Management and Control of Dengue Fever through One Health Approach

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ABSTRACT

Dengue fever, a virus transmitted by mosquitoes, continues to pose a significant health challenge on a global scale, especially in tropical areas. The One Health approach, which considers the interconnected areas of human, animal, and environmental health, is becoming a comprehensive strategy for managing and controlling this intricate infectious disease. A key aspect involves improved diagnostic abilities and smooth information exchange between healthcare facilities, which are crucial for surveillance and early detection. Effective dengue management relies on cooperation between public health and environmental agencies to carry out specific interventions such as insecticides, biological controls, and environmental modifications to prevent mosquito breeding. This collaboration is vital for controlling dengue. At the same time, a comprehensive approach to environmental management includes coordinated land use planning and recognizes the influence of climate change on mosquito carriers. Public awareness initiatives are essential in highlighting the importance of community involvement and individual accountability in reducing the breeding grounds for mosquitoes. It is crucial to conduct interdisciplinary research in order to progress our comprehension of dengue patterns and to encourage the development of inventive control methods, such as the genetic alteration of mosquitoes. In terms of policy, it is crucial to encourage collaboration between different agencies and countries, to support the creation and execution of policies that align with a unified One Health approach. By combining forces from various fields such as health, agriculture, environment, and education, the One Health strategy provides an effective way to reduce the spread of dengue fever, recognizing the complex interconnections between humans, animals, and the environment. This comprehensive method not only strengthens our ability to protect against dengue, but also lays a strong groundwork for tackling other new infectious risks that affect multiple areas of health.

Keyword: Dengue Fever; One Health Approach; Vector Control; Interdisciplinary Collaboration; Public Awareness.

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1. INTRODUCTION

Dengue fever is a major global health concern affecting millions of people globally. Dengue fever is widespread in more than 100 nations, as reported by the World Health Organization (WHO), causing an average of 390 million infections every year. Aedes mosquitos spread the disease, and its signs and symptoms vary from low-grade fever to severe hemorrhagic fever, which may prove fatal if neglected (WHO 2023). Because of the seriousness of the illness and expanding prevalence, successful dengue fever prevention and control have become a critical public health priority (Chowdhury and Chakraborty 2017).

One Health is a cooperative, multidisciplinary strategy that recognizes the interdependence of individual, animal, and environmental wellness. The One Health concept has gained importance in the past few years as a potential option for managing and preventing dengue fever. The One Health strategy seeks to limit the spread of virus and enhance the well-being of human and animal communities by targeting the disease's environmental, natural, and social factors (Cataldo et al. 2023).

Dengue fever has a large economic impact, with an anticipated 100 million symptomatic infections along with 10,000 deaths every year (Semenza et al. 2022). It has the greatest incidence in Asia, as well as Latin America, where most child having less than the age of 15 bear the majority of the disease's incidence. The growing frequency of dengue fever and the difficulties associated with its management and control render the One Health strategy an intriguing strategy for lowering the incidence of disease and enhancing public health benefits (Yang et al. 2021).

This chapter aims to offer a brief insight into dengue fever alongside the One Health approach, which further explains ways for preventing and treating dengue fever by adopting the One Health method.

2. BACKGROUND OF DENGUE FEVER

Dengue fever is an infection transmitted through the dengue virus (DENV) which is spread by the bite of infected *Aedes* mosquitos. It is most common in tropical and subtropical regions of the world, such as Asia, South America and Africa (Xiang et al., 2022). According to WHO, dengue fever is responsible for an estimated 50 million illnesses across the world each year.

The dengue virus is a member of family Flaviviridae, including the viruses responsible for Zika and yellow fever. Infections with one serotype do not resist the other strains (DENV-1, DENV-2, DENV-3, and DENV-4). On the other hand, additional infection with a distinct serotype might cause more severe forms of dengue hemorrhagic fever (DHF) or dengue shock disorder (DSS) (Zerfu et al. 2023).

Dengue fever has long been reported in Southeast Asia and other tropical places. Disease outbreaks were first documented in Asia, Africa, and the United States during the 1770s (Chong et al. 2023). Dengue fever has expanded to other nations and continents throughout the years, growing endemic in numerous regions of the world. Changes in the climate, urbanization, and population expansion are only a few variables that have led to dengue fever's growing impact (Petzold et al. 2022).

