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Mosquito-Free Village

CHINESE CENTER FOR DISEASE CONTROL AND PREVENTION
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Cover Image: Mosquito-Free Village logo, designed by Enfu Chen, Zhejiang CDC.

Preplanned Studies

Increased Incidence of Scarlet Fever — China, 1999–2018

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Summary

What is already known about this topic?

Scarlet fever had high incidence between the 1950s and 1980s, but during the 1980s and 1990s, the incidence of scarlet fever dropped to a relatively low and stable levels in China.

What is added by this report?

Starting in 2011, scarlet fever incidence significantly increased in China. In the eight years between 2011 and 2018, 479,555 cases were reported, which exceeded the total number of 241,365 cases reported in the previous twelve years 1999–2010.

What are the implications for public health practice?

Both patient and pathogen epidemiological surveillance need to be heightened to monitor serious cases of scarlet fever and to implement timely control measures.

Scarlet fever is a common pediatric respiratory disease caused by *Streptococcus pyogenes* (Group A *Streptococcus*; GAS), which can also cause other mild infections such as pharyngitis and impetigo and serious invasive infections including necrotizing fasciitis. The major clinical manifestations of scarlet fever include sore throat, fever, diffuse red rash, and a "strawberry tongue" (*1*). China CDC affiliated researchers analyzed reported scarlet fever cases from 1999 to 2018 from the National Notifiable Diseases Reporting System (NNDRS) of Mainland China to determine incidence trends. In this period, 720,920 cases were reported with a sudden increase in 2011 and a peak incidence in 2018 of 5.68 cases per 100,000 population, which represents a 2018 total of 78,864 reported cases.

Scarlet fever was considered a fatal disease during 19th and early 20th centuries. The morbidity and mortality of scarlet fever dramatically dropped worldwide when antimicrobial drugs became widely used. Most scarlet fever cases are now diagnosed as mild infections, and fatal infections are now rare. However, a small proportion of cases still may develop serious sequelae.

Since 1950 in China, scarlet fever has been listed as a Type B notifiable disease, which is required to be reported within 24 hours. According to previous analysis (*2*), the incidence of scarlet fever in China was high between the 1950s and 1980s and then dropped to a low level during the 1990s. In 2011, compared to the baseline level prior to the epidemic, a sudden 2.6-fold increase in the incidence of reported scarlet fever cases was recorded (*2*). Meanwhile, many other countries also reported significant increases of scarlet fever epidemics worldwide (*3*–*6*). The resurgence of scarlet fever has been a concerning public health problem globally.

In early 2019, an *emm12* genotype scarlet fever isolate related to UK scarlet fever outbreak strains was detected in Australia through sentinel hospital surveillance (*7*). The surveillance in China indicates that *emm12*-type GAS has been predominantly responsible for the scarlet fever resurgence since 2011. All isolates in China are susceptible to β-lactams but are mostly resistant to macrolide antibiotics (*2*).

Scarlet fever cases reported through the NNDRS of China from 1999 to 2018 were retrieved for analysis (*2*). Only verified clinic-diagnosed and laboratory-confirmed cases from Mainland China were included in the analysis, excluding Hong Kong, Macao, Taiwan, and foreign residents. Population size data from the China National Bureau of Statistics for denominators were used to calculate incidence rates of scarlet fever. Annual case number and incidence of reported scarlet fever from 1999 to 2018 were analyzed to investigate long term temporal trends. The geographic incidence data and case number were extracted from 1999 to 2018. After a comparison between each year, the incidence data for the year 2010 and 2018 were shown to reflect the variation of geographic incidence before and after the year 2011 when the outbreak started. The age data for scarlet fever incidence were also extracted and shown for the years 2010 and 2018 as representatives before and after the year 2011.

Between 1999 and 2018, there have been three peaks at four-year intervals including 2007, 2011, and 2015. A fourth peak has now been observed in 2018 with 78,864 reported cases and an incidence rate 5.68 per 100,000, which is the highest total over the last 20 years. The incidence increased 5.34% compared to that of 2017 (Table 1, Figure 1). Rare cases of death were reported during 1999 and 2018 (Table 1). The highest number occurred in 1999 with five reported deaths. There was one death in the 2011 epidemic, and in the following years, a total of five deaths were reported. Both 2010 and 2018 data show incidences of northern regions are higher than southern regions. The incidence rate of 2018 significantly increased compared to that of 2010 (Figure 2). The age group from 5 to 6 years old had the highest incidence for both 2010 and 2018 (Supplementary Figure S1 available in http://weekly.chinacdc.cn/).

