

# The Role of Governance in Vector Control for Dengue Fever: A Narrative Review

Thamra Al Ghafri<sup>1</sup>, Shauqi Al Zedjali<sup>2</sup>, Mazin Al Maamari<sup>2</sup>, Asim Al Minji<sup>3</sup>, Maryam Al Kalbani<sup>3</sup>, Ahmed Al Harthi<sup>4</sup>, Jannat Al Harthi<sup>5</sup>, Lamya Al Balushi<sup>3</sup>, Mohamed Amin<sup>3</sup> and Salah Al Awaidy<sup>6\*</sup>

<sup>1</sup>Department of family medicine and public health, Sultan Qaboos University, Muscat, Oman

<sup>2</sup>Health Affairs, Muscat of Municipality, Muscat, Oman

<sup>3</sup>Department of disease surveillance and control, Directorate of health services in Muscat, Oman

<sup>4</sup>College of medicine, Sultan Qaboos University, Muscat, Oman

<sup>5</sup>College of medicine, National University of science and technology, Sohar, Oman

<sup>6</sup>Ex. Ministry of Health, Muscat, Oman

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\*Corresponding author: [salah.awaidy@gmail.com](mailto:salah.awaidy@gmail.com)

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## Abstract

Dengue fever (DF) is a growing global public health concern and has emerged as a significant public health issue in Oman. The alarming trend of the rapid spread of dengue disease across the world in recent years necessitates a coordinated response across sectors and borders. Vector control measures are a critical component of disease control, with robust governance serving as the foundation for success. Structured governance is the basis for putting policies into action, allocating resources, and making sure that large, coordinated, cross-sectoral projects work. This narrative review analysis examines the effective vector control strategies utilized to manage DF outbreaks in Muscat, Oman, between 2019 and 2024. The notable decrease in the overall number of reported DF cases observed in 2024 was attributed to a series of coordinated actions led by the Muscat Municipality. This review outlined these actions utilizing the five components of the World Health Organization (WHO) Global Strategic Preparedness, Readiness, and Response Plan launched in October 2024. The components include emergency coordination, collaborative surveillance, community protection, safe and scalable care, and access to countermeasures. Based on the implementation of WHO global strategies, the dengue cases drop dramatically until 2024. Ultimately, emerging lessons and best practices from examining the Muscat governorate experience can inform the implementation of a sustainable, decentralized, and responsive vector control multi-sectoral approach to the prevention and control of DF across all regions of Oman and neighboring countries.

**Keywords:** *Aedes aegypti*; Dengue fever; Mosquito; Outbreak Muscat; Oman

## Introduction

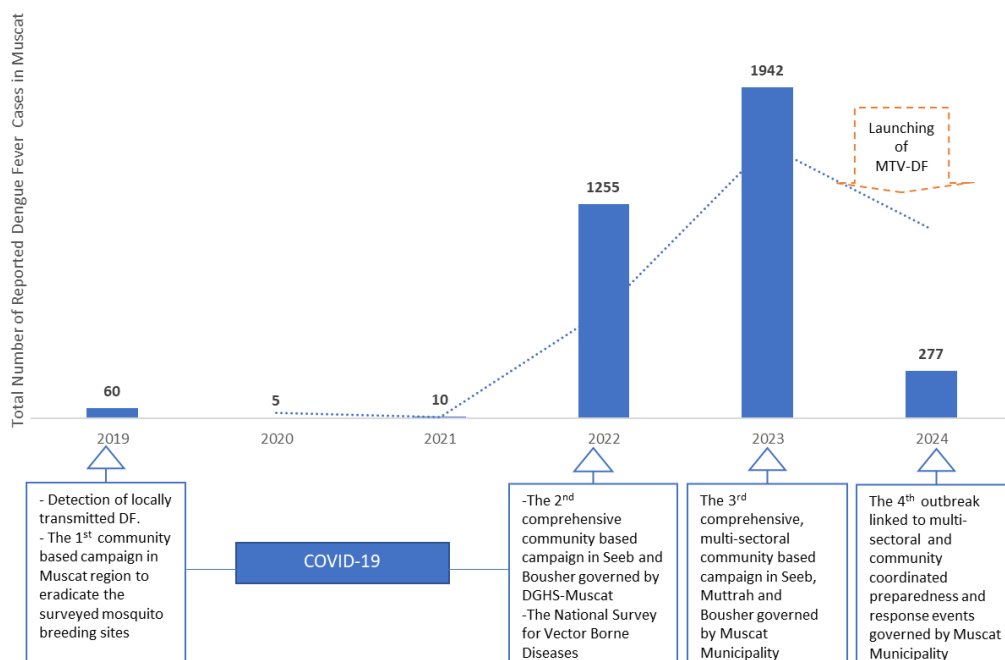
Dengue fever (DF) is a mosquito-borne viral disease caused by a positive single-stranded Ribonucleic acid (RNA) virus that belongs to the family Flaviviridae. Four distinct, closely related dengue virus serotypes (DENV1–4) were identified.<sup>1</sup> Lifelong immunity is acquired from infection by one serotype; however, cross-immunity to the other serotypes is only partial, and subsequent infections by other serotypes may lead to severe DF due to antibody-dependent enhancement (ADE).<sup>2</sup> According to the International Health Regulations (IHR), DF has the potential to