The primary underlying cause of the illness is infections caused by the dengue virus, which is transferred to humans via bite of infected *Aedes* mosquitos. *Aedes aegypti* is the principal carrier of the dengue virus in many regions of the world; however, *Aedes albopictus* may also propagate the disease. These mosquitos breed in stagnant water, such as flower pots, old tyres, and reservoirs for water (Manuahe et al. 2020).

Disease symptoms include a high temperature, severe headache, discomfort in the eyes, muscles and joints, rash, and slight bleeding from the nostrils or gums. In some situations, dengue fever might proceed to DHF or dengue shock syndrome (DSS); both can be lethal (Hashmi et al. 2023).

3. DIAGNOSIS OF DENGUE FEVER

Dengue fever laboratory diagnosis is critical for confirming the infection, identifying the viral serotype, monitoring disease development, and guiding treatment. Depending on the stage of infection, the availability of resources, and the goal of testing, multiple methods and assays can be employed for laboratory diagnosis of dengue fever(Kelly et al. 2023). Following are the tests used for diagnosis of infections:

3.1. NAATS (NUCLEIC ACID AMPLIFICATION TESTS)

These assays use reverse transcription polymerase chain reaction (RT-PCR) or loop-mediated isothermal amplification (LAMP) to detect viral genomic sequences. Because they are very sensitive, specific, and fast, they are the primary approach for laboratory diagnosis of dengue fever. They can also distinguish between virus serotypes and genotypes. NAATs should be done on serum samples collected within 7 days of the beginning of symptoms (Jiang et al. 2023).

3.2. ANTIGEN DETECTION TESTS

These immunoassay tests detect the viral nonstructural protein 1 (NS1) antigen. They are also sensitive, specific, and fast, and can be used on serum, plasma, or whole blood samples. The NS1 antigen is capable of detected from the very first day of infection until 9 days later2. In addition, NS1 antigen detection and IgM antibody detection can be coupled in a single test (Fisher et al. 2023).

3.3. ANTIBODY DETECTION TESTS

These examinations use enzyme-linked immunosorbent assays (ELISA) or rapid diagnostic tests (RDT) to detect the IgM and IgG antibodies that are produced by the host's immune system during response to dengue infection. They can help in diagnosis later in the disease (>4 days after fever onset), when NAATs and antigen detection examinations may be negative. They do, however, have certain limitations, including cross-reactivity with various other flaviviruses, difficulties identifying primary from secondary infections, and a delay in antibody generation (Fisher et al. 2023).

3.4. PRNT (PLAQUE REDUCTION NEUTRALISATION TEST)

This test determines whether or not neutralising antibodies can limit virus infectivity in cell culture. It is regarded as the gold standard for dengue serological diagnosis since it can confirm illness, identify viral serotypes, and distinguish between primary and subsequent infections. However, it is technically difficult, time-consuming, and necessitates the use of a biosafety laboratory of level 3 (Merakou et al. 2023).

Dengue fever laboratory diagnosis is critical but difficult, requiring a mix of several procedures and assays to produce an accurate and timely result. More research and development are required to improve the performance, availability, and affordability of dengue fever diagnostic assays. Dengue fever

laboratory diagnosis is critical but difficult, requiring a mix of several procedures and assays to produce an accurate and timely result. More research and development are required to improve the performance, availability, and affordability of dengue fever diagnostic assays (Kulkarni et al. 2023).

4. ONE HEALTH APPROACH

The One Health concept is an interactive, multidisciplinary strategy that acknowledges the interdependence of individual, animal, and environmental health. It recognizes that human, animal, and environmental health are all interconnected and that transmission of diseases can occur at the intersection of each of these areas. This approach emphasizes the importance of collaborative and integrated efforts throughout fields to address complicated health concerns (Cabrera et al. 2022).

5. IMPORTANCE OF THE ONE HEALTH APPROACH IN MANAGING AND CONTROLLING DENGUE FEVER

The One Health concept is becoming widely recognized as a valuable tool for preventing and treating dengue fever. The One Health strategy strives to limit virus transmission and enhance the well-being of human and animal habitats by tackling the disease's natural, environmental, and social causes (Socha et al. 2022).

The transmission of dengue fever is shown in Fig. 1.

The One Health strategy, for instance, acknowledges that variables which include shifting land use, urbanization, changes in the climate, and human behavior affects the dengue fever spread. Resolving these fundamental issues requires coordination among environmental health experts, public health officials, and other stakeholders to foster environment friendly land use, limit urbanization, and encourage behavior change, such as good waste management practices (Mulakoli et al. 2022).