Discussion and Conclusions

The data reported in this and a previous study (*2*) indicate the incidence of scarlet fever in China is still increasing, which emphasizes the importance of national scarlet fever alerts. Before 2011 when the epidemic began, the highest number of scarlet fevers occurred in 2007 during the period of 1999 and 2018 (Table 1, Figure 1). Similar epidemic patterns were observed in other East Asian countries including Singapore, and European countries (Germany), where an incidence peak was observed in 2008, prior to the 2011 epidemic surge (*4*,*6*). These clues may reflect a similar mechanism attributed to the resurgence of scarlet fever across different parts of the world. The higher incidence of northern regions suggests that more attention should be given to strengthen surveillance in these areas. Active bacterial surveillance on the susceptible populations of age group with highest incidence is necessary.

TABLE 1. Reported number of cases, incidence rates, and number of deaths caused by scarlet fever per year, 1999−2018 in China.

Year	Reported cases	Reported incidence (1/100,000 persons)	Reported deaths from scarlet fever
1999	15,246	1.23	5
2000	13,720	1.08	3
2001	11,261	0.94	2
2002	15,234	1.14	2
2003	10,063	0.75	1
2004	18,939	1.46	1
2005	25,068	1.93	2
2006	27,620	2.11	0
2007	33,488	2.55	1
2008	27,782	2.10	0
2009	22,068	1.66	0
2010	20,876	1.56	0
2011	63,878	4.76	1
2012	46,459	3.45	2
2013	34,207	2.53	2
2014	54,247	4.00	0
2015	68,249	5.00	1
2016	59,282	4.32	0
2017	74,369	5.39	0
2018	78,864	5.68	0

The reasons underlying the scarlet fever resurgence in China and other countries are still unclear. Several studies have suggested possible reasons for this scarlet fever incidence increase (*2*,*8*–*9*), such as weakened herd immunity, environmental factors, and genetic mutations in the pathogen. Because there is no commercial vaccine for scarlet fever (GAS) prevention (*1*), natural population immunity may play an important role in the disease epidemic cycle. Further investigations are needed to learn more about the changing immunity patterns in susceptible and resistant populations.

For the current epidemic in Western and Asian countries including China, multiple scarlet fever-causing serotypes and clones have been identified, many of which contain genetic elements carrying streptococcal exotoxins and antimicrobial resistance genes that are widely detected among Asian and European predominant clones. These virulence determinants are thought to play an important role in triggering the epidemic, though further investigations are required (*2*,*10*).

The findings in this report are subject to one limitation. The most accurate diagnosis of scarlet fever should be based on pathogen isolation. The majority of reported cases are clinically diagnosed and the proportion of confirmed cases based on pathogen isolation is less than 5%. Thus, the accuracy of surveillance data could be affected by introducing false negative or false positive clinically diagnostic cases.

In summary, China is in a new period of high incidence of scarlet fever. A vaccine is not available for prevention of scarlet fever currently, although advances are being made in GAS vaccine research. Nonetheless, antibiotic treatment is effective. Prevention and control measures for scarlet fever could include identifying cases as early as possible and providing effective antibiotic treatment, controlling cases clusters and

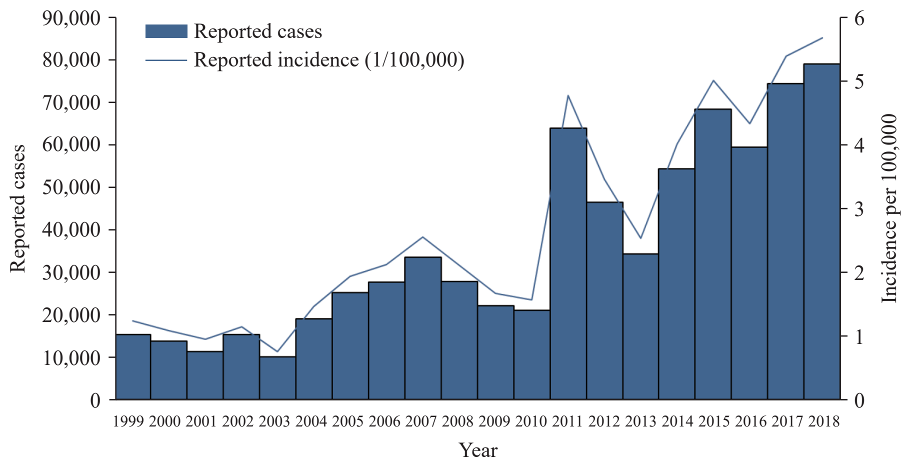

FIGURE 1. Total reported scarlet fever cases and incidence between 1999 and 2018 in China.

