JHAD
Health and Development Journal
https://jhad.kmu.ac.ir
doi:10.34172/jhad.1244
JHAD. 2025;14:1244

Policy Brief

Global Lessons for Aedes Control in Iran in the Era of Climate Change: A Policy Brief

Seyed Aria Nejadghaderi[1], Rasoul Ebrahimi[1], Mohammad Khalili[2], AliAkbar Haghdoost[3], Abbas Aghaei-Afshar[4], Hamid Sharifi[1*]

[1]HIV/STI Surveillance Research Center, and WHO Collaborating Center for HIV Surveillance, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[2]Department of Pathobiology, Faculty of Veterinary Medicine, Shahid Bahonar University of Kerman, Kerman, Iran
[3]Modeling in Health Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[4]Research Center of Tropical and Infectious Diseases, Kerman University of Medical Sciences, Kerman, Iran

*Corresponding Author: Hamid Sharifi, Email: sharifihami@gmail.com

Abstract
Aedes mosquitoes are among the most important vectors of viral diseases such as dengue, Zika, yellow fever, and chikungunya, imposing a substantial global health burden. Climate change, urbanization, and increased population mobility have contributed to the geographic expansion of these vectors. Given the absence of effective specific treatments and the limitations of available vaccines, vector control remains the primary prevention strategy. This study was conducted as a policy review of international evidence and national guidelines for *Aedes* control across different countries. Data were extracted from published studies in reputable scientific sources and analyzed within the framework of control strategies, surveillance systems, and innovative interventions. The findings showed that most countries adopt an integrated vector management approach, including larval and adult surveillance, environmental control, community education, and chemical and biological interventions. The use of novel technologies such as predictive modeling in some countries has led to a significant reduction in disease incidence. However, excessive reliance on larval surveillance, weaknesses in adult mosquito monitoring, and a lack of data integration remain important challenges. Sustainable control of *Aedes*-borne diseases requires a data-driven, multisectoral, and community-engaged approach, and strengthening surveillance systems and intersectoral collaboration is essential for preventing future outbreaks.
Keywords: *Aedes* mosquito, Dengue fever, Vector-borne diseases, Surveillance and early warning system, Community engagement

Citation: Nejadghaderi SA, Ebrahimi R, Khalili M, Haghdoost A, Aghaei-Afshar A, Sharifi H. Global lessons for aedes control in iran in the era of climate change: a policy brief. Health Dev J 2025;14:1244. doi:10.34172/jhad.1244

ed: Xx xx, 2024, **Accepted:** Xx xx, 2024, **ePublished:** Xx xx, 2025

Introduction

Mosquitoes of the genus *Aedes* are among the most important vectors of arthropod-borne viral diseases and play a major role in the transmission of illnesses such as dengue fever, Zika, yellow fever, and chikungunya. These diseases affect millions of people worldwide each year and impose a substantial burden on health systems in terms of mortality, disability, and economic costs. The complex nature of *Aedes*-borne diseases necessitates that control and prevention strategies be comprehensive, multidimensional, and evidence-based in order to effectively prevent disease spread(1). The biological and behavioral characteristics of these mosquitoes—including their strong preference for feeding on humans, oviposition in small artificial containers, daytime activity, and highly efficient host-seeking ability—have enabled them to adapt successfully to urban environments. At the same time, the growing trend of urbanization, climate change, rising temperatures, and altered rainfall patterns has created more favorable conditions for the survival and proliferation of these vectors (2). The ability of these mosquitoes to transmit viruses depends on a capability known as "vector competence," which refers to the mosquito's ability to acquire, replicate, and transmit viruses to humans and is influenced by interactions between the virus and the mosquito's immune system.

Among *Aedes*-borne diseases, dengue fever is considered one of the most significant emerging public health threats. The disease is mainly prevalent in tropical and subtropical regions; however, in recent years, the risk of its spread to other parts of the world has also increased. Over the past four decades, dengue fever has had a considerable impact on global health and national economies and is now regarded as one of the fastest-spreading viral diseases worldwide(3). The dramatic increase in dengue incidence since the 1980s—particularly in Asia, South America, and the Caribbean—has largely been attributed to the simultaneous circulation of four distinct viral serotypes and the geographical expansion of mosquito vectors (4).