6. ROLE OF DIFFERENT STAKEHOLDERS IN THE ONE HEALTH APPROACH

Collaboration and communication amongst many stakeholders, such as public health authorities, veterinary professionals, and health care professionals, are essential components of the One Health strategy. Public health personnel are in charge of illness monitoring and oversight, epidemiological studies, and knowledge dissemination to public. Veterinarians are crucial in discovering zoonotic infections and undertaking animal community monitoring. They can help with zoonotic disease prevention by emphasizing disease reservoirs and pushing for a global perspective, as well as concentrating on individual patient well-being. Both government and private veterinarians play critical front-line roles in national zoonoses surveillance (Steele et al. 2021).

The American Veterinary Medical Association (AVMA) considers that veterinarians play a crucial part in One Health since animals can influence and influenced by people and the environment. Veterinarians are critical to develop One Health strategies and maintaining the health and safety of its three pillars: animals, people, and the environment, whether as clinical practitioners, epidemiologists, or ecological experts (Ghanbari et al. 2020). Environmental health professionals can shed light on the effects of shifts in land use as well as additional external variables on the transmission of diseases (Iftikhar et al. 2023).

A recent study of Brazil discovered that the One Health approach, which involved collaboration among public health professionals, veterinary professionals, and environmentalists, was beneficial in reducing the prevalence of dengue fever and increasing public health outcomes (Owusu-Asenso 2023).

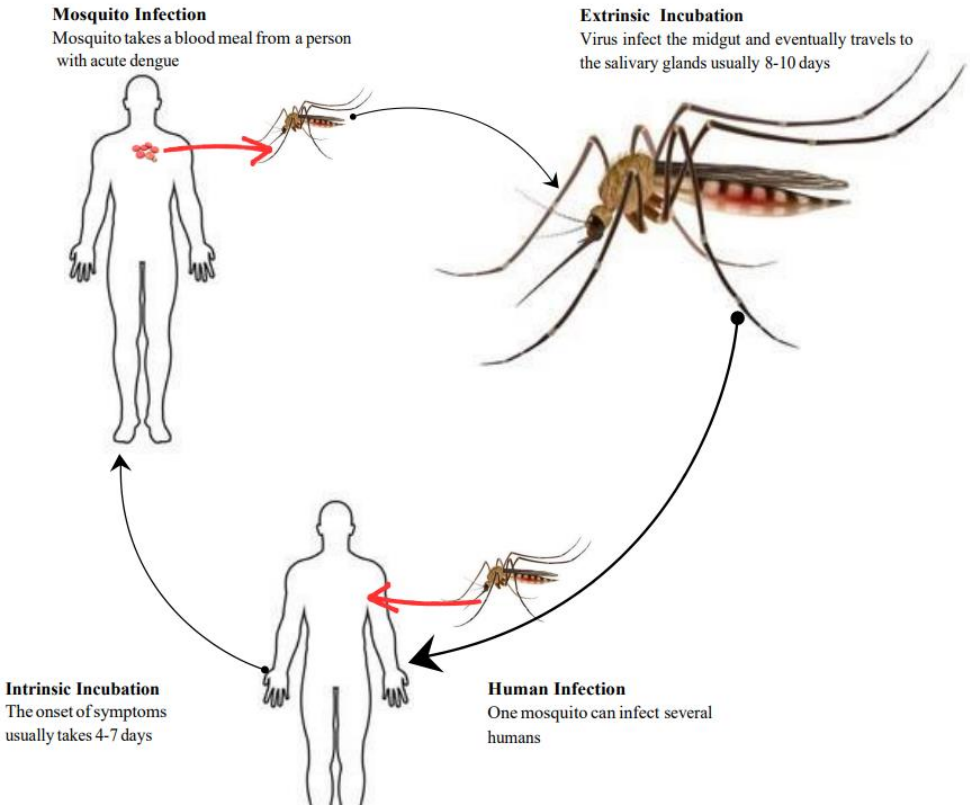

Fig. 1: Transmission of Dengue Fever

7. MANAGEMENT AND CONTROL STRATEGIES

7.1. VACCINATION PROGRAMS

Another key technique for managing and reducing dengue fever is vaccination programs. Several vaccinations have been produced and are already in use in various countries. Dengvaxia, the initial dengue vaccine, received clearance for use in numerous countries in 2015. TAK-003 as well as TV003/TV005 vaccines, are now being researched and evaluated in clinical trials (Wilder-Smith 2022).
Studies have demonstrated vaccination programs to be beneficial for decreasing the prevalence of dengue fever (Capeding et al. 2014; Hadinegoro et al. 2015). Dengvaxia was found to be beneficial in avoiding severe dengue fever among kids aged 9 to 16 years old in an investigation in Latin America (Villar et al. 2015). However, The efficiency of vaccination programs varies depending on the mosquito serotypes common in the location, the ages of people in the area, and vaccine effectiveness (Hussain et al. 2023).

