Towards Malaria Elimination: Monitoring and Evaluation of the “1-3-7” Approach at the China–Myanmar Border

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Abstract. The surveillance and response system remains one of the biggest challenges to malaria elimination along the China–Myanmar border. In China, “1-3-7” approach was developed to guide elimination activities according to the National Malaria Elimination Program, which is a simplified set of targets that delineates responsibilities and actions. The time frame of the approach has been incorporated into the nationwide web-based disease reporting system: 1, case reporting within 1 day after diagnosis; 3, case investigation within 3 days; and 7, focus investigation and action within 7 days. Herein, the data on malaria cases in 2005–2014 and after the “1-3-7” implementation in 2013–2014 of the 18 counties at the China–Myanmar border are reviewed and analyzed. Results showed that the total cases decreased while the proportion of imported cases rose. The “1-3-7” was well executed, except for the “3” indicator, which was 96.3% accomplished on average in the 18 border counties, but needs to be further strengthened. More efforts are highlighted for timely and accurate case detection as well as proactive mapping of disease transmission hot spots to facilitate the elimination of border malaria.

INTRODUCTION

Malaria has been one of the most serious public health issues in China for a long time. The government has made certain achievements in controlling malaria over the past few decades, and the incidence has reached historically low levels.¹ In 2010, China launched the National Malaria Elimination Programme (NMEP), to eliminate local malaria transmission nationwide by 2020.² Accordingly, the national malaria surveillance and response system has been reshaped in line with the guidelines to rapidly detect and identify all malaria infections and ensure appropriate treatment before any secondary cases or local transmission may occur.^{3,4} The “1-3-7” approach, used by the NMEP in China to deliver and monitor the key elimination strategy including case reporting, investigation, and response, was described as a simplified set of targets that delineate responsibilities, actions, and the time frame: 1, case reporting within 1 day after diagnosis, 3, case investigation within 3 days, and 7, focus investigation and action within 7 days.⁵ The time frame “1” requires the local health staffs to report both the confirmed and suspected cases within 1 day through web-based reporting system. After that, a cell phone short message service alert system informs local Center for Disease Control (CDC) staff to timely conduct the case follow-up. The time frame “3” contains two parts: one is case confirmation by microscopy (then further by microscopy and polymerase chain reaction [PCR] in the provincial reference laboratory beyond 3 days), the other one is case classification, which requires the county CDC staff to determine whether the case was locally acquired

or imported. The time frame “7” contains two steps, the first step is to investigate the focus and its classification and the second step is to adopt the actions based on the results of the investigation. Reactive case detection (RACD), target anti-malarial administration, indoor residual spray (IRS), and information, education, and communication activities can be chosen in the active or potential focus.

To date, China's NMEP runs successfully in general, but malaria remains one of the biggest problems in Yunnan Province, particularly at the China–Myanmar border.⁶ For example, in 2005, the total reported malaria cases in the 18 border counties of Yunnan Province account for 5.0% (10,607/136,455) of all 37 infectious diseases in China. From 2005 to 2014, Yunnan Province reported nearly 25.4% (range 14.0–35.6%) of all malaria cases in China, and the 18 counties at the China–Myanmar border were responsible for around 70%.^{7,8} Another challenge is the locally-acquired transmission that has not yet been blocked in this region. In 2014, 46 indigenous cases were detected in the 18 border counties, making up 80.7% of all local cases throughout the whole country.⁹ Furthermore, infections from neighboring countries pose a crucial threat to this area because the borders are porous, and migrant populations pass through frequently. Myanmar has the heaviest malaria burden in the Great Mekong Subregion (GMS), and malaria control activities in this country was compromised because of the limited availability of curative services, the difficulties in accessing malarious areas, and the relatively high costs of effective treatment of multidrug-resistant malaria.¹⁰ In addition, the spread of artemisinin resistance that emerged in the Thai–Cambodian border may be catastrophic to malaria control and elimination in bordering counties in the GMS.^{11,12}

Data from the Chinese malaria surveillance system from 2005 to 2014 were used in this study, because the Chinese web-based disease reporting system was established in 2004 and data going back to 2005 were available. The performance of case detection and response strategy in the China–Myanmar border counties from 2013 to 2014 was evaluated to facilitate

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better planning of border malaria elimination and an evidence-based “1-3-7” that could be referred to by other countries with the similar elimination programs.