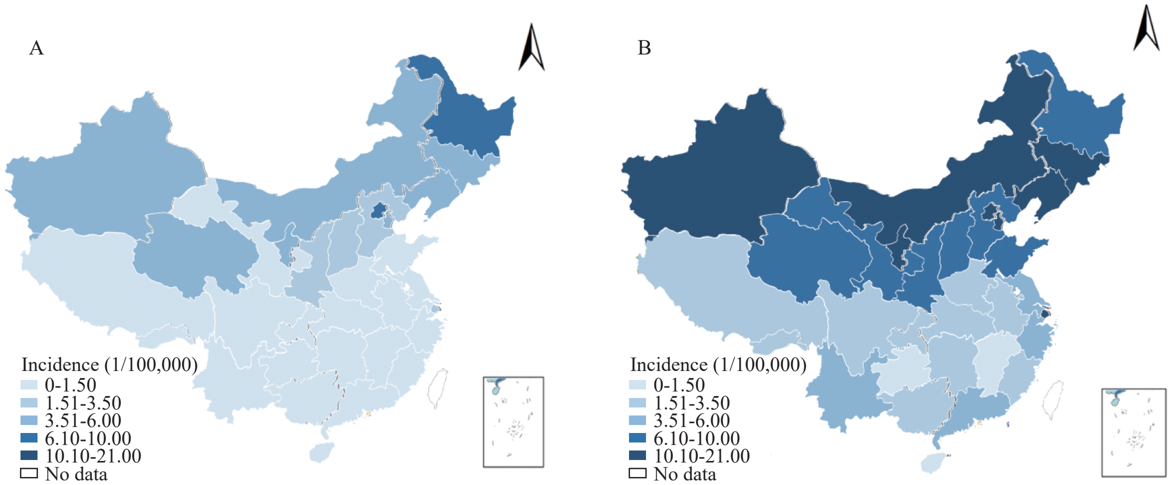

FIGURE 2. Reported scarlet fever incidence according to geographic region in China in 2010 and 2018. (A) Reported incidence in 2010. (B) Reported incidence in 2018.

dealing with public health events in a timely fashion, and strengthening health education in schools and kindergartens.

The increasing disease burden caused by scarlet fever suggest that health facilities and the public health professionals should pay increasing attention to scarlet fever prevention and control. Medical and health institutions at all level should enhance scarlet fever surveillance. Clinicians should be aware of the increasing trend of scarlet fever incidence in China and undertake early diagnosis and precise treatment with antibiotics. Public health facilities should report suspected cases and detect and control outbreaks in a timely manner. The general public should learn about the knowledge of scarlet fever control and prevention such that if children experience symptoms suspected to be scarlet fever, they should promptly seek a medical diagnosis and treatment.

Scarlet fever GAS pathogen surveillance capabilities should be established where not available, and enhanced if limited to only a few dispersed centers within provinces of China, so as to closely monitor epidemic foci, spread, complications and severe cases, and identify any genetic changes related to bacterial drug resistance, virulence and epidemiology.

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Conflict of interests

The authors declare no competing interests.

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Outbreak Reports

An Outbreak of Multidrug-Resistant Tuberculosis in a Secondary School — Hubei Province, 2019

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Summary

What is already known about this topic?

Multidrug-resistant tuberculosis (MDR-TB) is a type of tuberculosis with resistance to common treatments such as isoniazid and rifampicin. MDR-TB is a major global health challenge and needs to be controlled tightly through prevention measures, early diagnosis, and full treatment and management.

What is added by this report?

This outbreak was the first MDR-TB related public health emergency in Hubei Province. In total, five MDR-TB cases and nine clinically diagnosed cases were identified within one class in a secondary school. Students and teachers from other classes were monitored, but no other cases were found.

What are the implications for public health practice?

The implementation of TB prevention and control measures in schools is important to increase knowledge on TB and to raise awareness on protecting personal wellbeing. The Automatic Early Warning Information System alerted the local health department and allowed for a timely response to prevent further disease spread.

On April 6, 2019, Zaoyang-County CDC in Hubei Province received an alert from the Automatic Early Warning Information System for Tuberculosis for a 16-year-old student in a secondary school that had been recently been diagnosed with a positive sputum smear for tuberculosis (TB). The Zaoyang-County CDC verified the case, screened all close contacts, and carried out epidemiological investigation immediately (*1*). In total, five multidrug-resistant tuberculosis (MDR-TB) cases and nine clinically diagnosed TB cases were identified and subsequently isolated from school to start a multi-drug regimen. This outbreak was defined as an MDR-TB public health emergency on May 6, and the response was in accordance with the Regulations on Responses to Public Health Emergencies.