8. DENGUE SURVEILLANCE

Dengue surveillance is a way of monitoring dengue cases and vector populations on a regular basis. Dengue fever cases are reported to national health officials. The World Health Organization (WHO) recommends that every dengue-endemic country require official reporting of dengue cases. Electronic reporting solutions should be developed and widely deployed to accelerate data delivery to stakeholders. Dengue surveillance data should at the very least include rates of dengue fever, dengue hemorrhagic fever, dengue shock syndrome and dengue mortality (WHO 2023).

Hospitalization and mortality rates by age group should be provided. Additional studies (e.g., capture/recapture) should be undertaken on a regular basis to check under-detection, under-reporting, and surveillance quality. Standardization of laboratory methodologies and protocols is required. National governments should encourage laboratories to form networks in order to share expertise and data. The suggested procedures for confirming an acute dengue infection include RT-PCR and virus isolation (and perhaps identification of the NS1 protein), but only for the first four days after fever onset—after that, the IgM-capture enzyme-linked immunosorbent assay (ELISA) is advised (Beatty et al. 2010).

9. VECTOR CONTROL MEASURES

Vector control measures aim to reduce dengue virus transmission by targeting the *Aedes* mosquito. Standard vector control measures include using insecticides, sanitation measures, and implementing breeding site reduction programs. Insecticides, such as pyrethroids and organophosphates, are commonly used to control adult mosquitoes, while larvicides target mosquito larvae in breeding sites (Mahmud et al. 2022).

In addition to these precautions, WHO recommends that people take actions to control mosquitoes inside as well as outside their houses. This includes using screens on windows and doors, wearing long-sleeved shirts and long pants, treating boots, pants, socks and tents with 0.5% permethrin, or purchasing permethrin-treated clothes and gear. Effective vector control approaches are crucial for attaining and maintaining dengue morbidity reductions. The goal of preventive and vector control actions is to limit dengue transmission, lowering the incidence of illness and averting disease outbreaks (Rather et al. 2017).

10. CLINICAL MANAGEMENT

Dengue fever clinical care comprises symptomatic treatment, fluid management for severe dengue fever, close monitoring of vital signs and test markers, and early diagnosis and management of warning signals. Early warning indications of severe dengue include prolonged vomiting, severe stomach pain, fluid accumulation, mucosal bleeding, trouble breathing, lethargy/restlessness, postural hypotension, liver enlargement, and gradual increase in hematocrit. Other danger signals include clinical fluid accumulation and lethargy/restlessness. One of the laboratory signs to look for is an increase in hematocrit followed by a rapid decrease in platelet count (WHO 2023).

11. PUBLIC HEALTH EDUCATION CAMPAIGNS

Public health education efforts aim to increase awareness of dengue fever and encourage behavior change to reduce the possibility of transmission. Community involvement, social media marketing, and health education offered through universities and other community-serving organizations are standard methods. These programs may urge consumers to eliminate breeding places, use mosquito repellent, and seek medical attention if they show signs of dengue fever (Hasan et al. 2022).

Public health education has been shown to be effective in reducing the incidence of dengue fever. A neighborhood-based educational program in Brazil effectively decreased mosquito breeding sites and lowered the incidence of dengue sickness (Andrioli et al. 2020). However, the effectiveness of such initiatives may be influenced by the factors such as the population's economic standing, level of learning, and cultural attitudes toward sickness prevention (Hasan et al. 2022).