MATERIALS AND METHODS

Study site. The 18 counties at the China–Myanmar border, which have the highest prevalence of malaria in Yunnan Province, were selected for the performance evaluation of case detection and response strategy. The 18 border counties inhabited a total population of 480.7 million, with a borderline of 1,997 km (Figure 1). The cross-border trade, logging, quarry, and plantation activities are frequent in the border regions, which makes it difficult to manage the mobile population.

Anopheles sinensis is considered a major vector in the border, and malaria transmission had often taken place due to its high density under suitable conditions.¹³ But in the hilly bordering regions, *Anopheles minimus* is the predominant vector.¹⁴

Study design. Malaria data from 2005 to 2014 via web-based reporting system were carefully reviewed and analyzed.^{9,15–23} The data from Hong Kong, Macao, and Taiwan were not included for this statistics. Since the web-based information system could not provide the detail information of case classification as local transmission or imported from other country, it was obtained from the annual reporting system. Because the data of “1-3-7” implementation were available since 2013, herein we used the data from 2013 to 2014 via the web-based surveillance and reporting system specific to malaria elimination. The “1-3-7” may miss some data because it was not from the primary health facility records. Clinically diagnosed cases were defined as patients with malaria-like symptoms, but no parasites detected upon blood examination, and laboratory-confirmed cases were defined as cases confirmed using any of the diagnostic tests, such as PCR, rapid diagnostic tests (RDTs), and microscopy examination. Both types of cases were included in this analysis.

FIGURE 1. Mapping of 18 counties at the China–Myanmar border. Numbers indicated in the map represent as following: 1 = Gongshan 2 = Fugong, 3 = Lushui, 4 = Tengchong, 5 = Yingjiang, 6 = Longchuan, 7 = Ruili, 8 = Mangshi, 9 = Longlin, 10 = Zhenkang, 11 = Gengma, 12 = Cangyuan, 13 = Ximen, 14 = Menglian, 15 = Lancang, 16 = Menghai, 17 = Jinghong, and 18 = Mengla. The map was created using ArcGIS 10.1.

The map of the China–Myanmar border with 18 labeled counties was created using ArcGIS 10.1 (Environmental Systems Research Institute, Inc., Redlands, CA).

RESULTS

Malaria epidemiology. A total of 40,263 malaria cases occurred in the 18 border counties, accounting for 18.3% of total cases reported in China from 2005 to 2014 (Figure 2). Of all cases reported, 19,690 (48.9%) were locally acquired, and 2,916 (7.2%) were diagnosed as local *Plasmodium falciparum* cases. Despite a 96.3% decrease in total cases in the 18 border counties from 2005 ($N = 10,607$) to 2014 ($N = 392$), the proportion of locally acquired cases in the 18 border counties has increased from 15.6% to 82.1% nationwide²⁴ (Figure 2). The decline of the total cases in the 18 counties since 2006 was mainly due to the implementation of integrated strategy and effective interventions, such as the use of a timely and effective surveillance and response system to focus on the early diagnosis and appropriate treatment, focal vector control, case management among mobile populations, and health education and promotion.

The locally acquired transmission was mainly reported in the counties of Zhenkang ($N = 4,674$), Yingjiang ($N = 3,011$), Mangshi ($N = 2,545$), and Ruili ($N = 2,501$); these four counties took up 64.7% of all local cases in the 18 border counties from 2005 to 2014 (Figure 3). The scale of counties reported that local transmission was narrowed from 18 in 2005 to eight in 2014. In 2014, most of the local cases (71.7%, 33/46) occurred in Yingjiang County, neighboring with Kachin State Special Region 2 of Myanmar (Figure 3). In addition, the 18 border counties totally reported 61 death cases, and no death occurred since 2013.

Like the whole country, the imported malaria has been a great challenge to the border area.²⁵ From 2005 to 2014, 51.1% ($N = 20,573$) of the total cases were contributed to the imported cases and, particularly, in 2014, 346 imported cases were recorded, making up 88.3% of the total cases reported in the year. Myanmar was the main source country, which took up 80% of all the imported cases.