Currently, effective and specific therapeutic options for

dengue fever remain limited, and existing vaccines are associated with certain constraints. Dengvaxia is the only vaccine approved in some countries; however, the World Health Organization does not recommend its use in individuals without a prior history of dengue infection(5). Consequently, mosquito population control remains the most important and effective strategy for disease prevention. In this regard, the World Health Organization has developed a framework to assist countries in reviewing and strengthening their national vector control policies and programs(6).

Despite the increasing global burden of *Aedes*-borne diseases, important gaps remain in the evidence on the effectiveness of different control interventions across diverse geographical, economic, and social settings. Although numerous studies have examined localized vector control measures, comparative reviews that comprehensively analyze the experiences of different countries remain limited. Therefore, evaluating *Aedes* control policies and guidelines can help identify strengths, challenges, and potential pathways to improve national control programs.

Methods

This policy brief was developed based on a review of international evidence on the management and control of Aedes mosquitoes and the diseases they transmit. The reviewed studies examined strategies, guidelines, and successful experiences from various countries in vector control, dengue prevention, surveillance systems, community participation, and innovative interventions. Data were extracted from indexed scientific sources and included experiences from different countries.

Results

Effective control of *Aedes* mosquitoes and the diseases transmitted by them, particularly dengue, requires an integrated, multisectoral, and country-specific approach. In most countries, "Integrated Vector Management (IVM)" has been adopted as the primary policy framework. Alongside environmental management measures, countries have employed larval and adult mosquito surveillance, community participation, public education, targeted chemical control, and, in some cases, innovative interventions such as *Wolbachia*, smart traps, and data-driven predictive models.

However, significant gaps still remain, including excessive reliance on larval surveillance, weaknesses in adult mosquito monitoring, lack of coordination between entomological and clinical data, and the absence of sustainable intersectoral collaboration. In countries with more centralized, data-driven, and participatory systems, interventions have shown greater effectiveness. Therefore, the most successful models are those that simultaneously rely on accurate surveillance, rapid response, community engagement, and technological innovation.

Policy Recommendations

The first recommendation is the development and implementation of a comprehensive national program for the prevention and control of *Aedes*-borne diseases. This program should go beyond reactive and short-term measures and instead be designed as a medium- and long-term operational framework that clearly defines the responsibilities of each sector. The Ministry of Health should assume the leading role; however, the success of the program can only be ensured through the effective participation of municipalities, environmental protection agencies, ports and customs authorities, the Ministry of Energy, the education sector, the media, and local institutions. Experiences from successful countries demonstrate that *Aedes* control is not merely a health issue, but also an urban, environmental, social, and even commercial challenge.

The second priority is strengthening surveillance and early warning systems. In many countries, failure to conduct regular vector surveillance has resulted in delayed and costly interventions. Therefore, Iran should establish an integrated entomological and epidemiological surveillance system capable of consolidating data on mosquito density, climatic conditions, suspected and confirmed disease cases, and geographical risk patterns within a unified platform. Within this framework, larval surveillance should continue but is not sufficient on its own. Adult mosquito surveillance—particularly in high-risk areas, ports, airports, transit centers, and southern cities—should be incorporated as a standard component of the national program. The use of effective traps, risk maps, and data-driven predictive models can facilitate the early identification of high-risk hotspots and support rapid decision-making.

The third recommendation is reducing dependence on chemical control and moving toward Integrated Vector Management (IVM). Insecticide spraying and larvicides may still be used during outbreaks or in targeted situations; however, reliance solely on these methods is not sustainable in the long term and increases the risk of insecticide resistance. Consequently, priority should be given to eliminating breeding sites, improving stagnant water management, upgrading sewage and drainage infrastructure, environmental sanitation, and controlling larval habitats. Chemical interventions should only be implemented based on defined thresholds, field evidence, and continuous resistance monitoring. This issue is particularly important in urban and densely populated areas.

The fourth recommendation is investing in community participation and public education. Nearly all successful experiences indicate that no control program can remain sustainable without public cooperation. Awareness campaigns should move beyond broad and temporary messaging and instead focus on specific and actionable behaviors, such as regularly emptying stagnant water, covering water storage containers, removing unused containers from yards and rooftops, properly managing discarded tires, and promptly reporting suspected cases. To maximize effectiveness, educational interventions should be

tailored to different target groups. For example, residents of high-risk neighborhoods, school communities, municipal workers, warehouse owners, and transit facility operators require distinct and practical messages. In addition, the capacities of local leaders, religious authorities, local councils, non-governmental organizations, and volunteer health groups should be utilized to strengthen community ownership of the program.

