

Evaluation of a grid-based surveillance strategy to ensure elimination and prevent reintroduction of malaria in high-risk border communities in China

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Abstract

Grid management is a grassroots governance strategy widely implemented in China since 2004 to improve the government's efficiency to actively find and solve problems among populated regions. A grid-based strategy surveillancing high-risk groups, including mobile and migrant populations (MMPs), in the China–Myanmar border region has played an indispensable role in promoting and sustaining malaria elimination efforts by tracking and timely identification of potential importation or reintroduction of malaria among MMPs. This paper distills the implementation mechanism of the grid-based strategy for malaria surveillance and highlights the role of the grid-based strategy in the elimination and prevention of reestablishment of malaria transmission.

Introduction

The World Health Organization (WHO) awarded China malaria-free certification on June 30, 2021[1]. Despite this achievement, Yunnan Province, located in southwestern China, faces the risk of malaria resurgence threatening China's efforts to prevent the re-establishment of malaria [2]. The geography of Yunnan Province includes lowlands and steep altitudes up to 6,740m, and enjoys a climate ranging from tropical to subzero with varying suitability for mosquito breeding. Yunnan Province belongs to the Greater Mekong Subregion (GMS), which shares a 4,060km long porous, natural, barrierless border with malaria-endemic countries, particularly along the Myanmar border. Approximately 30% of the nearly 3,000 imported cases in China every year are reported from this border region largely due to frequent local population movement. 2,219 imported malaria cases were reported between 2014–2019, accounting for 97.2% of the total reported cases in Yunnan Province.[3] The potential spread of artemisinin-resistant *Plasmodium falciparum* threatens malaria elimination and prevention of reestablishment efforts in this border region. Furthermore, poor access to local health services poses significant risks to this border region. The Yunnan border area is the most underdeveloped province within China, and the residents living in these marginalized regions are at high risk for malaria infection, especially mobile and migrant populations (MMPs) who cross the border daily through informal border-crossing points for business, schooling, or medical care. [4]. Moreover, active case screenings conducted by the local malaria program in the community may be unable to track MMPs who traveled from high-transmission areas. Therefore, to prevent re-introduction of malaria to eliminated areas, it is important to improve access to malaria screening, diagnosis, treatment and prevention to MMPs who move around the border areas and are at high risk of getting malaria infection.

To maintain malaria freedom, detecting and treating infections in cross-border MMPs is important. However, the traditional health system surveillance and response system may miss these populations. For these reasons the China malaria elimination program has utilised an extension of the government administrative system, the Grid System, to try and reach such populations. The Grid System is a grassroots governance strategy that reallocates administrative resources at a neighborhood level and provides necessary trainings to community members, which originated from the 2003 SARS crisis, [5, 6] and is maintained by the Chinese government in case of social crisis. The term “grid” was introduced as

the lowest level of urban governance below urban communities, covering a small area of roughly 10 km². A grid administrator, from the community and selected by the local community as part of the broader administrative system, monitors the community members while at the same time provides services to the local community. The grid-based strategy relies on a variety of techniques, such as information sharing, following-up evaluations of people's satisfaction levels, and liaising with political-legal agencies such as the police, judiciary, and wider administrative systems [7]. The effectiveness of the grid-based strategy has been evaluated during dengue fever outbreaks in urban and rural settings [8, 9], and its value has become more prominent during the COVID-19 pandemic [10].

The grid-based strategy among MMPs in the China–Myanmar border region has played an indispensable role in promoting malaria elimination efforts. It supports the tracking and timely identification of any potential importation or reintroduction of malaria among MMPs in this border region. This paper aims to distill the operational mechanism of the grid-based strategy for malaria elimination in the China–Myanmar border region, and emphasizes the role of the grid-based strategy in elimination and preventing the reestablishment of transmission.