12. MANAGEMENT AND SUPPORTIVE TREATMENT FOR DENGUE FEVER

Dengue fever is caused by a viral infection carried by mosquitos. Dengue fever has no particular antiviral agent. Supportive care is recommended: Because of their anticoagulant qualities, patients should be encouraged to stay hydrated and avoid aspirin (acetylsalicylic acid), aspirin-containing medicines, and other nonsteroidal anti-inflammatory drugs (such as ibuprofen) (Kaagaard et al., 2023). Acetaminophen and tepid sponge baths should be used to treat fever. Fluids that might increase volume include 5% albumin, normal saline, plasma or plasma substitutes, ringer lactate, and 5% glucose diluted in normal saline in a 1:2 or 1:1 ratio. Fluids may be used with analgesics. The potential of carbazochrome sodium sulfonate to inhibit capillary permeability in dengue hemorrhagic fever/dengue shock syndrome has been evaluated however the results have been inconsistent (Majeed et al. 2023).

13. MEDICINAL PLANTS AGAINST DENGUE FEVER

Crude drugs derived from plants have emerged as essential constituents in the fight against dengue fever, highlighting their significance in treatment. Plant-based medicines contain bioactive compounds that possess antiviral, anti-inflammatory, and immunomodulatory properties, making them an advantageous addition to managing dengue fever. Many plants, including *Arrabidaea pulchra, Andrographis paniculata, Mimosa catechu, Carica papaya, Azadirachta indica, Allium sativum, Ficus septica,* and *Quercus lusitanica,* have shown potential activity against dengue fever treatment (Huang et al. 2017; Ali-Seyed and Vijayaraghavan 2020; Ester et al. 2020; Lim et al. 2021; Dwivedi et al. 2021; Altamish et al. 2022; Babbar et al. 2023). These plants contain diverse bioactive compounds, such as alkaloids, Phenolics and flavonoids, contributing to their therapeutic properties. Integrating crude drugs from these medicinal plants into dengue fever management strategies holds promise for developing effective treatments and reducing the disease burden as shown in Table 3.

14. CASE STUDIES

14.1. SINGAPORE

Singapore is a Southeast Asian Island city-state that has effectively adopted the One Health method to manage and control dengue fever. The nation has seen multiple dengue outbreaks, with 22,170 cases documented in 2013. Singapore implemented the One Health strategy to control dengue transmission, which entails coordination amongst several sectors and fields of study, particularly the health care, veterinary, and ecological sectors (Sim et al. 2020).

Singapore's primary techniques for controlling dengue fever include the One Health method and Wolbachia-infected *Aedes* mosquito. Wolbachia-infected *Aedes* mosquitos to limit the number of dengue-carrying *Aedes* mosquitos. *Wolbachia* is a commonly existing bacterium that can diminish *Aedes* mosquitos' ability to spread the dengue virus. In 2016, pilot research in Singapore found that releasing Wolbachia-infected mosquitos decreased the prevalence of dengue fever (Ong et al. 2022).

Singapore also employed active monitoring and reaction to the dengue epidemics as a control method. Singapore has established a statewide dengue monitoring program that tracks the total number of cases, their distribution, and the number of mosquitoes present. Whenever an outbreak is discovered, officials respond by implementing targeted vector control actions and health education efforts (Soh et al. 2021). A research investigation conducted in 2020 discovered that the arrival of Wolbachia-infected mosquitoes was linked with a 78% decrease in the prevalence of dengue illness in the pilot study region (Chng et al. 2022).

Table 1: Control and Management Strategies of Dengue Fever according to International Guidelines (WHO 2023)

Sr#	Strategy	International Guidelines
1.	Vaccination Programs	• Dengvaxia is recommended for use in children 9-16 years old.
2.	Surveillance	• Regular monitoring of dengue cases and vector populations • Reporting of cases to national health authorities
3.	Vector Control	• Integrated vector management (IVM) approach • Source Reduction (elimination of breeding sites). • Larviciding (use of larvicides to target mosquito larvae). • Insecticides-treated bed nets and screens
4.	Clinical Management	• Symptomatic treatment for dengue fever cases • Fluid management for severe dengue fever • Close monitoring of vital signs and laboratory parameters • Early recognition and management of warning signs
5.	Health Education	• Public awareness campaigns on dengue prevention • Education on personal protective measures • Community involvement in vector control efforts • Emphasis on cleanliness and proper waste management • Promotion of household-level preventive measures

Table 2: Management and Supportive Treatment for Dengue Fever (Majeed et al. 2023)

Sr. no.	Treatments
1.	Fluids that could increase the volume are 5% albumin, normal saline, plasma or plasma substitutes, ringer lactate and 5% glucose diluted in a ratio of 1:2 or 1:1 in normal saline. Analgesics may be used along with fluids.
2.	Acetaminophen can be used for the treatment of fever.
3.	Give carbazochrome sodium sulfonate to reduce the high permeability of blood vessels.
4.	The use of drugs like corticosteroids, aspirin, ibuprofen and NSAIDs should be contraindicated.

