

## 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 successfully 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, Pujian 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

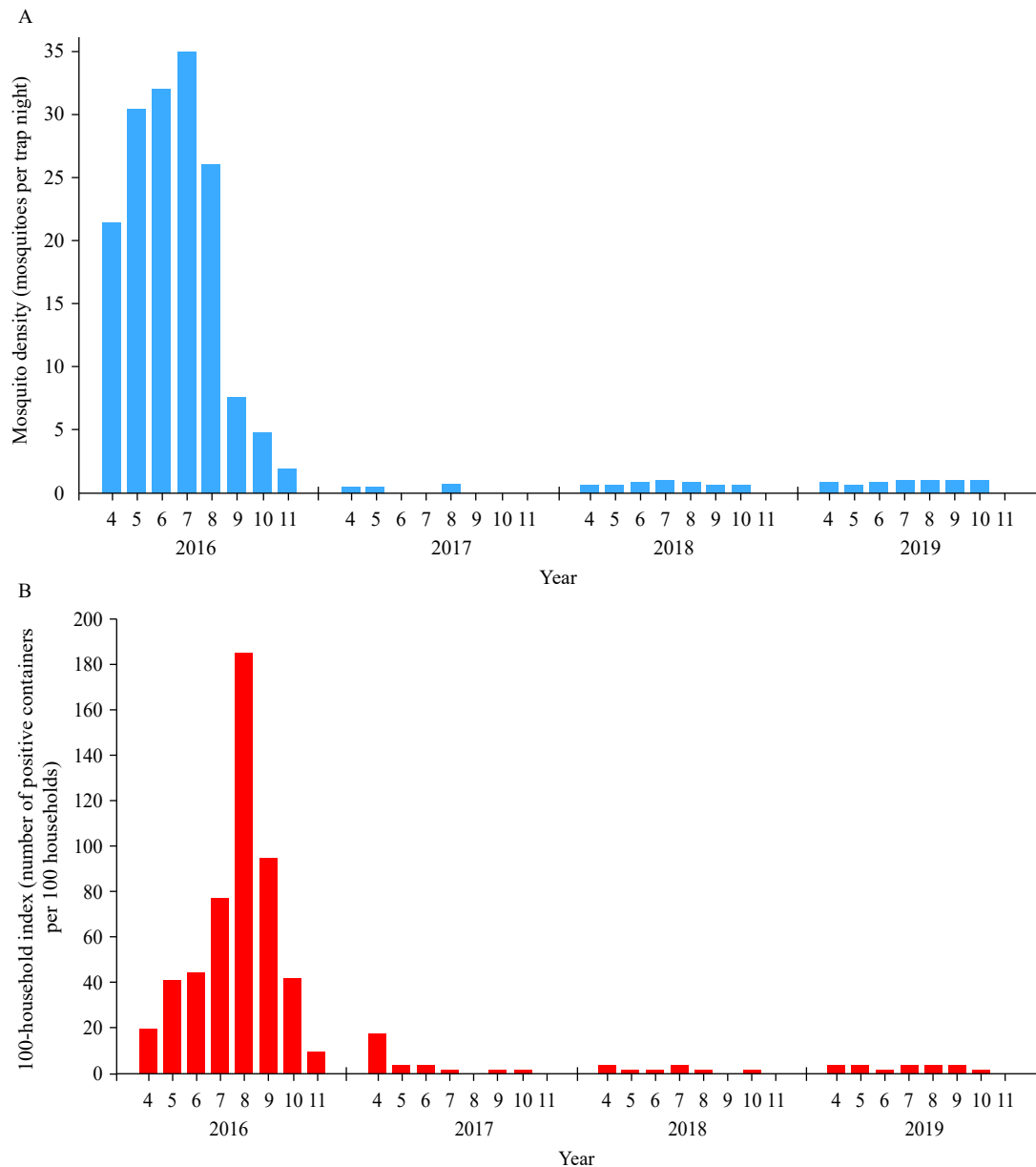


FIGURE 1. Mosquito surveillance data\* of Xuexiazhuang village from 2016 to 2019. (A) Light trapping method; (B) 100-household index method.

\*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 year-

round 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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