Methods

Study areas

Yunnan Province—situated in the southwestern part of China with an area of 394,000 km² and 4,061 km of border with Myanmar – has a population of 45 million. The rural population along this border area is among the poorest in China with an average annual gross domestic product per capita of <US\$ 100 [11]. Historically, Yunnan Province has stable malaria endemicity due to its mountainous valleys, proximity to the Indian Ocean and a Pacific monsoon climate along with frequent human movement contributing to the highest burden of malaria in the areas that border Myanmar. The border areas face many challenges including continuous importation of malaria infections, increases in population movement and wide distribution of efficient vectors [12].

Study design

A mixed methods retrospective study including the quantitative and qualitative survey and analysis of the grid-based surveillance strategy was conducted.

Study sites and population

Tengchong County was chosen based on having the highest malaria incidence in China–Myanmar border region from 1 January 2013 to 31 December 2020. A total of 36 key stakeholders including 4 participants from county-level centers for disease control (CDC) and 32 participants from 16 township hospitals (2 from each sample hospital) having at least 3 years of experience in malaria control and elimination were selected to assess the practices of a grid-based strategy on malaria control and elimination.

Study procedures

To understand the implementation of the *China Malaria Elimination Action Plan (2010-2020)* in the Yunnan border area and all the adaptation that took place with the grid-based approach, questionnaires were administered to the sampled township hospitals and county CDC personnel involved in case reporting, case investigation, and reactive case detection (RACD) activities. A total of 36 individuals divided by 4 groups were interviewed through focus group discussion to assess the knowledge and practices of malaria case tracking, case reporting, case investigation, and RACD through the grid-based strategy. Data on risk population, malaria case reporting, case investigation, and RACD were extracted from the patients registered in local CDC and 16 township hospitals for the 7-year period from 1 January 2013 to 31 December 2020.

Quality control and data collection

The study protocol was developed and finalized with inputs from stakeholders as well as experts in malaria control and elimination. A pre-survey was conducted and the questionnaire was finalized before start of the study. This study has been approved by the Ethical Review Committee of Chinese Center for Disease Control and Prevention. Written informed consent was obtained from each respondent. Data were collected using Microsoft Excel and data were double entered. All data were summarized and verified with the township hospitals and local CDC within 15 days after completion of field survey.

Results

Operational mechanism of the grid-based surveillance strategy

Tengchong, the border county to Myanmar, reported the most imported malaria cases in Yunnan Province during 2013–2019 [13], has implemented the grid-based strategy for malaria community case management since 2016[14]. The county has a vertical-horizontal combined structure monitoring MMPs: The vertical structure reports the MMPs' information from the village to township to county and to provincial levels then up to the national level to the Migrant Population Service Center (MPSC), an affiliation to the National Health Commission, through the annual China Migrants Dynamic Survey (CMDS) program (<https://www.chinaldrk.org.cn/>). The targeted MMPs are people older than 15 years, whose registered permanent residence (also called 'Hukou') who do not belong to the locality and have stayed for more than one month in a place. The CMDS requests two types of surveys: one for MMPs and one for the village/residential committees. For MMPs, the surveys collect information on: (1) family members and family income/expenditure; (2) employment status; (3) basic public health and family planning services, and; (4) medical and health services for the elderly. For the village/residential committees, the survey collects information on: (1) basic status of the village population; (2) community health education, and; (3) public health service management. [15]

The horizontal structure is characterized by the grid-based strategy across the communities. It supports the annual national MMPs survey as well as takes the responsibility of day-to-day MMPs surveillance. In

Tengchong County, the 'grid' unit is composed of community groups, village doctor, and village committee (Figure 1). The grid administrator, usually represented by the leader of the community groups who is selected by or volunteered from the local community, collects the necessary information (i.e. travel plan/history) on MMPs within the community and submits the information to the officer at the point-of-entry copied to the local village committee and village doctor through a mobile messaging application. The village committee is responsible for checking and registering the information. In some villages, for example, in Jietou village, the village committee convenes monthly meetings with the village doctor to confirm the information of MMPs. Nevertheless, the information from the grid administrator and the village committee are not the only sources of information for the village doctors. As a supplement, the village doctors also register the MMPs missed by the formal registration process during healthcare delivery. With this information, the village doctor develops a detailed spreadsheet with MMP departure and arrival information. The arrival and departure information includes the date and duration of travel, point-of-entry/exit, travel destination, and companion information. Based on this relevant information, the village doctor can identify high-risk populations and deliver targeted services, such as health education on malaria prevention, deliver long lasting insecticide-treated bednets and other preventive tools for those who are ready to depart, refer febrile and suspected patients to higher-level medical facilities, follow-up case treatment, and assist the local county Centers for Disease Control and Prevention (CDCs) on foci investigation and clearance, and supervise implementation of the spring treatment.