cause serious public health impacts due to its capacity to spread internationally.<sup>1</sup> One modeling estimate indicates 390 million dengue virus infections per year, of which 96 million manifest clinically.<sup>3</sup> Another study on the prevalence of dengue estimates that 3.9 billion people are at risk of infection with dengue viruses.<sup>4</sup> The disease is now endemic in more than 100 countries in the WHO Regions of Africa, the Americas, the Eastern Mediterranean, Southeast Asia, and the Western Pacific. The Americas, Southeast Asia, and Western Pacific regions are the most seriously affected, with Asia representing around 70% of the global disease burden. Climate change, leading to unusual rainfall, has reported outbreaks in middle- and high-income countries such as Egypt, Oman, and Saudi Arabia.<sup>5-7</sup>

Oman launched a communicable disease surveillance and control program in 1991.<sup>8</sup> It is mandatory to report DF and dengue haemorrhagic fever (DHF) within 24 hours of suspecting or diagnosing them as Group A diseases and syndromes, respectively, to ensure a quick response.

173 travel-related cases of DF were reported from 2001 to the end of 2017, and 30 travel-related cases were reported from 1 January to mid-December 2018.<sup>9</sup> A review of surveillance data from the 2022 dengue fever epidemic in Muscat Governorate, Oman, revealed that fever was the most often reported symptom (100%), followed by myalgia (56%), tiredness (33%), headache (27%), and arthralgia (25%), in decreasing order. Hemorrhagic symptoms occurred in 10% of patients, and hospitalization was necessary in 55.1% of verified cases.<sup>10</sup>

The cumulative reported cases of DF in the Muscat governorate from 2019 to 2024 show a substantial rise from 60 cases in 2019 to 1942 cases in 2023. Subsequently, there was a substantial decline of almost 85% in the total number of reported DF-positive cases in 2024. [Figure 1] This was associated with the execution of integrated strategies that mandated multi-sectoral collaborative efforts, data exchange, environmental hygiene, and community involvement.



**Figure 1:** Total number of reported dengue fever cases in Muscat governorate, 2019 to 2024 MoH: Ministry of Health, DF: dengue fever, DGHS-Muscat: Directorate of Health Services in Muscat, MTV-DF: Muscat Team in Vector Control for the Management of dengue fever (DF)