Investigation and Results

The outbreak occurred at a public secondary school with 3 grade-levels, over 3,900 students, and over 300 staff members. The index case occurred in a 16-year-old student with positive TB sputum smear tests. An interview with the student revealed that in February 2019 he had an onset of coughing that was treated as a common cold. In late March, the student suffered from significant fatigue, more frequent coughing, and occasional left chest pain. On April 4, the student visited the county hospital for a diagnosis where chest computed tomography (CT) showed his lungs were infected with TB. A positive sputum smear test result confirmed the diagnosis, and the student was subsequently transferred to the Xiangyang Tuberculosis Control Hospital the following day. The student was further tested with GeneXpert testing and anti-TB drug sensitivity test (DST), and the student was shown to have resistance to rifampicin (R), isoniazid (H), and ethambutol (E).

All TB cases in this outbreak were diagnosed per the National Guidelines of Diagnosis for Pulmonary Tuberculosis (WS 288-2017) (*2*), which require TB cases to classified as bacteriological confirmed, clinically diagnosed, or presumptive cases and classify patients resistant to R and H to be diagnosed as multidrug-resistant tuberculosis (MDR-TB). According to these guidelines, this patient with MDR-TB was confirmed to be the index case of this outbreak in the secondary school.

According to the National Regulations for Tuberculosis Prevention and Control in Schools (*1*), the Zaoyang-County CDC screened all students' regular classmates as they all had direct contact with the index case of MDR-TB. All close contacts were screened by symptom screening, purified protein derivative (PPD) skin test, chest X-ray, and sputum smear test. Following the results of these tests, some students were further examined with tests including GeneXpert testing and DST.

Out of the student's regular classmates, 30 out of 60 students (50.00%, 30/60) had strongly positive PPD reactions. Chest X-rays showed that 13 out of these 30 students (43.33%, 13/30) had lesions of active TB in lung, which is consistent with imaging manifestations of TB (*3*). In the following days, GeneXpert testing and DST indicated that 4 of these 13 students had confirmed cases of MDR-TB (R, H, and E resistant) and 9 TB cases were clinically diagnosed.

The screening was then expanded to all teachers and students for the index-case patient's grade. Among the remaining 1,144 students in other classes, 22 cases (1.92%, 22/1,144) had strongly positive PPD reaction but had normal chest X-ray results. Screening was ended as no more TB cases were found in the other classes. The rate of strongly positive PPD and incidence of TB in students in the index-case patient's class is significantly higher than other classes (chi-square test, $p<0.05$; Table 1). This indicates that classmates of the index-case patient were more vulnerable due to close contact.

To explore the epidemiological linkage among patients, strains from those five bacteriologically-confirmed MDR-TB students were tested with whole genome sequencing. The results indicated infection by the same *Mycobacterium tuberculosis* (MTB) strain, which means that the index case acted as the source of transmission in this outbreak. Though no further epidemiological investigation was conducted between the index case and the nine clinically-diagnosed TB cases, the patients had close contact as classmates and the index-case patient was also considered as the source of transmission.

The results of an environmental hygiene survey indicated that the secondary school was in good condition. However, most of the doors and windows of classrooms were closed in the winter, which resulted in poor ventilation and encouraged MTB spread in the environment. In accordance with the Regulations on Response to Public Health Emergencies, this outbreak was defined as an MDR-TB public health emergency on May 6 and had been responded to appropriately.

The 14 students with TB were treated with a multi-drug regimen at a hospital for the first two months and then at home for the rest of the treatment course. While preventative treatment effectively lowers the risk of disease progression for contacts of individuals with drug-susceptible tuberculosis, the effectiveness of this strategy is not well understood for contacts of people with MDR-TB (*4*–*5*). Therefore, students with strongly positive PPD reactions and normal chest X-ray results were strongly encouraged to take chest X-rays and be monitored at regular intervals at 3, 6, and 12 months. The Zaoyang-County CDC provided health education on TB to enhance the awareness of TB control among students, to encourage students with suspected TB symptoms to prioritize visiting clinics, and for TB patients to be compliant to physician-supervised treatment. Presently, no new cases have been reported.

Further epidemiological investigation into the index case by the Zaoyang-County CDC revealed that a distant relative had dinner with the index-case patient towards the end of 2018 and also had MDR-TB. The distant relative's TB drug resistance spectrum was the same as the index case (R, H, and E resistant). However, during the epidemiological investigation of the index case, this distant relative had negative sputum smear test results, and the reporting hospital did not retain the resistant strain during the initial diagnosis. Though a preliminary epidemiological association can be established, gene homology analysis cannot be done to fully confirm MDR-TB.

Discussion

MDR-TB has become a global epidemic due to inadequate TB treatment and a vicious cycle of diagnostic delay and improper treatment (*6*). China ranks 2nd of high burden countries of MDR-TB globally, and TB outbreaks in schools in China are especially problematic. TB treatment has notable morbidity and mortality and is lengthy, expensive, and associated with poor adherence (*4*).

This MDR-TB public health emergency may be the result of several factors. First, the index case was

TABLE 1. Rate of strongly positive PPD and TB incidence among contacts.