“1-3-7” implementation. All 858 malaria cases in the 18 counties were reported within 1 day in 2013–2014 (Supplemental Table 1). This was not surprise because this is the timeline required by law. The interval between the fever onset and diagnosis of that case was on average 8.5 days in the 18 counties.

Regarding the “3” indicator, the relative number of cases confirmed and investigated within 3 days was 96.3% on average in the 18 counties, with 92.4% in 2013 and 99.7% in 2014.

All the foci were investigated and classified within 7 days in the 18 counties. For the inactive foci, RACD was adopted to screen the contacts of “the focus” such as coworkers traveled to the same area. For the active and potential foci where viable vectors were identified, IRS and more intensive RACD were initiated, and no secondary cases were identified in the 18 border counties (Supplemental Table 1).

DISCUSSION

In China, the malaria surveillance and response in elimination stage includes refinement in both the spatial aspects of reporting and the timeliness of activities, which enables the rapid infections identification and transmission interruption. It was an important component in control activities leading

FIGURE 2. Malaria prevalence in 18 counties at the China–Myanmar border, 2005–2014. The columns of different colors show the change trend of total cases in 18 counties (black), total cases of China (gray). The black dash line indicated the malaria incidence of 18 border counties.

up to elimination, as indicated by data regarding the work on malaria in the People's Republic of China, United Republic of Tanzania, and Zanzibar.²⁶

Historically, high malaria morbidity and mortality rates have been reported in 24 provinces in China.²⁷ After the integrated strategy and control activities performed through primary health-care networks and community participation, including vector control interventions (such as insecticide treated nets, IRS combined with environment improvement,

case management, one radical medical treatment involving administration of primaquine alongside pyrimethamine or quinine, and prophylactic chemotherapy in high-transmission settings), malaria was reduced to low transmission levels and eliminated in most provinces.²⁸ Despite this, malaria at the China–Myanmar border is still a considerable problem for the NMEP in China. In this study, the malaria surveillance and response system in counties along the China–Myanmar border was evaluated and analyzed.

The “1-3-7” approach was rolled out in February 2012. It is defined as a means of guiding elimination activities. It was implemented in elimination settings where the goal was to investigate and respond to every case, as in many low-malaria-endemic countries. In the current findings, all cases were reported within 1 day in these border counties, as in other parts of China. This was not surprising because of the widespread usage of mobile phones and internet throughout. Despite this, the accuracy of diagnosis must be improved as it is the initial step for effective case management and quick public health response.

However, as noted by Moore and others, poor access to health services is a significant risk factor at the China–Myanmar border, and it can delay diagnosis.²⁹ This was also observed in the current work. Though the interval from fever onset to diagnosis was less than the national average (9.1 days), the interval in this area was still quite long. *Falciparum* malaria may be fatal if treatment is delayed beyond 24 hours after the onset of clinical symptoms, which means that training should be provided to physicians to ensure accurate diagnosis and appropriate treatment. Because the local malaria strains, both *P. vivax* and *P. falciparum*, persist in and around the border counties, and the gametophyte emerges 2–3 days after phorozoan, delayed diagnosis can increase the risk that the illness will be transmitted across the border and cause unnecessary death. A study performed in Iran also revealed that there may be striking differences in time interval between onset of symptoms and diagnosis because of the scarcity and varying quality of detection in malaria epidemics, and case management and epidemic preparedness and response must

FIGURE 3. Locally acquired transmission cases in 18 border counties in 2005 (green), 2010 (yellow), and 2014 (red). The total cases were classified into five section using Natural Breaks (Jenks) in the ArcGIS 10.1.

be improved.³⁰ Therefore, the most important for “1-3-7” approach is to ensure every infection entering the chain of “1-3-7” and timely access to diagnosis should continue to be strengthened at the border. Public awareness, diagnosis, capacity maintenance, and adequate supplies and equipment should be supplied. This could ultimately facilitate prompt diagnosis and treatment.³¹

Meanwhile, case confirmation and investigation within 3 days remains a challenge. This was partly because of the longer time required to transport and process samples, which can delay the diagnostic result. Another factor is the great difficulty of tracking cases in the mobile population at the border.³² Currently in China, malaria case follows the principle of localized management. This means that the case investigation of mobile population is carried out by the local county CDC, whom will send the information to the CDC where the patient lived, then the CDC where the patient lived will adopt the foci response according to the result of the foci investigation. In addition, when investigating cases, the classification of local and imported *P. vivax* should be performed carefully due to the risk of relapses and recrudescence infections, and this is also a challenge at the border.