14.2. AUSTRALIA

Australia is another region that has effectively applied the One Health strategy to manage and control dengue fever. Dengue fever is uncommon in Australia; however, cases have been observed in the country's north. Australia has created a robust surveillance system that combines coordination between the public wellness, veterinary, and ecological sectors to avoid the arrival and transmission of dengue (Madzokere et al. 2022).

Australia's primary goal is the adoption of border management measures that will avoid the spread of the dengue virus entering the country. It involves screening travelers from dengue-endemic nations, using pesticide sprays, and fumigating all the aircraft and ships coming from these countries where dengue is common (Akter et al. 2019).

Active monitoring and reaction to foreign dengue cases are other tactics that Australia employs. The authorities launched focused vector control initiatives and public health awareness programs in response to discovering an immigrant dengue patient to avert local spread (Trewin et al. 2022).

Above mentioned studies have demonstrated that the One Health strategy, which incorporates measures to control borders and continuous monitoring and reaction, has successfully halted the arrival and expansion of dengue in Australia. Australia has efficient border control procedures and a monitoring system; therefore the danger of dengue transmission is low (Nguyen et al. 2022).

14.3. PUNJAB, PAKISTAN

Among the areas with the worst dengue fever outbreaks is Punjab which is Pakistan's largest state. A record high of 22,000 cases was recorded in 2011 during one of the province's previous dengue fever

Table 3: Medicinal plants having natural cures against Dengue fever

Botanical name	Phytopharmaceuticals	Part used	Formulation	Mechanism	Reference
Arrabidaea pulchra	Caffeoylcalleryanin	leaves	Ethanol extract	Showed anti-DENV-2 activity	(Lim et al. 2021)
Andrographis paniculata	Flavonoids, flavonoid glycosides, diterpenes glycosides, lactones and diterpenes(andrographolide).	Whole plant	Methanol extracts	Inhibited the viral activity of DENV-1.	(Ali-Seyed and Vijayaraghavan 2020)
Mimosa catechu	catechin, quercetin, catechol, and catechol amines	Several plant portions	Crude extract	Reduced peptides found in the DENV outer coating in various DENV types	(Babbar et al. 2023)
• *Carica* papaya	Quercetin	Leaves	Methanolic crude and methanolic silver synthesized nanoparticles	Effective against dengue virus type 2 by Increasing platelet counts	(Babbar et al. 2023)
• *Azadirachta indica*	Bioflavonoids (kaempferol,, rutin hyperoside and epicatechin	Leaf	Aqueous crude extract	Inhibited DENV-2 replication in both in vitro and in vivo, Increased the platelet counts	(Dwivedi et al. 2021)
• Allium sativum	Allicin, Diallyl disulfide	Bulb	Solutions with different concentration	Killing Aedes sp. at larval stage.	(Ester et al. 2020)
• *Ficus septica*	Alkaloids, i.e. phenanthroindolizidine, aminocarophenone and pyrrolidine.	Fruit, heartwood, leaves and stem	methanol extract	Inhibited DENV infection in human lung epithelial carcinoma cells and human hepatocellular carcinoma cells. Disrupt DENV-1 and DENV-2 enveloped viral layer	(Huang et al. 2017)
Quercus lusitanica,	Methyl gallate	Gall	crude methanol extracts/	Inhibited NS3 protease activity, effective against DENV-2 serotype.	(Altamish et al. 2022)

epidemics. The One Health strategy was adopted by the Punjab government to prevent the global spread of dengue (Akram et al. 2022).

Punjab utilized an integrated vector management (IVM) program as one of its main strategies to combat dengue fever as shown in Table 1. This program included public health campaigns to raise awareness and targeted vector control methods such as applying insecticides and eliminating breeding grounds (Azhar and Khan 2020).

Punjab implemented a proactive surveillance and reaction system as an additional tactic. The authorities established a dengue surveillance system to keep track of the prevalence and dispersion of dengue cases. The government's response to the outbreak was to launch focused vector control operations and public health awareness campaigns (Khatri et al. 2022).