Outcome of the grid-based malaria surveillance strategy

The application of the grid-based strategy allows for a more targeted proactive surveillance approach based on known high-risk populations. As indicated in Table 1, the implementation of a grid-based strategy has increased the screening positivity rate, which rose from 1.04–2.71% (through universal screening) in 2013–2015 to 31.8–56.14% in 2016–2020 by screening the identified (targeted) high-risk populations in these border areas. As a result of early detection and response to imported cases, there were no local malaria cases for five consecutive years from 2016 to 2020 in Tengchong County, which reported the most imported malaria cases during 2013–2019. Tengchong County became the first county to pass the national evaluation of malaria elimination in 2016 among the 18 counties in this border region, and two years ahead of the original timeline [16].

Table 1

Positivity rate of MMPs (%) before and after the implementation of the grid-based strategy in Tengchong County, China–Myanmar border region

Elements	Before grid-based strategy			After grid-based strategy				
	2013	2014	2015	2016	2017	2018	2019	2020
MMPs	13215	11372	5424	3177	2325	1859	2014	1533
At-risk pop.	13215	11372	5424	114	95	51	62	74
Identified cases	138	125	147	64	35	18	22	23
Positivity rate	1.04	1.10	2.71	56.14	36.84	35.29	35.48	31.08

Note: MMPs, mobile and migrant populations

Adaptation of the grid-based surveillance strategy in practice

According to the National Malaria Elimination Action Plan (2010–2020), township-level health facilities are the lowest units that diagnose, treat, and follow up malaria cases in China’s malaria elimination program structure. Yet, when malaria incidence was high in these border areas, community surveillance, case management, and response activities were shifted to the grid strategy engaging the village doctors, village committees, and community groups. This strategy remained in place through the successful elimination of malaria and ongoing prevention of reestablishment. The grid approach for malaria management has been adapted in the villages varied from high and low malaria incidence stages with shifted duties of village doctors. The results of the interview shows that, during the high malaria incidence stage, the grid-based village doctors supported the preliminary screening of malaria patients using malaria rapid diagnostic tests, referred positive patients to higher-level health facilities, and supported case investigation with local CDCs, as well as supporting the implementation of seasonal malaria chemoprevention. While in the low malaria incidence stage, the grid-based village doctors help identify the at-risk MMPs and take over the role of township health centers to follow up treatment compliance and outcomes as malaria incidence decreased. (Table 2).

Table 2

Adapted practices for community case management of malaria in different incidence stages and addressed issues through grid-based strategy in Tengchong County, China–Myanmar border region

Elements	High malaria incidence stage (normally >1% at village level)	Low malaria incidence stage (normally <1% at village level)	Addressed issues
Diagnosis	Village doctors conduct initial diagnosis by mRDTs and/or clinical symptom (fever), and refer to the township health center for further confirmation (by mRDTs and/or microscopy)	Village doctors identify high-risk populations (mobile population) and refer them to the township health center for further confirmation (by mRDTs and/or microscopy)	To improve prompt malaria diagnosis in mobile populations as well as reduce missed cases or misdiagnosis
Treatment	Township health centers provide standardized treatment for confirmed cases, while village doctors follow up on treatment compliance and outcomes	County-level medical institutions provide the standardized treatment for confirmed cases; township health centers follow up on treatment compliance and outcomes	To improve medication adherence and standardization among high-risk populations (mobile patients)
Training	Township health centers with high malaria incidence send key personnel to local county CDCs for further training; county CDCs organize the annual training for local lab technicians, public health doctors, and clinicians	Training by annual skill competition organized by county CDCs at the grassroots level	To maintain basic awareness and skills for malaria diagnosis and treatment within the grassroots workforce
Supervision	County CDCs conduct at least two on-site supervision or evaluation sessions (verification of Plasmodium microscopy results) at local township health centers each year	County CDCs conduct at least two on-site supervision sessions each year at the township health centers of high malaria incidence areas and request* that each hospital shall have at least one professional staff member in service	To identify challenges in key aspects of the local malaria program, and provide guidance to township health centers on standardized diagnosis and treatment

