COMMENTARY

Malaria-free Certification in China: Achievements and Lessons Learned from the National Malaria Elimination Programme

Jun Feng^{1,2}, Li Zhang¹, Zhi-Gui Xia¹, Shui-Sen Zhou¹ and Ning Xiao^{1,2,*}

Abstract

Malaria was once one of the most severe public health problems in China. However, after 70 years of integrated interventions, substantial progress has been made, and remarkable milestones have been met in malaria elimination in China. On June 30th, 2021, China was officially certified as a malaria-free country by the World Health Organization. This paper highlights the achievements of, and lessons learned from the malaria elimination programme.

Key words: Malaria, Elimination, 1-3-7 approach, Control, China

Edited by:

Wei Wang, Jiangsu Institute of Parasitic Diseases, China

Reviewed by:

Lynn Soong, University of Texas Medical Branch, USA
Xiaoping Dong, Chinese Center for Disease Control and Prevention, China

*Corresponding author:

E-mail: xiaoning@nipd.chinacdc.cn (NX)

BACKGROUND

Currently, the world still faces great challenges in fighting against the scourge of malaria. In 2019, 87 countries reported a total of 229 million malaria cases worldwide, representing an increase of 1 million cases over the previous year, while the number of malaria deaths reached 409,000 [1]. Malaria was one of the most important public health problems, and it severely affected human health and economic and social development for approximately 4,000 years in China's history. Since 1949, China has strived to eliminate malaria. The national malaria control and elimination programmes were classified primarily into five phases: the key-point investigation and control phase (1949–1959), the severe epidemic control phase (1960–1979), the incidence reduction phase (1980–1999), the control achievement consolidation phase (2000–2009), and the elimination phase (2010–2020) (Table 1) [2,3]. Owing to the integrated strategies and interventions, indigenous malaria cases and malaria endemic areas have been

sharply reduced [4]. The National Malaria Elimination Action Plan (2010–2020) (NMEAP) was initiated in 2010, with the goal of eliminating malaria nationwide by the end of 2020 [5]. The plan has made great progress, and all 24 endemic provinces, including 258 endemic prefectures and 2,158 endemic counties, have completed malaria verification as scheduled (Fig 1). On June 30th, 2021, the World Health Organization (WHO) formally declared that China has been awarded a malaria-free certification.

EXPERIENCES AND LESSONS

During the 70 years of the battle against malaria, various integrated interventions have been used for malaria elimination under the principle of government leadership, multi-sectoral cooperation, and whole-society mobilization. The main achievements were as follows. First, the goal of malaria elimination nationwide was achieved as scheduled. After nearly 70 years of concerted efforts, a milestone of zero indigenous malaria cases was achieved

¹National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention (Chinese Center for Tropical Diseases Research), NHC Key Laboratory of Parasite and Vector Biology, WHO Collaborating Centre for Tropical Diseases, National Center for International Research on Tropical Diseases, Shanghai, People's Republic of China

²School of Global Health, Chinese Center for Tropical Diseases Research, Shanghai Jiao Tong University School of Medicine, Shanghai, People's Republic of China

Received: July 7 2021

Revised: July 14 2021

Accepted: July 15 2021

Published Online: July 23 2021

FIGURE 1 | Sub-national malaria verification progress in China, 2017–2020.

2017: Shanghai; 2018: Zhejiang and Jiangxi; 2019: Jiangsu, Anhui, Shandong, Guangdong, Guangxi, Hainan, Fujian, Henan, Hubei, Guizhou, Sichuan, Chongqing, Tibet, Xinjiang, Gansu, Shanxi, and Hebei; 2020: Liaoning, Yunnan, and Hunan.

TABLE 1 | Evolution of the national malaria control and elimination programme and corresponding strategies in China.

Phase	Time period (year)	Mean incidence (1/100,000)	Main strategies and interventions
Key-point investigation and control	1949–1959	555.85	The main task was organizing teams to carry out case investigations and malaria control activities. Professional institutions for malaria control were established successively in various regions.
Severe epidemic control	1960–1979	1,150.77	Large-scale malaria outbreaks were controlled through implementation of the control strategy with a focus on mass drug administration and infectious source control.
Incidence reduction	1980–1999	62.87	Various comprehensive control measures were used according to the epidemic characteristics of malaria and biological characteristics of malaria vectors.
Control achievement consolidation	2000–2009	2.87	The malaria control strategies comprising timely diagnosis and standard treatment, and integrated measures including medication for high-risk populations, vector control, and health education and promotion were intensified in malaria-endemic foci of the Huanghuai Plain region, where resurgence and local outbreaks of malaria occurred.
Elimination	2010–2020	—*	A classified malaria elimination strategy was implemented to achieve malaria elimination.

