected in 1990 revealed that there were 117 thousand malaria cases in China, the morbidity being 0.0106%, having dropped by 95% in comparison with that in the 1950s. The proportion of malaria cases among the total cases of 25 acute infectious diseases was reduced from 61.83% in 1954 to 3.55% in 1990. Most of the original hyperendemic areas became meso- or hypo-endemic areas and for most of the meso- or hypo-endemic areas, the disease became sporadically detected. Malaria distribution and endemic intensity also exhibited great changes (Fig 5).

In 1990, about 984 million people in 2,573 counties/cities lived in areas where malaria incidence was less than 0.1 per thousand (including original malaria-free areas as well as endemic areas now freed from the disease); 100 million people in 187 counties/cities with an incidence of 0.1–1.0 per thousand; 27 million in 69 counties/cities with an incidence of 1.1–10 per thousand, and 0.26 million in 2 counties with an incidence above 10 per thousand (Advisory Committee on Parasitic Diseases, 1991).

The parasite rates in the population were high in the early 1950s. In south and southwest parts of China, the parasite rate was 10–20%, the highest being over 60%. In the middle part of China, the parasite rate was 5–10% but when outbreaks occurred, over 50% rates were recorded (Chinese Association of Medicine, 1958). Surveys on 0.553 million inhabitants in longitudinal investigations in field and pilot areas in 15 provinces/autonomous regions/municipalities were undertaken in 1990: the average parasite rate had been reduced to 1.16% and 0.24%, respectively.

In the early 1950s, falciparum malaria was prevalent in all the 15 provinces/autonomous regions/municipalities south to 33° NL (Fig 6). Falciparum malaria cases accounted for 30% and 10–20% of the total malaria cases for hyper-endemic areas in the south part and in other provinces in the middle part of China, respectively. In the early 1960s, falciparum malaria accounted for 20–80% of the total cases when a malaria outbreak occurred in southern Anhui, Jiangsu and northern Zhejiang (Zhang *et*

Fig 5 – The distribution of malaria in China in 1990



al, 1988), but in 1990, indigenous falciparum malaria cases were found only in 58 counties of 4 provinces/autonomous regions (Fig 7), while non-indigenous falciparum cases were reported from 78 counties of 8 provinces/municipalities. Among parasitologically confirmed cases, 8.95% were falciparum malaria (including mixed infection) (Advisory Committee on Parasitic Diseases, 1991).

SUMMARY OF MAIN POINTS IN MALARIA CONTROL

1. Great attention was paid to the antimalarial program by the Central Government, which composed the administrative policy and technical guidelines for malaria control. Funding allocations and personnel recruitment assistance were offered to the units concerned at different levels.

2. Establishment of energetic and efficient antimalarial organizations, employment of qualified professionals, mobilization of community participation, transfer of appropriate

science and technology to the grass-roots level, and theoretical and practical training of antimalarial staff ensured the accomplishment and success of the control program.

3. Integrated control measures dealing with both prevention and treatment were applied; the emphasis was modified in different areas according to different vector species and environmental conditions to achieve the target of disease control.

4. Provincial and regional intersectoral linkages were strengthened, collaborative studies and the resulting synchronized efforts underscored progress in malaria control.

5. Scientific research in the areas of parasite biology, vector biology, immunodiagnosis, epidemiology and pharmaceutical chemistry greatly assisted the reduction of malaria in many endemic areas.