*: If the supervision reveals the absence of a microscopist, they immediately report this to the local authority. By issuing official documents from the local health committee, it should be ensured that each hospital has at least one professional in service. Note: mRDTs, malaria rapid diagnostic tests; CDC, center for disease control

Discussion

With the recent stalled global progress in reducing malaria mortality and morbidity, WHO has updated its Global Technical Strategy for Malaria 2016–2030 in 2021, with an emphasis on providing the appropriate

interventions to the populations that need them, instead of a one-size-fit-all approach[17]. The grid-based surveillance strategy is an innovative approach to serve as a useful model for other countries to increase local government and community engagement, governance and accountability, surveillance, and delivery of tailored malaria services to high-risk populations in the last mile of elimination and to help prevent reestablishment of local transmission.

There are benefits of the grid-based surveillance strategy. It increases the effectiveness of community case management of malaria (CCMm) with a more targeted proactive surveillance approach based on known high-risk populations. It facilitates rapid communication of positively-identified cases to the response teams to prevent onward transmission from the imported case by emphasizing the multi-sectoral approach, promotes information sharing and breaks down communication barriers among key relevant stakeholders, including the local public security department, the local health department, and the local entry-exit inspection, and quarantine department. The grid-based surveillance strategy allows for more comprehensive information to be collected on MMPs' basic conditions and travel history, and through regular field visits and communication with the local community, greater communication and understanding among local key stakeholders is strengthened to accelerate malaria elimination efforts. Moreover, the grid-based surveillance strategy offers an example of how to broaden local stakeholder involvement in the delivery of malaria control and elimination activities. The grid-based strategy actively involved local political leadership, other government departments, and local communities to solve malaria delivery strategies and develop tailored and targeted approaches suitable to local context. In global malaria control, multi-stakeholder involvement and community engagement are quoted as vital for long-term cost effective success in malaria control and elimination yet are frequently overlooked in programming. The grid-based strategy provides a solution of how to operationalize community engagement[18] and multi-stakeholder involvement.[19]. Strengthening lower level health program involvement in the design and iteration of delivery strategies is recognized as the future of malaria control in Africa, where national-led strategies need to be tailored by district-level decision-making to suit local context and populations, providing the district with more flexibility and resources for demand-driven and problem-based solutions to local operational challenges[19]. The grid-based strategy gives an example of how community organizations can link to health systems to improve public health impact and to maximize resources from all sectors.

The grid-based surveillance strategy did identify some challenges that need to be considered further. First, beyond the MMPs who do legal activities, there is a need to determine how to reach and work with more illegal or hidden populations who could benefit from health services in the region. Second, a lack of standardized work procedures and quality of care provided by different grids can be variable. The UNICEF M&E indicators for monitoring community level initiatives might be introduced towards a more standardized strategy to measure effectiveness across different grids. Third, the grid administrators are volunteers and are not receiving compensation. There is a need to develop incentives for the extra responsibilities for sustained and stable-quality of service.

Conclusion

In the context of malaria elimination in the GMS, MMPs who move from their permanent residence to malaria-endemic areas for work or other purposes are a key population threatening elimination targets. Therefore, the WHO has called upon governments in the GMS to include activities targeted at them [20]. Difficulty in managing these high-risk populations can hinder malaria elimination efforts. The successful consolidation of malaria elimination gains in Yunnan and China requires effective strategies to be further employed to maintain robust public health infrastructure for disease surveillance. The grid-based surveillance strategy has acted as a cornerstone of community malaria case management in the Yunnan border area, which can reach high-risk populations and support the tailored malaria intervention strategy and adaptive management that is needed.