However, the “7” was performed well with the current “1” and “3” in the border. In foci investigation and disposal, microscopy and RDTs were used to screen the close contacts of index case including the family and neighboring households. If the parasite carrier is detected, then each one in the foci should be screened using microscopy and RDTs. In this research, none of the secondary cases were identified in the RACD, though a number of individuals were screened in the foci response. Because the local transmission is still not blocked in the China–Myanmar border, it is likely that low density infections are being missed. To avoid missing the low parasitemia infections, filter paper of dried blood spots were kept for PCR detection, indicating that more sensitive point-of-care detection technology should also be developed to facilitate case investigation and treatment.

At the malaria elimination stage, surveillance and response system should be highly vigilant and effective to remove or avoid any transmission. Given that the mapped hot spots exhibit the infected households at most risk, the RACD become the most widely adopted surveillance and response approach for malaria elimination that targets a household or groups of households and other contacts of passively detected cases in a focus and is often deployed in combination with vector control and community education and participation.³³ China’s “1-3-7” approach is one of the ways to practice such a reactive surveillance and response and has been proved effective in reducing the local transmission even in China–Myanmar border of Yunnan Province. However, in recent years, the indigenous cases were still prevalent in some of the counties of this area, suggesting more active actions are needed to achieve the ultimate malaria-eliminating goal on schedule besides the abovementioned improvements to “1-3-7”. Proactive mapping of disease transmission hot spots and the genetic diversity and population dynamics are effective means of facilitating early detection, allowing prompt treatment using efficacious drugs.³⁴ Referring to the elimination program in China, specific response packages should be tailored.²⁶ For example, imported *P. falciparum* was predominant in Jiangsu Province, while in Motuo County of Tibet and China–Myanmar border in

Yunnan Province, *P. vivax* was still prevalent with mixed *P. falciparum* and *P. vivax* infection.²⁴ Therefore, the prioritizing of surveillance and response activities based on different risk characteristics of malaria transmission is suggested for achieving the entire malaria elimination.

CONCLUSIONS

In conclusion, a surveillance and response system is important during the elimination stage, and must be carefully planned and well managed to ensure timely transmission recognition and prompt response. The current findings showed that the China “1-3-7” approach has been well executed even in the most difficult border areas. However, public awareness of malaria must be increased and more plentiful supplies and equipment should be made available. Moreover, to achieve the elimination of border malaria as scheduled, proactive mapping of disease transmission hot spots and the genetic diversity and population dynamics will be effective means of facilitating early detection and interruption of the remaining transmissions.

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REFERENCES

- Li YN, Wen L, Li CY, Zhang WY, Sun HL, Zou W, Li SL, Sun YS, 2013. Descriptive analysis of trends of malaria prevalence in China from 2006 to 2010. *Chin Pub Health* 29: 263–265.
- Ministry of Health, 2010. *National Malaria Elimination Action Plan (2010–2020)*. Beijing, China: Ministry of Health.
- Ministry of Health, 2012. *Guideline on Malaria Surveillance during Elimination*. Beijing, China: Ministry of Health.
- Ministry of Health, 2011. *Guideline on Malaria Technology during Elimination*. Beijing, China: Ministry of Health.
- Cao J, Sturrock HJ, Cotter C, Zhou S, Zhou H, Liu Y, Tang L, Gosling RD, Feachem RG, Gao Q, 2014. Communicating and monitoring surveillance and response activities for malaria elimination: China’s “1-3-7” strategy. *PLoS Med* 11: e1001642.
- Yin JH, Yang MN, Zhou SS, Wang Y, Feng J, Xia ZG, 2013. Changing malaria transmission and implications in China towards National Malaria Elimination Programme between 2010 and 2012. *PLoS One* 8: e74228.
- Zhang JM, Wu LO, Yang HL, Duan QX, Shi M, Yang ZQ, 2008. Malaria prevalence and control in Yunnan Province. *J Pathol Biol* 3: 950–952.
- Li HX, Jiang H, Yang YC, Li ZH, 2006. Analysis of current malaria prevalent situation in Yunnan Province from 2002 to 2004. *Chin Trop Med* 6: 1942–1944.