Evidence suggests that local governance frameworks are crucial in mobilizing resources and fostering partnerships that enhance the efficacy of mosquito control programs.<sup>11</sup> Research by Bhowmik et al. (2020)

emphasized that areas with strong governance are more likely to implement comprehensive and sustained vector control strategies. Recent suggestions indicate that strategies aimed at controlling the transmission of DF are more effective in settings that include multi-sectoral cooperation throughout the implementation phase.<sup>12</sup> The use of the multi-sectoral approach in the prevention and control of vector-borne diseases has been recommended by the WHO<sup>13</sup> and cited in several studies including the one health SMART approach in Indonesia, and the Eco-Bio-Social Research in Asia.<sup>14,15</sup> Additionally, investing in vector control is cost-effective compared to the expenses associated with treating severe dengue and other Aedes-borne viral diseases.<sup>16</sup> Therefore, augmenting efforts and resources is needed to ensure that vector control strategies are rapid and effective. Thus, the objective of this review was to describe the role of governance in the multi-sectoral actions for vector control in DF experienced in Muscat governorate from 2019 to 2024 utilizing the components of the WHO Global Strategic Preparedness, Readiness, and Response Plan (SPRP).<sup>17</sup>

## ***Dengue Fever Vector Control in Muscat governorate: A Multi-Sectoral Approach Guided by the components of the WHO SPRP***

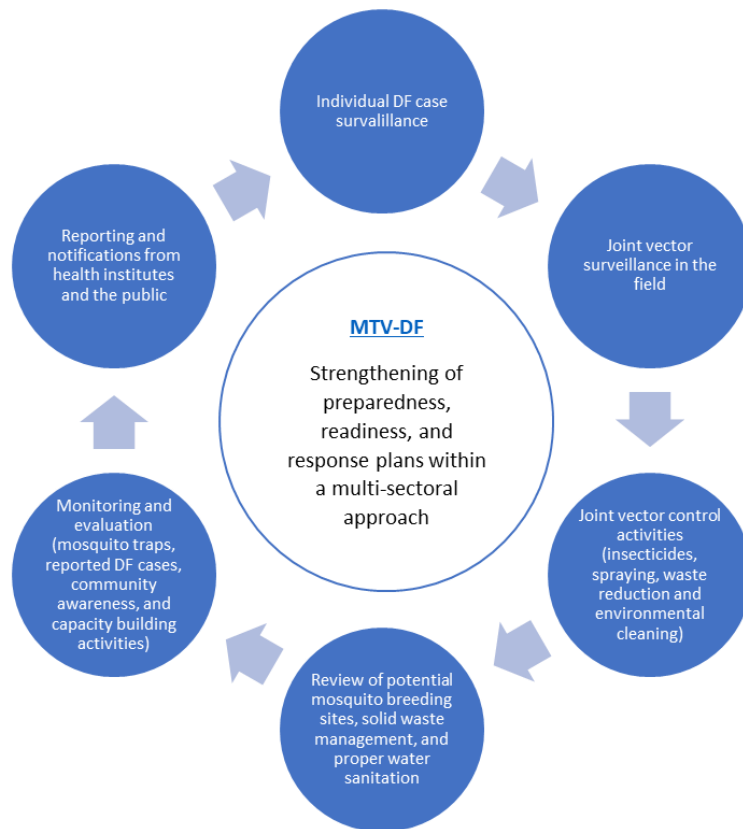
### ***Emergency coordination "leadership and coordination activities"***

In response to the first DF outbreak in Muscat in 2018-2019, the Ministry of Health (MoH) launched a broad-based, multi-sectoral community campaign from 8 to 23 January 2019 to curb the spread of the disease. Despite extensive door-to-door vector control efforts to eliminate mosquito breeding sites in previously surveyed communities, the vector remained uncontrolled. The administrative structure involved in the campaign included technical, logistical, and community communication teams. The planning, implementation, and supervision of the campaign were the responsibility of the Ministry of Health (MoH). However, due to the interruption of vector control and surveillance activities during the Coronavirus disease-19 (COVID-19) pandemic, the second and third outbreaks occurred. In response, a decentralized approach was adopted to prevent further outbreaks through the deployment of the Muscat Team in Vector Control for the Management of DF (MTV-DF). The team was formed on July 13th, 2023, by the governor of Muscat governorate and chaired by the president of Muscat Municipality (MM) and the membership of MoH, Ministry of Workforce, Ministry of Education, Ministry of Environment and Climate Change, the Royal Oman Police (ROP), Ministry of Agriculture, and the private companies in the industrial areas. The primary goal of the team was to interrupt the disease transmission cycle and reduce disease incidence by controlling mosquito populations and limiting human-mosquito contact.