*Because imported malaria cases were predominant during the elimination phase, the real malaria incidence cannot be estimated.

across China for the first time in 2017 [2,6,7]; since then, no indigenous cases have been reported to date, thus meeting the national malaria elimination criteria set by the WHO. Second, the burden of malaria morbidity and mortality has fallen sharply. Before 1949, approximately 30 million malaria cases were reported in China annually, and the malaria mortality rate was approximately 1% [8]. As many as 1,829 counties (more than 70% of all counties in the country) were identified as endemic for malaria in China in the early 1950s [9]. Two large-scale outbreaks occurred in

China in the early 1960s and early 1970s. The peak was in 1970, with more than 24 million malaria cases nationwide, including 21.98 million reported in the Huanghuai Plain region. By 2010, however, the number of reported malaria cases decreased to 7,855 and accounted for only 0.23% of the total number of reported infectious diseases [10]. Moreover, the number of indigenous malaria cases decreased from 1,308 in 2011 to 0 in 2017 (and has remained at zero since then) [11,12]. The number of deaths with malaria has decreased from an annual mean of 2,653 cases in the 1950s

to 41 cases annually in the 2000s, and decreased to a mean of 17 cases per year by the 2010s. After 2010, all deaths due to malaria were imported cases [13]. Third, malaria elimination has promoted the country's overall social and economic development. The overall control of malaria epidemics has greatly reduced the disease burden of the entire population, enhanced public health system, and decreased the population's poverty caused by malaria in China. The prevention of a return to poverty due to malaria has also effectively ensured the health of the labor force.

In general, several main factors contribute to the success of malaria control and elimination in China. First, strong governmental leadership is essential. The central government developed a series of documents providing substantial guidance to help public health staff adopt appropriate technical strategies and measures to respond to malaria epidemics or outbreaks. Moreover, adequate funding support has demonstrated the strong political will in eliminating malaria. Since 2010, the central and provincial governments and the Global Fund against HIV/AIDS, Tuberculosis and Malaria have invested a total of 1.38 billion Chinese yuan as special funds to support the national malaria elimination programme at all levels. The regional and inter-sectoral collaboration called the Five Provinces Malaria Joint Control and Prevention Mechanism in central China (Jiangsu, Anhui, Shandong, Hubei, and Henan) was established in 1973, and Southern Three Provinces Malaria Joint Control and Prevention (Guangdong, Guangxi, and Hainan) was launched in 1992 [14,15]. Since 2017, 24 pre-endemic provinces have been divided into four Joint Regions. The regional collaboration mechanism has further enhanced the sharing of timely information and experience in managing the mobile population, and has improved the case management and foci response capacity of medical staff, thereby facilitating malaria elimination. Second, the case-based surveillance and response system has been crucial for malaria control and elimination. The case surveillance system in China has undergone an extensive transition. Malaria case reports were made monthly and delivered by local post between 1950 and 1985, or by telephone or other electronic means between 1985 and 2003; in 2004, reports were made in real time via the Infectious Diseases Information Reporting System [16]. An additional reporting system, the National Information Management System for Malaria, was established in 2011, in line with the transition from the control to the elimination phase, with the aims of ensuring prompt investigation and detection of each case, administration of appropriate treatment, and prevention of transmission re-establishment. This system was adopted to monitor and document cases within the time frame indicators by using the 1-3-7 approach [17], which has been demonstrated to be successful and may serve as a model for other countries [18,19]. Third, capacity building is crucial in malaria control and elimination. Annual training workshops have been organized and performed in China, including malaria detection at ports, malaria diagnosis and treatment at medical institutions, and

epidemiological investigation and foci disposal at CDCs. Meanwhile, on-site technical guidance and technology competitions were conducted to help maintain and update the skills of professional staff. A total of 24 reference laboratories for malaria diagnosis in pre-endemic provinces have been established. To support laboratory quality assurance measures for malaria diagnosis, at least one microscopist in each province of China has obtained WHO competency certifications. Fourth, science and technology have greatly supported malaria control and elimination. Basic science research and field studies have focused on strategies and key technologies, including pathogen biology, vector biology, diagnostics, antimalarial drugs, and control strategies. The timely transformation and application of those research results have clearly advanced science and technology for malaria control and elimination. Finally, global cooperation and information sharing is essential to promote malaria control and elimination in other countries. For example, since 2010, to reduce the malaria burden at the China-Myanmar border, local CDC staff on both sides of the border have conducted joint control and prevention activities, particularly information sharing regarding border-specific mobile population management and surveillance systems [20]. Moreover, China has initiated cooperative efforts in malaria control with countries in Africa and Southeast Asia, under the framework of the Belt and Road initiative. The China-UK-Tanzania malaria pilot project has aimed to improve malaria diagnosis, reporting, treatment, and tracking on the basis of the 1-3-7 approach and surveillance systems, and has explored a 1,7-mRCTR model for effectively reducing local malaria disease burden. This is one example of integrating the knowledge and lessons learned from the malaria control and elimination programme in pilot areas [21,22]. Through international cooperation, the goal of malaria elimination can be achieved in other countries and regions.

CONCLUSIONS

In summary, China has achieved great success with the malaria elimination programme and has been awarded a malaria-free certification by the WHO in 2021. China's active engagement and contributions to regional malaria elimination initiatives have helped promote malaria elimination efforts in neighboring countries where malaria remains a severe public health problem. Building on its 2021 milestone of malaria-free certification and sustainable national efforts, the country will adopt appropriate strategies and interventions to prevent the re-establishment of malaria transmission and assist highly endemic countries in their malaria control and elimination efforts by sharing China's experiences and products produced from the national malaria elimination programme. Our ultimate goal is to build a global community with a shared future public health and safety.