9. Zhang L, Zhou SS, Feng J, Fang W, Xia ZG, 2015. Malaria situation in the People's Republic of China in 2014. *Chin J Parasitol Parasit Dis* 33: 319–326.
10. Smithuis FM, Kyaw MK, Phe UO, van der Broek I, Katterman N, Rogers C, Almeida P, Kager PA, Stepniewska K, Lubell Y, Simpson JA, White NJ, 2013. The effect of insecticide-treated bed nets on the incidence and prevalence of malaria in children in an area of unstable seasonal transmission in western Myanmar. *Malar J* 12: 363.
11. Dondorp AM, Nosten F, Yi P, Das D, Phyo AP, Tarning J, Lwin KM, Arie F, Hanpithakpong W, Lee SJ, Ringwald P, Silamut K, Imwong M, Chotivanich K, Lim P, Herdman T, An SS, Yeung S, Singhasivanon P, Day NP, Lindegardh N, Socheat D, White NJ, 2009. Artemisinin resistance in *Plasmodium falciparum* malaria. *N Engl J Med* 361: 455–467.
12. Ashley EA, Dhorda M, Fairhurst RM, Amaratunga C, Lim P, Suon S, Sreng S, Anderson JM, Mao S, Sam B, Sopha C, Chhor CM, Nguon C, Sovannaroeth S, Pukrittayakamee S, Jittamala P, Chotivanich K, Chutasmit K, Suchatsoonthorn C, Runcharoen R, Hien TT, Thuy-Nhien NT, Thanh NV, Phu NH, Htut Y, Han KT, Aye KH, Mokuolu OA, Olaosebikan RR, Folaranmi OO, Mayxay M, Khanthavong M, Hongvanthong B, Newton PN, Onyamboko MA, Fanello CI, Tshefu AK, Mishra N, Valecha N, Phyo AP, Nosten F, Yi P, Tripura R, Borrmann S, Bashraheil M, Peshu J, Faiz MA, Ghose A, Hossain MA, Samad R, Rahman MR, Hasan MM, Islam A, Miotto O, Amato R, MacInnis B, Stalker J, Kwiatkowski DP, Bozdech Z, Jeeyapant A, Cheah PY, Sakulthaew T, Chalk J, Intharabut B, Silamut K, Lee SJ, Vihokhern B, Kunasol C, Imwong M, Tarning J, Taylor WJ, Yeung S, Woodrow CJ, Flegg JA, Das D, Smith J, Venkatesan M, Plowe CV, Stepniewska K, Guerin PJ, Dondorp AM, Day NP, White NJ; Tracking Resistance to Artemisinin Collaboration (TRAC), 2014. Spread of artemisinin resistance in *Plasmodium falciparum* malaria. *N Engl J Med* 371: 411–423.
13. Zhou DC, Zhao FM, Yang SK, Fang KP, Shen CL, Li B, 2010. Study on the distribution and the major vectors of *Anopheles* from 1989 to 2008 in Ning'er County. *Chin Pathol Biol* 5: 10003–10004.
14. Huang JX, Xia ZG, Zhou SS, Pu XJ, Hu MG, Huang DC, Ren ZP, Zhang SS, Yang MN, Wang DQ, Wang JF, 2015. Spatio-temporal analysis of malaria vectors in national malaria surveillance sites in China. *Parasit Vectors* 8: 146.
15. Zhou SS, Wang Y, Tang LH, 2006. Malaria situation in the People's Republic of China in 2005. *Chin J Parasitol Parasit Dis* 24: 401–403.
16. Zhou SS, Wang Y, Tang LH, 2007. Malaria situation in the People's Republic of China in 2006. *Chin J Parasitol Parasit Dis* 25: 439–441.
17. Zhou SS, Wang Y, Fang W, Tang LH, 2008. Malaria situation in the People's Republic of China in 2007. *Chin J Parasitol Parasit Dis* 26: 401–403.
18. Zhou SS, Wang Y, Fang W, Tang LH, 2009. Malaria situation in the People's Republic of China in 2008. *Chin J Parasitol Parasit Dis* 27: 455–456.