The fifth recommendation is strengthening intersectoral collaboration based on the "One Health" approach. Sustainable *Aedes* control can only be achieved when human health, urban management, environmental sanitation, climate change, population mobility, and even veterinary and ecological considerations are addressed simultaneously. Permanent national and provincial task forces with clearly defined mandates should therefore be established to coordinate prevention, surveillance, outbreak response, and performance evaluation activities. These task forces should remain active continuously rather than only during crises and should regularly report to high-level decision-making authorities. At the operational level, coordination with municipalities for waste management, with ports and customs authorities for monitoring high-risk imported goods such as used tires, and with healthcare facilities for the rapid reporting of suspected and confirmed cases is essential.

The sixth recommendation is the gradual adoption of effective and low-risk innovations. Experiences from countries such as Singapore, Indonesia, Australia, and several regions in Latin America indicate that technologies such as *Wolbachia*, sterile insects, auto-dissemination traps, and smart surveillance systems can contribute significantly to reducing vector populations and interrupting transmission chains. However, these technologies should be introduced progressively and accompanied by careful assessments of cost-effectiveness, operational feasibility, social acceptance, and environmental considerations. For Iran, conducting limited pilot projects in high-risk areas could represent an appropriate first step, provided that technical, legal, and communication capacities are simultaneously strengthened.

The seventh recommendation is improving the preparedness of the health system for diagnosis and clinical response. Although prevention remains the cornerstone of dengue control, delays in diagnosis and appropriate treatment can increase mortality. Therefore, physicians, nurses, and emergency personnel should receive enhanced training on warning signs, management of suspected cases, differential diagnosis of dengue from other febrile illnesses, and timely referral procedures. In high-risk areas, preparedness protocols, rapid referral pathways, and reserves of essential equipment for outbreak response should be established. At the same time, coordination between healthcare facilities and vector surveillance systems should be strengthened so that clinical reports can rapidly trigger field interventions.

The eighth recommendation is the development of data infrastructure and applied research. Control programs become more effective when they rely on up-to-date local evidence. Accordingly, a national database should be established to record human cases, entomological indicators, climatic data, and intervention outcomes. Such a database could support both operational decision-making and applied research. Support for field studies, risk modeling, insecticide resistance monitoring, and evaluations of innovative interventions should be prioritized by research centers and universities.

Finally, experiences from different countries demonstrate that successful *Aedes* control can only be achieved when prevention, surveillance, community participation, technological innovation, and multisectoral governance advance simultaneously. For Iran, the opportunity to prevent the widespread and permanent establishment of this vector still exists; however, this window of opportunity is limited and requires immediate, coordinated, and evidence-based action.

Conclusion

Diseases transmitted by *Aedes* mosquitoes, particularly dengue fever, have become major public health threats globally and regionally due to their rapid geographical expansion, climate change, increasing travel, and urbanization. A review of experiences from different countries demonstrates that the most successful control programs have been based on Integrated Vector Management (IVM), continuous surveillance, active community participation, intersectoral collaboration, and the use of innovative technologies and interventions. At the same time, excessive reliance on chemical methods, weaknesses in early warning systems, and the lack of effective coordination among sectors remain among the most significant challenges.

For Iran, given the risk of introduction and establishment of vector mosquitoes in certain regions of the country, adopting a preventive, data-driven, and "One Health"-based approach is essential. Strengthening surveillance systems, expanding public education, improving environmental management, and investing in technical and research capacities can play a critical role in preventing future outbreaks and reducing the burden of *Aedes*-borne diseases.

Acknowledgments

This policy brief was derived from a research project No. 403000324 approved by Kerman University of Medical Sciences. The authors would like to express their gratitude to the Center for Communicable Disease Management of the Ministry of Health and Medical Education for its financial support of this project.

Authors' Contribution

Conceptualization: AliAkbar Haghdoost, Abbas Aghaei-Afshar, Hamid Sharifi.
Investigation: Seyed Aria Nejadghaderi, Rasoul Ebrahimi, Mohammad Khalili.
Supervision: Hamid Sharifi.
Validation: AliAkbar Haghdoost, Abbas Aghaei-Afshar, Hamid Sharifi.
Writing–original draft: Seyed Aria Nejadghaderi, Rasoul Ebrahimi, Mohammad Khalili.

Writing–review & editing: All Authors.

Availability of Data and Materials
Not applicable.

Competing Interests
The authors declare that they have no conflicts of interest.

Ethical Approval
Not applicable.

Funding
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Supplementary File
Supplementary File. The Persian version of this article

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