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Insights

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Malaria elimination measures in Guangdong, China

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Malaria is an vector borne disease caused by *Anopheles* mosquito carrying *Plasmodium vivax*, *Plasmodium falciparum* and *Plasmodium malarie*. Historically, Guangdong province has been an endemic area of malaria. After the elimination of malaria in 2018, the main goal of malaria prevention and control in Guangdong has shifted to the prevention of imported malaria. In this article, we reviewed the whole elimination process of malaria in the epidemic area of Guangdong, which used to be one of the provinces with the most serious malaria prevalence in China.

From 1950s to the middle of 1980s, the annual incidence rate of malaria was between 0.0122%-1.8323%, and in 1990s, it fell to 0.0062%. After that, the malaria incidence continued to fall below 0.0010%[1]. In October 2010, Guangdong province has launched the malaria elimination work plan, and eventually eliminated malaria across the province in June 2018[2]. On 30 June 2021, the World Health Organization announced that China had been certified malaria-free[3] owing to the scientific and effective anti-malaria measures taken all over the country. According to the epidemic characteristics of malaria in different periods in Guangdong province, the national malaria control plan and the anti-malaria measures in Guangdong province were implemented in six stages.

From 1950 to 1959, over 560000 cases of malaria were reported annually in Guangdong province, with an average annual incidence rate of 1.8323% and an average annual mortality of 0.0009%[4], and most of them showed obvious clustering. Early at the founding of the People's Republic of China, human and material resources were extremely scarce. The large-scale Patriotic Health Campaign (eliminating the four pests) was the most important measure to prevent malaria. Concurrently, professional malaria prevention institutions and grass-roots malaria control networks were established; professional and technical personnel were trained; comprehensive case investigation was carried out to detect and treat patients timely. A thorough investigation was conducted in the whole province, probing into the morbidity, mortality, spleen swelling rate, protozoan rate, infant malaria new infection rate and malaria epidemic season investigation; treatment of existing patients was strengthened. In a survey of 14.5 million people in Guangdong, 60% belonged to the medium malaria area (splenomegaly rate of 10-25%), and the low malaria area (splenomegaly rate of less than 10%) accounted for about 40%[4]. Through the investigation, the epidemiological characteristics of malaria were basically found out, which laid a solid foundation for the formulation and implementation of malaria control programs.

The annual morbidity of malaria was 0.2066% in 1960s, accounting for 13.01% of the total number of acute infectious cases in the same period. Compared with 1960s, the annual morbidity decreased by 90.17% in 1970s, and the epidemic situation was relatively stable[4]. The measures implemented in Guangdong at this stage included carrying out the treatment for new cases and those with a history of malaria infection; strengthening the management of malaria patients and eradication treatment during the incubation period; actively carrying out comprehensive prevention and control measures such as epidemic point treatment; enhancing team building; establishing and improving testing institutions. The most important measure was characterized by universal dormancy eradication treatment and universal preventive medication every

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half month in epidemic season, together with the retreatment for children with malaria history under the age of 15 years and those with malaria history in that year. The morbidity of malaria has been greatly reduced due to the implementation of these measures, and the spread of the epidemic has been fully controlled.

In the 1980s, the construction of Shenzhen Special Administrative Region gathered a large number of migrant population, and the incidence of malaria increased year by year, spreading from Shenzhen to Huizhou and Dongguan. The annual incidence rate also increased from 0.0091% in 1980 to 0.0210% in 1985[4]. The management of mobile population was the most critical measure at this stage. Joint prevention and control measures have been put forward and implemented in different regions too. In 1990, Guangdong presided over the establishment of the "Shen-Dong-Hui" joint prevention and control zone of malaria, and Fengkai, Huaiji and Lianshan counties in the northwest also established joint defense and control with neighboring counties in Guangxi. The "Guangdong, Guangxi and Hainan" joint malaria control system was launched in 1991. Through joint prevention, those provinces have timely exchanged information on the epidemic situations, prevention and control, and case changes to promote regional anti-malaria progress. Mosquito eradiction and control was the most effective measure to control malaria at all stages (Figure 1).

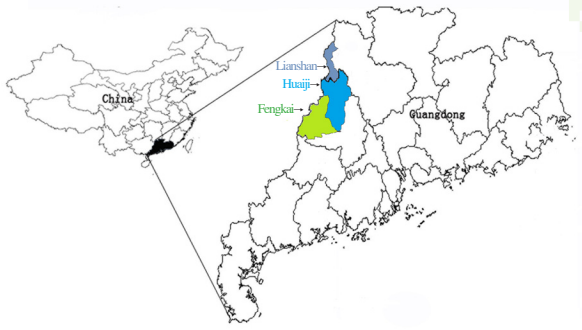

Figure 1. The location of Fengkai, Huaiji and Lianshan counties in Guangdong, China.