TECHNICAL PROBLEMS ENCOUNTERED

Although great success has been achieved in

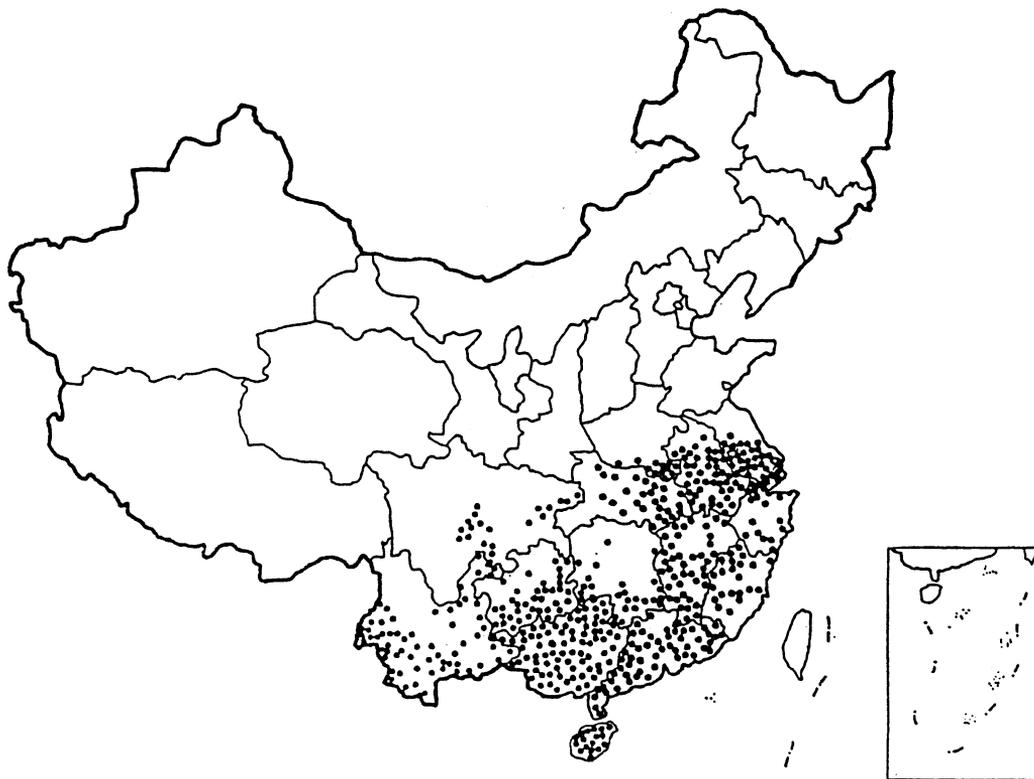


Fig 6 - The distribution of falciparum malaria in China before 1966

malaria control, in the countryside of south and middle parts of China malaria is still one of the important diseases impinging on people's health. There are some problems which hinder the progress of antimalarial activities. In the forest hilly regions of Hainan Province where *An. dirus*, the chief vector, is exophilic, residual spraying or use of insecticide-treated bednets are not effective for its control. The presence of chloroquine-resistant falciparum malaria in some areas has a tendency to spread; concurrently, the decrease of sensitivity to piperazine, pyronaridine and qinhausu derivatives has been observed. In addition, population movements have increased, especially in Yunnan Province but also in many other parts of the country, the primary health care nets have loosened and insecticides are often lacking (Zhou, 1985; Tang, 1990).

PERSPECTIVE

The national authorities responsible for malaria control recognize the current situation.

In order to consolidate existing achievements and to further decrease the disease incidence, intermediate and long term plans for malaria control have been drawn up, which stress the need to further strengthen scientific research and solve technical problems, to take steps to improve awareness and ability for self-protection in the community through various forms of education, and to consolidate the primary health care nets, so as to attain the ultimate objective of malaria eradication in the whole country. The target of the malaria control program by the year 2000 is to reduce malaria morbidity to less than 1 per ten thousand in the whole nation (Ministry of Public Health, 1991), coinciding with the target of the World Health Organization's "Health for all by the year 2000"

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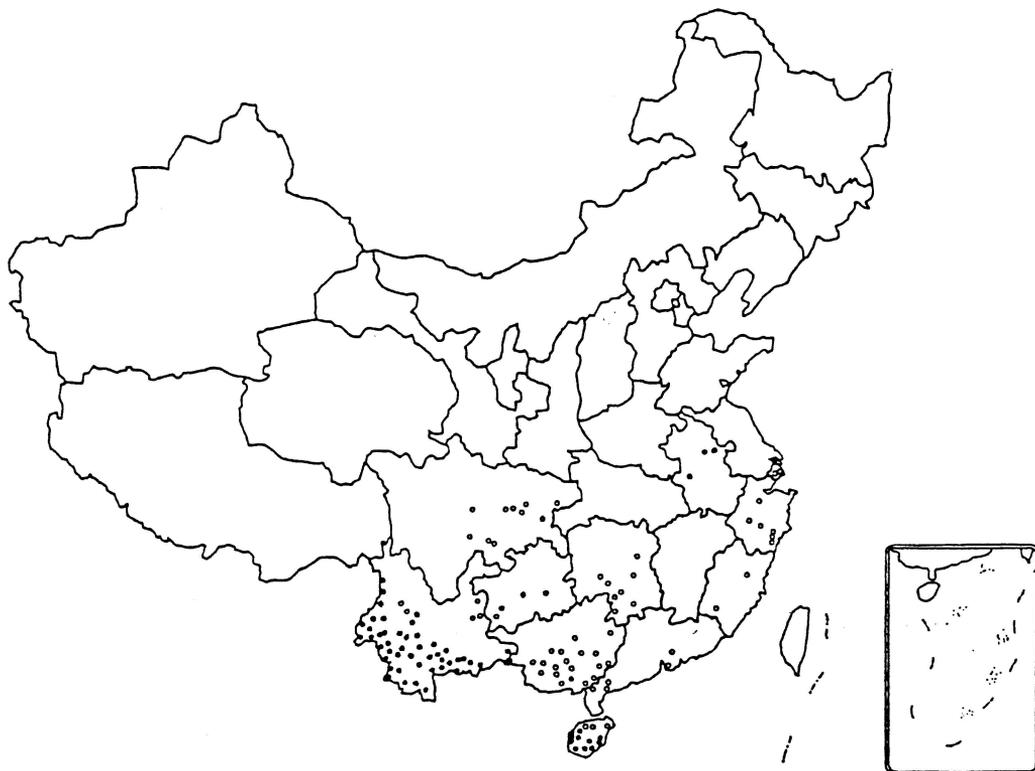