19. Zhou SS, Wang Y, Xia ZG, 2011. Malaria situation in the People's Republic of China in 2009. *Chin J Parasitol Parasit Dis* 29: 1–3.
20. Zhou SS, Wang Y, Li Y, 2011. Malaria situation in the People's Republic of China in 2010. *Chin J Parasitol Parasit Dis* 29: 401–403.
21. Xia ZG, Yang MN, Zhou SS, 2012. Malaria situation in the People's Republic of China in 2011. *Chin J Parasitol Parasit Dis* 30: 419–422.
22. Xia ZG, Feng J, Zhou SS, 2013. Malaria situation in the People's Republic of China in 2012. *Chin J Parasitol Parasit Dis* 31: 413–418.
23. Zhang L, Feng J, Xia ZG, 2014. Malaria situation in the People's Republic of China in 2013. *Chin J Parasitol Parasit Dis* 32: 407–413.
24. Feng J, Xiao H, Xia Z, Zhang L, Xiao N, 2015. Analysis of malaria epidemiological characteristics in the People's Republic of China, 2004–2013. *Am J Trop Med Hyg* 93: 293–299.
25. Feng J, Xia ZG, Yang WZ, Zhou SS, Xiao N, 2014. Preparedness for malaria resurgence in China: case study on imported cases in 2000–2012. *Adv Parasitol* 86: 231–265.
26. Yang GJ, Tanner M, Utzinger J, Malone JB, Bergquist R, Chan EY, Gao Q, Zhou XN, 2012. Malaria surveillance-response strategies in different transmission zones of the People's Republic of China: preparing for climate change. *Malar J* 11: 426.
27. Ho CF, Lan C, 1965. Studies on malaria in New China. *Chin Med J* 84: 491–497.
28. Yin JH, Zhou SS, Xia ZG, Wang RB, Qian YJ, Yang WZ, Zhou XN, 2014. Historical patterns of malaria transmission in China. *Adv Parasitol* 86: 1–19.
29. Moore SJ, Min X, Hill N, Jones C, Zaixing Z, Cameron MM, 2008. Border malaria in China: knowledge and use of personal protection by minority populations and implications for malaria control: a questionnaire-based survey. *BMC Public Health* 8: 344.
30. Raiesi A, Nikpour F, Ansari-Moghaddam A, Ranjbar M, Rakhshani F, Mohammadi M, Haghdost A, Taghizadeh-Asl R, Sakeni M, Safari R, Saffari M, 2011. Baseline results of the first malaria indicator survey in Iran at the health facility level. *Malar J* 10: 319.
31. Zheng CJ, Zhang Q, Li HZ, 2010. Analysis on the diagnosis and report of malaria cases in China during 2005–2008. *Chin J Dis Contr Prev* 14: 507–509.
32. Carrara VI, Lwin KM, Phyo AP, Ashley E, Wiladphaingern J, Sriprawat K, Rijken M, Boel M, McGready R, Proux S, Chu C, Singhasivanon P, White N, Nosten F, 2013. Malaria burden and artemisinin resistance in the mobile and migrant population on the Thai-Myanmar border, 1999–2011: an observational study. *PLoS Med* 10: e1001398.
33. Moonen B, Cohen JM, Snow RW, Slutsker L, Drakeley C, Smith DL, Abeyasinghe RR, Rodriguez MH, Maharaj R, Tanner M, Targett G, 2010. Operational strategies to achieve and maintain malaria elimination. *Lancet* 376: 1592–1603.
34. Tambo E, Ai L, Zhou X, Chen JH, Hu W, Bergquist R, Guo JG, Utzinger J, Tanner M, Zhou XN, 2014. Surveillance-response systems: the key to elimination of tropical diseases. *Infect Dis Poverty* 3: 17.