ACKNOWLEDGEMENTS

We thank all staff in the provincial CDCs in China.

FUNDING

The work was supported by the key techniques in collaborative prevention and control of major infectious diseases in the Belt and Road initiative (grant no. 2018ZX10101002-004).

COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

- World Health Organization. World Malaria Report 2020. Geneva; 2020.
- Feng J, Zhang L, Huang F, Yin JH, Tu H, Xia ZG, et al. Ready for malaria elimination: zero indigenous case reported in the People's Republic of China. *Malar J*. 2018;17:315.
- Feng J, Zhou SS. From control to elimination: the historical retrospect of malaria control and prevention in China. *Chin J Parasitol Parasit Dis*. 2019;37:505-513.
- Feng J, Tu H, Zhang L, Zhang S, Jiang S, Xia Z, et al. Mapping transmission foci to eliminate malaria in the People's Republic of China, 2010–2015: a retrospective analysis. *BMC Infect Dis*. 2018;18:115.
- Ministry of Health: National Malaria Elimination Action Plan (2010–2020). Beijing; 2010.
- Xiao N, Xu QL, Feng J, Xia ZG, Duan L, Wang DQ, et al. Approaching malaria elimination in China. *China CDC Wkly*. 2021;2:293-297.
- Feng J, Zhang L, Tu H, Zhou SS, Xia ZG. From elimination to post-elimination: characteristics, challenges and re-transmission preventing strategy of imported malaria in China. *Chin Trop Med* 2021;21:5-10.
- Zhou Z. Current status of malaria in China. In: *The Asia and Pacific Conference on Malaria*; 1985. pp. 31-39.
- LH T. Chinese achievements in malaria control and research. *Chin J Parasitol Parasit Dis*. 1999;17:257-259 [in Chinese].
- Zhou SS, Wand Y, Li Y. Malaria situation in the People's Republic of China in 2010. *Chin J Parasitol Parasit Dis*. 2011;29:401-403 [in Chinese].
- Xia ZG, Yang MN, Zhou SS. Malaria situation in the People's Republic of China in 2011. *Chin J Parasitol Parasit Dis*. 2012;30:419-422 [in Chinese].
- Zhang L, Jun F, Zhang SS, Xia ZG, Zhou SS. The progress of national malaria elimination and epidemiological characteristics of malaria in China in 2017. *Chin J Parasitol Parasit Dis*. 2018;36:201-209 [in Chinese].
- Zhang L, Hong T, Zhou SS, Xia ZG, Feng J. Malaria deaths – China, 2011–2020. *China CDC Wkly*. 2021;3:360-365.
- Kong XL, Liu Y, Wang WM, Xu X, Li KJ, Zhang HW. A retrospective analysis on the effectiveness of falciparum malaria joint control in Jiangsu, Anhui and Henan provinces. *Chin Trop Med*. 2016;16:986-988 [in Chinese].
- Li JH, Lin RX, Wang GZ. Evaluation on the effect of cooperative malaria control in the floating population of 3 provinces in 11 years. *J Appl Prev Med*. 2018;18:297-302 [in Chinese].
- Wang L, Wang Y, Jin S, Wu Z, Chin DP, Koplan JP, et al. Emergence and control of infectious diseases in China. *Lancet*. 2008;372:1598-1605.
- Cao J, Sturrock HJ, Cotter C, Zhou S, Zhou H, Liu Y, et al. Communicating and monitoring surveillance and response activities for malaria elimination: China's "1-3-7" strategy. *PLoS Med*. 2014;11:e1001642.
- Feng J, Liu J, Feng X, Zhang L, Xiao H, Xia Z. Towards malaria elimination: monitoring and evaluation of the "1-3-7" approach at the China–Myanmar border. *Am J Trop Med Hyg*. 2016;95:806-810.
- Wang D, Cotter C, Sun X, Bennett A, Gosling RD, Xiao N. Adapting the local response for malaria elimination through evaluation of the 1-3-7 system performance in the China–Myanmar border region. *Malar J*. 2017;16:54.
- Li S, Yin S, Wang J, Li X, Feng J. Shifting from control to elimination: analysis of malaria epidemiological characteristics in Tengchong County around China-Myanmar border, 2005–2014. *Malar J*. 2016;15:45.
- Wang D, Chaki P, Mlacha Y, Gavana T, Michael MG, Khatibu R, et al. Application of community-based and integrated strategy to reduce malaria disease burden in southern Tanzania: the study protocol of China–UK–Tanzania pilot project on malaria control. *Infect Dis Poverty*. 2019;8:4.
- Mlacha YP, Wang D, Chaki PP, Gavana T, Zhou Z, Michael MG, et al. Effectiveness of the innovative 1,7-malaria reactive community-based testing and response (1,7-mRCTR) approach on malaria burden reduction in Southeastern Tanzania. *Malar J*. 2020;19(1):292. doi: 10.1186/s12936-020-03363-w