In 1987, Guangdong province first proposed the use of deltamethrin or permethrin soaked mosquito nets to prevent malaria vectors transmission. The implementation of the measure effectively controlled malaria transmission and reduced the incidence rate of malaria, and was favored and promoted by World Health Organization. Other important measures were summarized as "one prevention, three treatments and peak surpression". One prevention referred to preventing and killing mosquitoes and improving residents' awareness of self-protection; three treatments were standard treatment, phased treatment and dormancy eradication treatment; the peak surpression is the preventive medication during the epidemic season to reduce the peak incidence (throughout the whole epidmic season, preventive medication was applied to reduce peak incidence). Under the intervention of these measures, the epidemic characteristics of malaria in the whole province have changed from epidemic to local, and then to one case point or one outbreak point within one village (construction site) or several villages (construction site). In 1990s, malaria was basically eliminated, and the incidence rate decreased year by year, with an average annual incidence rate of 0.0062%[4].

From 2000 to 2009, the annual average morbidity was about 0.0005%. The malaria situation was stable across Guangdong province, and the number of cases decreased year by year. Most of them were sporadic imported cases, of which the number of cases brought mobile population accounted for 80%, mainly concentrated in the relatively developed Pearl River Delta region and the main malaria vector was *Anopheles sinensis*. The prevention and control measures included comprehensively carrying out the blood test of fever patients of three typical histories (traveling to malaria-endemic countries within the last 2 years, a blood transfusion within 2 weeks, previously being attacked by malaria); realizing 24-hour online case report (since 2003); continuing to strengthen the management of mobile population; and enhancing the diagnosis and treatment training in medical institutions. Briefly, strengthening monitoring, consolidating achievements, early detection, early treatment and early disposal were adopted at this stage. Obviously, the implementation of these measures has improved malaria monitoring and treatment capacity, consolidated the prevention and control achievements and reduced the number of local cases.

In 2010, Huidong County, Huizhou City reported the last case of local infection with *Plasmodium vivax* malaria. At this stage, the prevention and control strategy was transformed from "targeting high morbidity areas, reducing morbidity" to "controlling every case and epidemic point, blocking malaria transmission", and the prevention and control measures were generally clues tracking and source investigation. Therefore, an epidemic reporting and early warning network system covering the whole province has been established and improved. Meanwhile, a standard case treatment, blood test network for patients with unexplained fever, and "1-3-7" management mode of malaria cases were carried out, and the latter one referred to case report within one day, epidemiological investigation within three days and epidemic point disposal within seven days. Also, other effective measures included setting up provincial malaria reference laboratory; strengthening the training of medical personnel and microscopic inspectors, improving the technical level of professional technicians; providing disease control institutions at all levels with various anti-malarial treatment and drugs, employing standardized use of anti-malarial drugs; and enhancing supervision and evaluation to accelerate the elimination of malaria in the whole province. To guarantee the malaria containment, Guangdong has also launched publicity compaign on

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malaria prevention and control, advocated active communication and coordination between entry-exit inspection and quarantine departments, cultivated people's awareness and knowledge of malaria prevetion when going to high malaria areas, conducted malaria screening for inbound personnel from high malaria areas, and constantly strengthened the management and monitoring of imported malaria cases. Subsequently, there were no locally infected malaria cases and imported secondary cases for nine consecutive years, finally achieving the goal of malaria elimination. In addition, in order to explore the experience of malaria elimination, from 2010 to 2012, Guangdong province carried out a pilot study on malaria elimination in Meizhou Xingning City, class III county and Huicheng District, Huizhou City class II county. The pilot work provided a scientific basis for improving the national assessment and evaluation program for the elimination of malaria and promoting the national elimination of malaria.

With the elimination of malaria in Guangdong province, malaria cases have changed from local cases to only imported ones, which will be a long-term stage of malaria control in the future. The prevention and control measures have shifted to "timely detection and accurate blocking of transmission". In early 2020, with the global outbreak of COVID-19, strict immigration control measures were implemented. All the returnees were required to receive 14 days of quarantine observation. According to the characteristics of the epidemic situation, we have stressed the prevention and control strategy of multi-disease prevention in quarantine sites, and carried out rapid detection test (RDT), publicity and education for personnel returnees from malaria endemic areas[5]. Through rapid screening, more than 90% of the imported cases were detected in time at the quarantine sites. Guangdong province has become the province with the largest import of malaria in China. With the elimination of malaria in Guangdong, the pressure of malaria prevention and control will also be reduced. To a certain extent, it will lead to many problems, such as weak awareness of prevention and control, insufficient investment of funds, reduction and instability of professional team personnel, decline of detection ability and treatment level and other negative effects, which needs the attention and vigilance of the health administrative department.

Close government supervision and unified leadership are key to the success of malaria control. The establishment of malaria prevention professional institutions, teams and grass-roots malaria control networks were the technical guarantee. Strengthening publicity and education, mobilizing the masses and multi-sectoral joint prevention and control have paved the important foundation. In addition, we should take measures according to local conditions and classified guidance in combination with the characteristics of malaria incidence and the current situation of malaria control and monitoring, so as to achieve the final goal of one health of human and environment.

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Authors' contributions

Deng ZH contributed to the conception and design of the study. Wu D drafted and revised the manuscript. Lin RX, Pan B, Pei FQ contributed to the critical revision of the article. All authors contributed to the final version of the manuscript.

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