According to research, the One Health strategy, which includes enacting an IVM program and active surveillance and reaction, has successfully lowered dengue fever prevalence in Punjab. According to a 2019 study, the region's prevalence of dengue fever and mosquito population significantly decreased when the IVM program was implemented (Khatri et al. 2022).

15. CONCLUSION

One Health strategy is essential for controlling and handling dengue fever. This strategy aims to find and treat the disease's underlying causes through interdisciplinary interaction between the human, animal, and ecological health sectors. The epidemiological studies, dynamics of transfer, and variation in genes of the virus that causes dengue need to be better understood in Pakistan, where it is an endemic disease. Recent research has highlighted the importance of community involvement, vector surveillance, and effective mosquito control techniques in preventing and managing dengue epidemics. Therefore, future studies in Pakistan should focus on implementing these strategies and assessing their effectiveness in reducing the incidence of dengue fever.

REFERENCES

Akram M et al., 2022. Vector indices and metrological factors associated with dengue fever outbreak in Punjab, Pakistan. Environment, Development and Sustainability 2022: 1-12.

Akter R et al., 2019. Spatial and temporal analysis of dengue infections in Queensland, Australia: Recent trend and perspectives. PloS one 14(7): e0220134.

Ali-Seyed M and Vijayaraghavan K, 2020. Dengue virus infections and anti-dengue virus activities of Andrographis paniculata. Asian Pacific Journal of Tropical Medicine 13: 49–55.

Altamish M et al., 2022. Therapeutic Potential of Medicinal Plants against Dengue Infection: A Mechanistic Viewpoint. ACS Omega 7: 24048–24065.

Azhar H and Khan A, 2020. Resistance to insecticides and synergism by enzyme inhibitors in Aedes albopictus from Punjab , Pakistan. Scientific Reports 2020: 1-8.

Babbar R et al., 2023. The Current Landscape of Bioactive Molecules against DENV: A Systematic Review. Evidence-Based Complementary and Alternative Medicine 2023: Article # 2236210.

Beatty ME et al., 2010. Best Practices in Dengue Surveillance : A Report from the Asia-Pacific and Americas Dengue Prevention Boards. PLoS Neglected Tropical Diseases 4: e890.

Cabrera M et al., 2022. Dengue Prediction in Latin America Using Machine Learning and the One Health Perspective: A Literature Review. Tropical Medicine and Infectious Disease 7: 322.

Capeding MR et al., 2014. Clinical efficacy and safety of a novel tetravalent dengue vaccine in healthy children in Asia: A phase 3, randomised, observer-masked, placebo-controlled trial. The Lancet 384: 1358–1365.

Cataldo C et al., 2023. One Health challenges and actions: Integration of gender considerations to reduce risks at the human-animal-environmental interface. One Health 2023: 100530.

Chng JWQ et al., 2022. Knowledge, attitudes and practices of dengue prevention between dengue sustained hotspots and non-sustained hotspots in Singapore: a cross-sectional study. Scientific Reports 12: 1–10.

Chong V et al., 2023. Dengue in Pregnancy: A Southeast Asian Perspective. Tropical Medicine and Infectious Disease 8(2): 86.

Chowdhury S and Chakraborty P, 2017. Universal health coverage - There is more to it than meets the eye. Journal of Family Medicine and Primary Care 6: 169–170.

Dwivedi VD et al., 2021. Anti-dengue infectivity evaluation of bioflavonoid from Azadirachta indica by dengue virus serine protease inhibition. Journal of Biomolecular Structure and Dynamics 39: 1417–1430.

Ester M et al., 2020. Efficacy of Garlic Solution (Allium sativum) in Killing of Aedes SP Larva. Malaysian Journal of Medicine and Health Sciences 16: 2636–2646.

Fisher R et al., 2023. The Role of NS1 Protein in the Diagnosis of Flavivirus Infections. Viruses 15: 1–13.

Ghanbari MK et al., 2020. One health approach to tackle brucellosis: a systematic review. Tropical Medicine and Health 48: 1–10.

Hadinegoro SR et al., 2015. Efficacy and Long-Term Safety of a Dengue Vaccine in Regions of Endemic Disease. New England Journal of Medicine 373: 1195–1206.

Hasan MM et al., 2022. Devastating dengue outbreak amidst COVID-19 pandemic in Bangladesh: an alarming situation. Tropical Medicine and Health 50: 1–5.

Hashmi MF et al., 2023. Uncovering the Hidden Threat: A Case Report of Suspected Dengue Fever in Armenia. Cureus 15(6).