Class	No. of students	No. of strongly positive PPD reaction	Rate of strongly positive PPD reaction (%)	χ^2	*p* value	No. of TB patients	Incidence (%)	*p* value*
Index-Case Patient's Class	60	30	50.00	307.348	<0.05	13	21.67	0.000
Other Classes	1,144	22	1.92			0	0.00	

*Using Fisher's Exact Test.

diagnosed extremely late. The patient likely had contact with MDR-TB at the end of 2018 and his symptoms appeared in February 2019, but he did not visit a hospital until April 4 after his condition deteriorated. Delayed diagnosis and treatment increased the probability of transmission in his school, especially among classmates.

Second, infectious disease prevention and control measures in schools were not fully implemented, and early screening failed to identify sick students. Early interventions could include daily screening of symptomatic or absent students by asking their family members, school staff, or fellow students to help identify TB symptoms. In this situation, however, the contacts of these students were not familiar with common symptoms of TB, which include onset of cough and expectoration for more than 2 weeks, so no suspected TB cases were reported or referred to hospital.

Finally, poor ventilation in classrooms in the winter and spring may increase the rate of TB transmission for students studying in these areas. The investigation results suggest that close contact significantly increased the likelihood of TB transmission between the index-case patient and his regular classmates. However, a major limitation in the epidemiological investigation is that the index-case could not be linked to the patient's distant relative due to the hospital discarding the distant-relative's MDR-TB sample.

This investigation suggests that local CDCs should increase TB health education efforts in schools, especially during colder seasons which may result in poor ventilation for students. Increased TB knowledge may encourage those with suspected symptoms to seek diagnosis earlier or help close contacts identify possible symptoms.

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Healthy China

"Mosquito-Free Villages": Practice, Exploration, and Prospects of Sustainable Mosquito Control — Zhejiang, China

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Editorial *China CDC Weekly* established the "Healthy China" column to report on the public health implementation, progress, and experiences related to the Healthy China 2030 program. Healthy China 2030 represents the Chinese Government's active response to current health challenges and includes the Healthy China 2030 Outline and the Healthy China 2019–2030 Action Plan. These components reflect the Chinese Government's strategic prioritization on improving Chinese citizens' health, provide documents to guide and assess disease control and prevention for the next ten or so years, and describe measures to help China comply with international trends and fulfill international commitments.

The Healthy China 2019–2030 Action Plan describes clearly 15 areas of focus across 3 categories including 6 health-risk factors (health literacy, healthy diets, fitness habits, tobacco control, mental health, and healthy environments), 4 major segments of the population (maternal and newborn health, primary and secondary school student health, worker health, and senior citizen health), and 5 major categories of diseases for control and prevention (cardiovascular diseases, cancers, chronic respiratory diseases, diabetes, and infectious and endemic diseases).

Each area of action has clear goals, assessments, and specific divisions of responsibilities for all levels of government, for the society, and for individuals. The following article describing a Mosquito-Free Village (MFV) outlines how Zhejiang Provincial CDC implemented two of the Healthy China 2019–2030 Action Plan's areas of focus on healthy environments and infectious and endemic disease control through a successful, low-cost initiative. Healthy China 2030 is a major step that indicates China's support for developing health innovations for Chinese citizens and the global community.

Summary

Mosquitoes and mosquito-borne diseases have always been a great threat to human health. Mosquito control based on sustainable vector management strategy is particularly important. In Zhejiang Province, exemplary villages of sustainable mosquito control ("mosquito-free villages") have been successful operated, providing a new model of mosquito control in rural areas based on local conditions. The construction of "mosquito-free village" will apply environmentally-friendly and appropriate technologies to eliminate and transform mosquito breeding sites and to establish mechanisms of cultivating villagers' health literacy of scientific mosquito control and voluntary participation in control activities to keep mosquito density low long-term.

Mosquito infestations and transmission of diseases such as dengue fever have been difficult problems for urban and rural residents in Zhejiang Province (*1*). Control of mosquito breeding through environmental management has long been considered effective (*2*–*3*), but construction of rural health infrastructure has lagged behind that of urban areas (*4*). The initial stages of construction include sanitary toilets, rivers, and drainage systems, and proper disposal systems for household garbage, sewage, and livestock are largely inadequate. Furthermore, villagers are influenced by a lack of health education and awareness and may have resultingly poor health habits and behaviors. Together, these factors may contribute to large mosquito breeding in rural areas.

To solve the challenges of mosquito breeding in rural areas, Zhejiang Center for Disease Control and Prevention (Zhejiang CDC) explored a new model of localized mosquito control in rural areas. In 2018, the first model village of sustainable mosquito control (also known as a "mosquito-free village" or MFV) in Zhejiang Province was successfully piloted in Xuexiazhuang Village, Hangping Town, Pujiang County (*5*). The construction of an MFV is an innovative initiative of vector control in rural areas and is being implemented in 72 villages across 11 cities in Zhejiang Province.