The team continued to meet regularly with follow-up agendas and to monitor key performance indicators across the governorate. The key responsibilities included supervising the implementation of the policies, legal frameworks, and guidelines for outbreak response and ensuring alignment with the International Health Regulation (IHR); Ensuring that decisions were evidence-based, resources were used effectively, and communication with the public was constant; Coordinating efforts across government agencies, non-governmental organizations (NGOs), international bodies (e.g., WHO, Center for Diseases Control (CDC), industrial areas, and local communities; Strengthening surveillance, preparedness plans, and response mechanisms; Ensuring adequate funding, human resources, and logistics to support outbreak response; Building public trust through effective risk communication, combating misinformation, and promoting compliance with public health measures; We encourage research and innovative technologies and tools for the early detection and control of DF.

### ***Vector control surveillance collaborative***

The regional MTV-DF orchestrates the initiatives of the impacted sectors to provide efficient mechanisms for the early identification and management of dengue epidemics. Preventive strategies include cooperative monitoring and control initiatives, eradication of breeding sites, regional insecticide application, and the dissemination of field data via advanced automation systems. Figure 2 delineates the collaborative process used inside the MTV-DF.



**Figure 2:** Summary of the collaborative methodology within Muscat Team in Vector Control for the Management of Dengue Fever (MTV-DF).

The collaboration between members of the MTV-DF, namely MM and MoH, is instant and integrative. Suspected cases of DF from MoH facilities and private hospitals (hospital and primary care) are reported to the regional focal points within 24 hours through an automated notification system called "Tarassud.". The data is then shared with MM to prepare for field inspections. A regional team from MoH and MM visits the location of the reported positive case and utilizes the phone application "epicollect" to upload information on the geographical location, results of inspections for breeding sites, type of residence, and waste management around the affected areas. *Aedes aegypti* mosquitoes' breeding sites are eliminated and treated with insecticides. Thermal fogging and cold fogging with pyrethroid insecticides are used to control adult mosquitoes as per the national protocols. In high-risk areas, joint teams use thermal fogging or ultra-low volume (ULV) spraying to target adult mosquitoes. Spraying is scheduled based on the shared surveillance data, usually in the early mornings or evenings when mosquitoes are most active. Additionally, MTV-DF responds to community complaints of mosquito presence in houses and open spaces. Simultaneously, warnings or fines are issued to properties with repeated mosquito breeding grounds.

Importantly, MTV-DF supports the review of pesticides used in vector control for DF, and resistance to pesticides is monitored and supervised. Moreover, environmental sanitation works, and the management of solid waste is coordinated closely by members of MTV-DF through the Ministry of Agriculture, the Ministry of Environment and Climate Change, and the private companies in the industrial areas. Farmers and local landowners are regularly educated about DF, including the spread of the disease, ways of prevention (personal protection protocols), and danger signs. This is done through field visits, community meetings, workshops, and the distribution of multilingual educational materials.

Since there are different ports of entry (PoE) to and from Muscat governorate, the MTV-DF supervises delivering practical programs and trained personnel for the surveillance and control of vector reservoirs in and near

PoE according to IHR and the WHO Handbook on vector surveillance and control at ports, airports, and ground crossings.<sup>18</sup>

### ***Community protection "engaging the community and cultural adaptation of prevention and response measures"***

To produce significant results in reducing the impact of dengue outbreaks, effective governance requires enforcing collaboration between governmental sectors, concerned agencies, and community organization.<sup>19</sup> This partnership is critical to harmonizing efforts and ensuring that resources are directed where they are most needed. All members of MTV-DF work jointly to conduct educational campaigns in schools, mosques, industrial areas, government institutes, and neighborhoods to educate residents on mosquito prevention (e.g., covering water storage, eliminating standing water). The local campaigns are supported by local leaders, social influencers, faculties of schools and universities, and mosques' attendants. The campaigns are structured to induce positive behavior change within the community to support vector control efforts. Examples of the educational materials in various languages are attached in the supplementary file.