Declarations

Ethics approval and consent to participate

This study has been approved by the Ethical Review Committee of Chinese Center for Disease Control and Prevention. Written informed consent was obtained from each respondent. All methods were carried out in accordance with relevant guidelines and regulations

Consent for publication

Not applicable.

Availability of data and materials

The study datasets are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SL and WD were major contributors in writing the manuscript; JW, XZ and QX performed the field survey; QX and XS contributed significantly to data analysis and manuscript preparation; CC, MH, AT and RG

helped reviewed the analysis and manuscript with constructive discussions; SL and DW contributed to the conception of the study and reviewed the manuscript.

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Figures

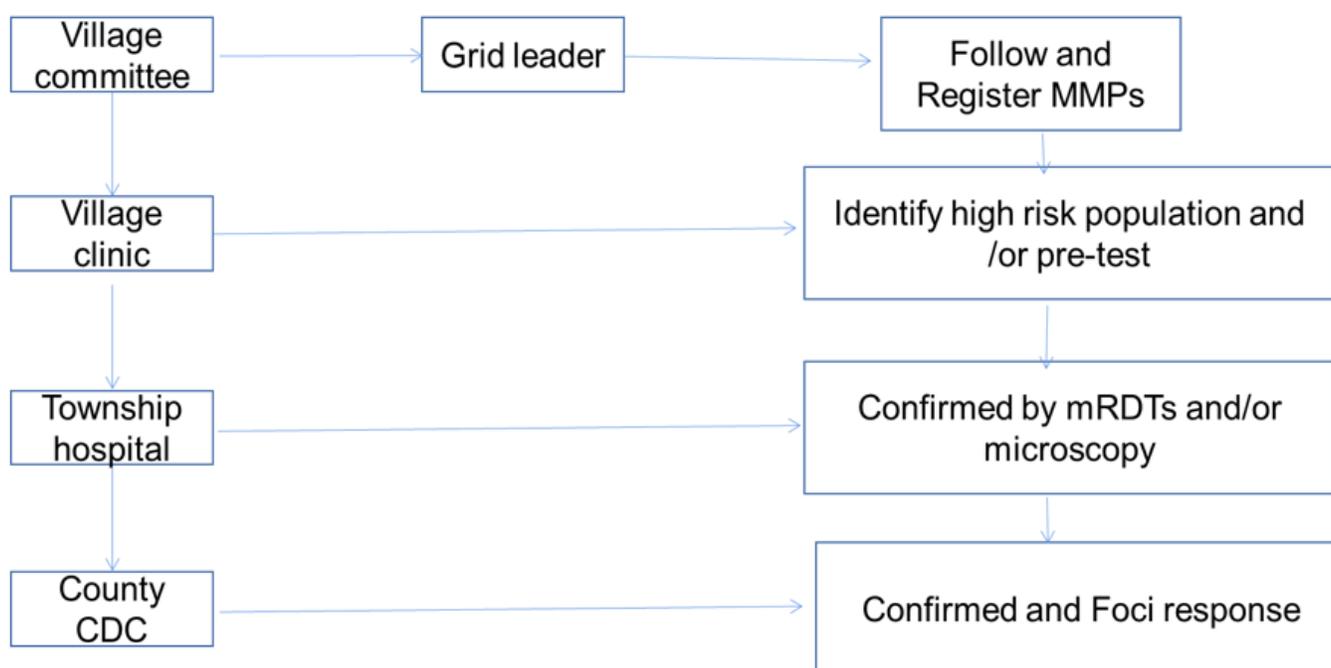


Figure 1

Flowchart of the grid-based strategy for malaria case management in MMPs in Tengchong County, China–Myanmar border region. Note: MMPs, mobile and migrant populations; mRDTs, malaria rapid diagnostic tests; CDC, center for disease control and prevention