Goals of Mosquito Control

The goal of constructing MFVs is to implement mosquito control and elimination work through stages based on scientific principles. With the guidance of technical departments in Zhejiang Province such as local CDCs, village committees set up management organizations to publicize mosquito-control work and health education and then lead all villagers to participate in specific mosquito-control activities that are localized to each village's conditions. The health administration mostly provides financial and political support.

The construction of MFVs promotes environmentally-friendly and appropriate technologies that are focused on removing and transforming mosquito breeding sites and establishing long-term change through strategies such as cultivating villagers' scientific health literacy and voluntary participation in mosquito eradication. The underlying goal is to control mosquito breeding with minimal risk and environmental impact. MFVs do not initially intend to eradicate all mosquitoes from a village. Rather, the primary purpose of MFVs is to control the density of mosquitoes to a low level in accordance with promoting green environmental principles, economic stability, and scientific progress.

MFV Construction

MFV construction in Xuexiazhuang Village has been largely successful so far. Xuexiazhuang Village which is in a mountainous region of central Zhejiang Province with a subtropical monsoon climate, is surrounded by rivers on three sides, and backed by green, bamboo-filled mountains. There are approximately 170 households scattered in the village which attracts tourists for swimming, barbecuing, and other recreational activities. Due to tourist complaints of high mosquito density, village committees sprayed pesticides several times but failed to effectively control mosquito populations.

In 2016 with guidance from the Zhejiang CDC, the village committee of Xuexiazhuang led villagers to investigate mosquito breeding sites and mosquito density in the village and used scientific mosquito management measures to begin MFV construction. Thousands of bottles, cans, vats, trashes, and other water containers were cleared, roads with potholes were repaired, and ditches were dredged throughout the village. About 40 households converted their pit toilets into sanitary toilets, and more than 10,000 bamboo poles were removed from the bamboo forests around the village. Villagers installed three solar mosquito traps in the green belt to help eliminate mosquitoes. A science exhibition hall on mosquito knowledge has been built to provide health education for villagers.

During 2016 and 2017, professionals of Zhejiang Provincial and Pujiang County CDCs carried out 5 large-scale popular science lectures and investigation activities on mosquito control and conducted on-site guidance and surveillance once a month in the village. From April to November 2017, the average monthly density of adult mosquitoes in Xuexiazhuang decreased by 98.89%, and the 100-household index, which measures the number of containers with mosquito larvae per 100 households, decreased by 93.79% compared with that in 2016. Mosquito density was significantly lower than that of the same period of 2016 (Figure 1), and the formation rate of correct behavior of villagers to prevent and eliminate mosquitoes reached 82.8% (*6*). The control effect was stably maintained in 2018 and 2019. The MFV vector control model can effectively reduce mosquito density and increase the efficacy and sustainability of mosquito-control work.

Discussion

Under the guidance of Zhejiang CDC and other professional departments, experts assess target villages on MFV construction suitability based on the village environment, type and quantity of mosquito breeding sites, density of mosquitoes, village committee and constituents' willingness for and knowledge-level of mosquito control, and the village committee's coordinating capabilities. Suitable villages for MFV construction are selected based on comprehensive assessments.

Villages suitable for MFV construction will establish a mosquito control management organization under the leadership of their village committee to coordinate the whole village and make plans based on the results of the assessment. The MFV construction process is subject to guidance and participation from professional technicians of CDCs in Zhejiang Province. Organization members are responsible for mobilization