### ***Safe and scalable care "effective clinical management and resilient primary, secondary and tertiary health services"***

DF can develop into a serious illness that requires immediate medical attention to prevent death. Appropriate clinical management ensures that patients receive timely supportive care, including fluid management and close monitoring for warning signs such as plasma leakage, severe bleeding, or organ damage, and that appropriate measures are taken to treat these complications. Clinical treatment protocols are developed and updated by the central authority at the MoH. Healthcare providers identify trends in disease presentation and severity, providing valuable data to public health authorities. Inter-departmental collaboration and surveillance data within the inpatient setting are strengthened and promptly monitored. The role of laboratory and diagnostic services are uplifted and enhanced to maximize public health responses. Additionally, clinicians followed a manual for management of dengue fever which was created and accompanied by serial of HCW education activities. This information is critical to monitoring the spread of the disease, evaluating the effectiveness of control measures, and adjusting the public health response accordingly.

Infection prevention and control (IPC) in health care facilities during dengue outbreaks is crucial to protect patients and health care workers and prevent further virus spread. Regional MTV-DF presented by the IPC sub-teams in the Directorate General of Health Services in Muscat governorate (DGHS-Muscat) ensures the availability and proper use of personal protective equipment (PPE) for health care workers when handling suspected or confirmed DF cases.

Additionally, the IPC sub-team supervises the implementation of IPC standard precautions in all the health facilities within DGHS-Muscat, focusing on hand hygiene, safe injection and sharps injury prevention, environmental cleaning, and health care facilities assessments.

Blood banks, on the other hand, are well informed about the geographical distribution of the positive DF cases for which adequate supply of blood is ensured to meet the needs of dengue patients. Also, the blood bank in Muscat launched DF tests for all blood donations, especially for donors residing in geographically mosquito-dense areas. This is important to prevent the transmission of DF through blood transfusions.

The introduction of the rapid DF tests in primary, secondary, and tertiary health facilities, including the private sector, in 2023 facilitated early detection and management of DF cases and contributed to the reduction of DF cases in [Figure 1].

## ***Access to countermeasures through research and innovative interventions***

Members of the MTV-DF are exposed to external participation in conferences and workshops. The experience of MTV-DF was presented at the 1st international conference on vector control interventions for DF on 29-30 October 2024 in Muscat. The conference provided opportunities for the national public health workers across all the concerned sectors to learn about the updates on vector control projects around the world.

The use of mosquito smart traps was encouraged by WHO, as entomological vector surveillance is a requisite for designing, planning, monitoring, and sustaining cost-effective vector control interventions. In Oman, different mosquito traps are used. More than 71 and 15 smart traps are monitored by MoH and MM respectively. All traps are distributed in the mosquito-dense areas. Data from the traps is analyzed and tracked to facilitate preparedness plans and prevent DF outbreaks. The MTV-DF is working to deploy more innovative mosquito traps to improve mosquito detection and identification, as recommended in the literature.<sup>20</sup>

## ***Conclusion and the way forward***

This review advocates the importance of good governance in vector control interventions for DF in the Muscat governorate, particularly in the context of the main components of the WHO SPRP. The multi-sectoral approaches that have been described are intended to serve as a model for other regions to reduce the transmission of diseases and maximize their capabilities. Therefore, to optimize resource utilization and achieve co-benefits, it is prudent to incorporate vector control measures into routine sectoral activities. Strong political will and collaborative solidarity are essential for designing effective and efficient multi-sectoral programs to prevent and control vector-borne diseases. To achieve successful vector control for DF, it is essential to build capacity through regional/decentralized training, strengthen surveillance and control strategies, empower health care facilities, engage the community, and encourage innovative projects. Integrated vector management, in conjunction with continuous surveillance and evaluation through multi-sectoral shared platforms, is the most effective approach to reducing the morbidity and mortality associated with vector-borne diseases.

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