Fig 7 - The distribution of falciparum malaria in China in 1990

kindly revising the manuscript.

REFERENCES

- Advisory Committee on Parasitic Diseases, MOPH. Malaria situation in China. *Chin J Parasitol Parasitic Dis* 1990; 8: 241-4.
- Advisory Committee on Parasitic Diseases, MOPH. Malaria situation in China. *Chin J Parasitol Parasitic Dis* 1991; 9: (in press).
- Chinese Association of Medicine. Studies on malaria in new China. Shanghai: Scientific Health Publishing Press 1958.
- Deng D. Malaria. In: Geng GY, ed. *Epidemiology*. Beijing: People's Health Publishing House, 1980.
- Department of Control of Endemic Diseases, MOPH. Handbook of malaria control. Beijing: People's Health Publishing House, 1988.
- Department of Health and Epidemic Prevention, MOPH. Collection of papers on malaria intersection linkage in Jiangshu, Shangdong, Henan, Anhui and Hubei Provinces, 1984; 1-7.
- Huang SZ, Lin SX, eds. Public health in contemporary China. Beijing: Chinese Social Science Publishing House, 1986; 248-68.
- Li JW. Introduction on malaria history. *J Chin Tradit Med* 1963; 8: 24-6.
- Liu CF, Qian HL, Gu ZC, Pang JY, Zheng X. Comparative studies on the role of *Anopheles anthropophagus* and *Anopheles sinensis* in malaria transmission in China. *Chin J Epidemiol* 1990; 6: 360-3.
- Liu DQ, Qiu CP, Liu RJ, Qen DX. Investigation on extent and geographic distribution of chloroquine-resistant *Plasmodium falciparum* in China. *J Parasitol Parasitic Dis* 1986; 4: 81-5.
- Malaria Commission, Committee of Medical Sciences. Malaria situation in China, 1985. *J Parasitol Parasitic Dis* 1986; 4: 241-3.
- Ministry of Public Health. National program for malaria control 1983-1985. Documents 1983.
- Ministry of Public Health. National program for malaria control 1991-1995. Documents 1991.
- Ren DX, Liu CF, Zhang JX, et al. Plasmodium and malaria. In: Wu ZJ, ed. Chinese encyclopaedia of medicine: Parasitology and parasitic diseases. Shanghai: Shanghai Science Technology Publishing House, 1984.
- Tang LH. Malaria control in China [Abstract]. Bangkok: 5th Asia Congress on Rural Medicine, 1990; 145.
- Wang KA, Qian HL. The review of epidemic situation of malaria from 1977 to 1986. *Chin Dis Surveillance* 1988; 8: 5-8.
- Zhang BX, Sheng BL, Zhang HJ, et al. Malaria. In: Zheng G, ed. Historical experience on preventive medicine in new China. Beijing: People's Health Publishing House, 1988; 286-307.
- Zhang JX. Chemotherapy of protozoic diseases. In: Liu YH, ed. Chemotherapy of Parasitic Diseases. Chongqing: The North-west Normal University Press, 1988; 22-58.
- Zhou ZJ. Current status of malaria in China. Proceedings of the Asia and Pacific Conference on Malaria, 1985; 31-9.