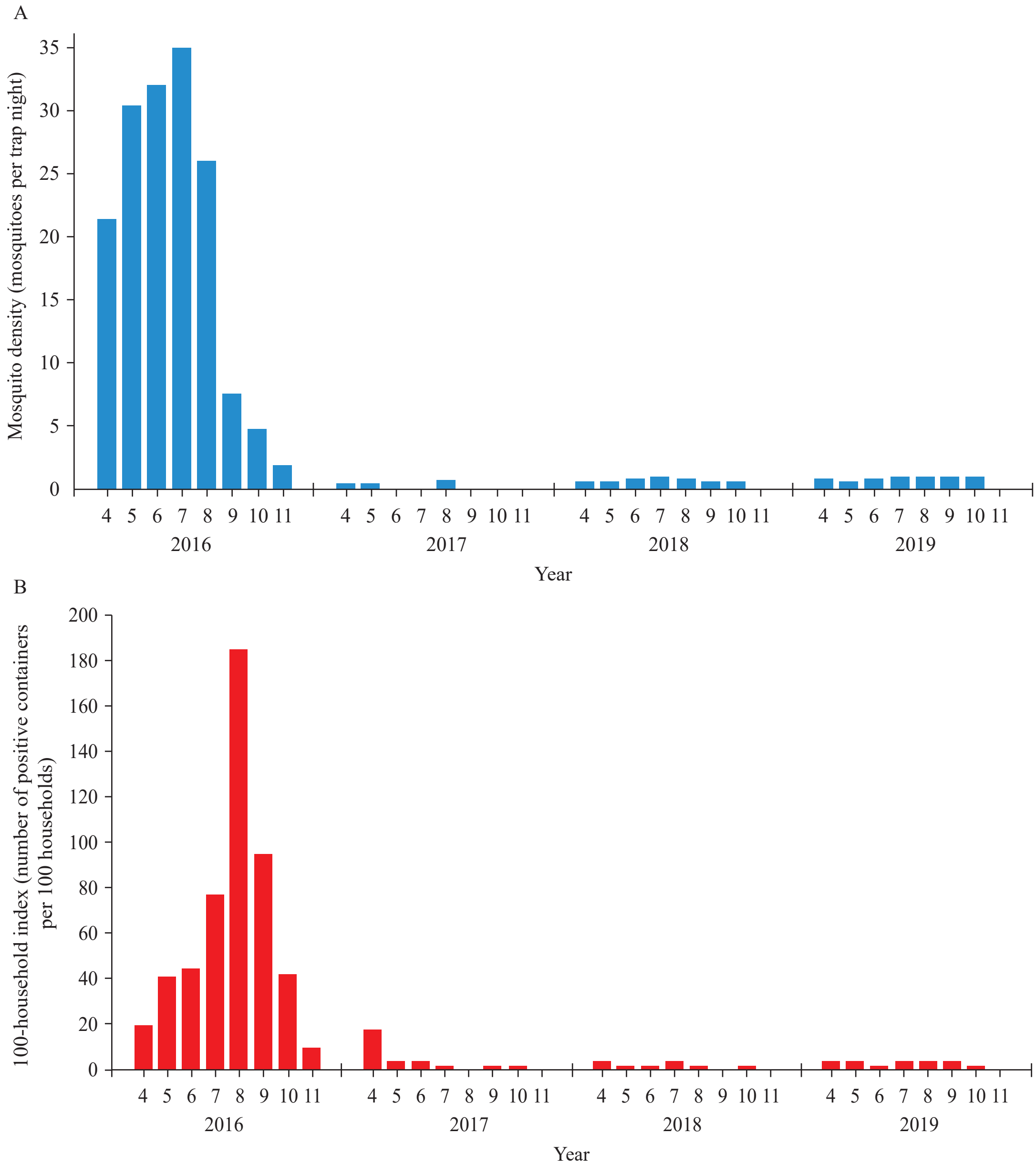

FIGURE 1. Mosquito surveillance data* of Xuexiazhuang village from 2016 to 2019. (A) Light trapping method; (B) 100-household index method.

*According to *Surveillance methods for vector density-mosquito* (GB/T23797-2009), the density of adult mosquitoes (A) and larvae (B) were monitored from April to November by using the mosquito light trapping method and the 100-household index method, respectively. The monitoring period of the data was from April 2016 to October 2019.

of villagers and daily management tasks, which include objectives to improve village residents' mosquito-control-related scientific knowledge and habits.

MFV system construction incorporates scientific mosquito control measures into village regulations, which will influence culture changes, guide and restrict behavior of villagers, and have an important role in village social governance.

Because mosquitoes can breed in containers and in places with standing water such as ditches, ponds, paddy fields, sewage pits, waste tires, bamboo piles, and tree holes, etc., MFV construction advocates for comprehensive control measures guided by environmental governance that is supplemented by physical, biological, and chemical methods with equal emphasis on mosquito control and prevention (*7*). For breeding sites with a high degree of difficulty, work should be carried out in stages based on local conditions. Active control of overwintering mosquitoes and those emerging in the early spring are key to yearround mosquito control. Solar mosquito traps and local fish such as *Oryzias latipes*, *Hemiculter leucisculus*, and *Cyprinus carpio haematopterus* can be used as supplementary means of mosquito control. For example, 10 *O. latipes* fish per square meter of a river or pond can effectively eliminate mosquito larvae.

Sustainable vector management emphasizes the continuous implementation of vector control and management under the guidance of surveillance and assessments (*8*–*9*). For the MFV, regular mosquito vector surveillance should be carried out at least once a month from April to November to appropriately evaluate the effectiveness of control measures and levels of improvement. After MFV establishment and implementation, surveillance will continue to play a crucial role in guiding mosquito control, but the frequency of checks can be reduced. The evaluation criteria of MFV are composed primarily of four aspects: mosquito density, village management, the effects of health education, and the attitudes of villagers (*10*).

Village committees can regularly promote health education for villagers through lectures, posters, publicity materials, the WeChat Official Account, and village rules to help villagers gain a more comprehensive scientific understanding, master mosquito control basics, and develop a more hygienic and healthier lifestyle. The long-term success of MFVs depends on promoting health education, better maintenance habits, and villager health literacy.

Furthermore, MFV construction aims to form an initiative based on voluntary participation to maintain mosquito control standards by consistently removing mosquito breeding sites and keeping the environment clean. After experiencing the benefits of science-based mosquito control, residents of MFV have adopted a self-reinforcing atmosphere of “everyone is responsible, everyone is involved”.

MFV construction is funded by government-encouraged investment or by funds raised by the selected villages. These funds may be used for the modification and maintenance of public environments and facilities, health education, publicity, and surveillance and assessment of the mosquito-control methods. For example, 118,000 RMB was invested in the MFV construction in Xuexiazhuang Village from 2016 to 2017, of which 86,000 RMB was spent on the renovation of basic infrastructure such as toilets, 5,000 RMB was spent on health education, and 27,000 RMB was used to pay for labor costs. Follow-up maintenance costs are funded by independently by the village. The collective Xuexiazhuang village economy pays 15,000 RMB per year, which is equivalent to an annual investment of about 87 RMB to each of the households in the whole village. Therefore, following MFV establishment, villages will have low long-term mosquito density and low sustainable maintenance costs.

Conclusion

In MFV construction, sustainable vector management strategies and measures are adopted to strengthen the development of rural living environments. By relying on the guidance and training of CDCs in Zhejiang Province as well as organization by village committees and individual villager participation, villages can implement long-term solutions to control mosquito density. In addition to fundamental mosquito control principles, MFV control measures are also adapted to the conditions and characteristics of specific rural areas, which allow villagers to directly address aspects in their lifestyles or communities that may contribute to higher mosquito density. MFV construction helps the countryside communities develop into more livable spaces and improve the health of village residents.

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Commentary Obituary

Po Tien
(1931-2019)
A Pioneer in Virology in China

As an academician of the Chinese Academy of Sciences (CAS), the honorary director of the CAS Key Laboratory of Pathogenic Microbiology and Immunology in the Institute of Microbiology, a full member of the America Society for Virology, Professor Po Tien was a highly honored scientist and one of the largest players in the Chinese virology community. He passed away on December 15, 2019.

Professor Po Tien was born in December 1931 in Huantai, Shandong. He graduated from Beijing Agricultural University, now China Agricultural University and then was assigned to the Fungus and Plant Disease Research Laboratory, the precursor of the Institute of Microbiology of the CAS. There, he proposed a virus-free seed potato production scheme that has been widely used in China and has generated significant economic value for Chinese agriculture.

In the early 1980s, Professor Tien visited many famous plant virology laboratories in the world. During his visit to the University of Adelaide in Australia, he realized the importance to understand the interactions among satellite RNAs, viruses, and host plants. After returning to China, Professor Tien immediately began researching the subject and successfully developed virus satellite-based biological reagents that can control plant viruses.

After 1986, he focused on study of viral and viroid disease-resistant transgenic plants. He constructed cucumber mosaic virus-resistant transgenic tobacco and tomato strains, and constructed rice-stripe and rice-dwarf virus-resistant transgenic rice and found the phenomenon of silence of the resistant genes. He provided the first example of a ribozyme capable of completely inhibiting nuclear replication of the viroid in transgenic potatoes, and thus, developed a new ribozyme application approach.

Towards the end of the last century, Professor Tien's research interest turned to medical virology. He led the discovery of a complex of an antigen peptide and heat shock protein gp96 in liver cancer tissues infected with hepatitis B virus, which proved that gp96 and its N-terminal fragment have adjuvant function. He also led the study of the molecular mechanism of 7-peptide repeats of SARS and HIV fusion proteins including cell fusion and the design of a triple helix protein resistant to HIV.

The research topics Professor Tien chose always aimed to solve practical problems of China. When the country's food production was low, Professor Tien devoted himself to researching and solving shortages in food and clothing; when food production increased and food and clothing were mostly resolved, he devoted himself to defend against diseases with science.

Professor Tien was also a great educator. Countless students and collaborators of his are now undertaking important research missions in China and making great contributions to the country.

We feel that Professor Tien will still live in our hearts. His tireless pursuit for innovation in science will continue to guide us to explore the world of virology.

Yeping Sun and Weihua Zhuang are part of Professor Tien's laboratory group. Yeping Sun worked with Professor Tien for nearly 10 years, and Weihua Zhuang worked with Professor Tien for over 20 years. Email: sunyeping@im.ac.cn and zhuangwh@im.ac.cn.

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