Huang NC et al., 2017. Ficus septica plant extracts for treating Dengue virus in vitro. PeerJ 2017: Article # 3448.

Hussain Z et al., 2023. Dengue determinants: Necessities and challenges for universal dengue vaccine development. Reviews in Medical Virology 33: Article # 2425.

Iftikhar S et al., 2023. Control of Dengue Epidemic in Lahore: A fortuitous application of One Health Approach. One Health Cases.

Jiang K et al., 2023. Next-generation diagnostic test for dengue virus detection using an ultrafast plasmonic colorimetric RT-PCR strategy. Analytica Chimica Acta 1274: 341565.

Kaagaard MD et al., 2023. Frequency of pleural effusion in dengue patients by severity, age and imaging modality : a systematic review and meta- analysis. BMC Infectious Diseases 23(1): 1-9.

Kelly ME et al., 2023. Molecular Characterization and Phylogenetic Analysis of Dengue Fever Viruses in Three Outbreaks in Tanzania Between 2017 and 2019. PLoS Neglected Tropical Diseases 17: 1–14.

Khatri G et al., 2022. The simultaneous crises of dengue and COVID-19 in Pakistan: a double hazard for the country's debilitated healthcare system. Tropical Medicine and Health 50: 1–5.

Kulkarni P et al., 2023. Prospective study to compare results of FIA (fluorescent immunoassay) test with gold standard ELISA test in Dengue NS1 patients admitted in a tertiary care hospital. Indian Journal of Medical Microbiology 45: 100376.

Lim SYM et al., 2021. Recent insights on anti-dengue virus (DENV) medicinal plants: review on in vitro, in vivo and in silico discoveries. All Life 14: 1–33.

Madzokere ET et al., 2022. Human Seroprevalence for Dengue, Ross River, and Barmah Forest viruses in Australia and the Pacific: A systematic review spanning seven decades. PLOS Neglected Tropical Diseases 16: Article # 0010314.

Mahmud MAF et al., 2022. The application of environmental management methods in combating dengue: a systematic review. International Journal of Environmental Health Research 2: 1-20.

Majeed W et al., 2023. Mosquito-Borne Dengue Fever-An Update. In: Khan A, Abbas RZ, Anguiler-Marcelino L, Saeed NM, Younas M, editors. One Health Triad: Unique Scientific Publishers: pp: 1–7.

Manuahe C et al., 2020. Aedes Mosquito Population density of Dengue Fever Vectors in The Area of Pineleng Minahasa. Indonesian Biodiversity Journal 1: 34–49.

Merakou C et al., 2023. Diagnosis of dengue virus infections in Italy from November 2015 to November 2021: a national reference laboratory surveillance report. International Journal of Infectious Diseases 130: S117.

Mulakoli F et al., 2022. Dengue Virus Surveillance and Blood Safety: A One Health Perspective. Latest Research and Recent Advances. DOI: 10.5772/intechopen.109413

Nguyen TT et al., 2022. Clinical features and management of children with dengue-associated obstructive shock syndrome: A case report. Medicine (United States) 101: E31322.

Ong J et al., 2022. Assessing the efficacy of male Wolbachia ‐ infected mosquito deployments to reduce dengue incidence in Singapore : study protocol for a cluster ‐ randomized controlled trial. Trials 2022: 1–13.

Owusu-Asenso CM, 2023. Bridging Vectors of Dengue Fever: The Endless Cycle. In: Speranga MA, editor. Dengue Fever in a One Health Perspective-Latest Research and Recent Advances: IntechOpen.

Petzold S et al., 2022. Dengue algorithms integrated into the IMCI guidelines: An updated assessment in five Southeast-Asian countries. PLOS Neglected Tropical Diseases 16: e0010832.

Rather IA et al., 2017. Prevention and control strategies to counter dengue virus infection. Frontiers in Cellular and Infection Microbiology 7: 1–8.

Semenza JC et al., 2022. Climate Change and Cascading Risks from Infectious Disease. Infectious Diseases and Therapy 11: 1371–1390.

Sim S et al., 2020. A greener vision for vector control: The example of the Singapore dengue control programme. PLOS Neglected Tropical Diseases 14(8): e0008428.

Socha W et al., 2022. Vector-Borne Viral Diseases as a Current Threat for Human and Animal Health—One Health Perspective. Journal of Clinical Medicine 11(11): 3026.

Soh S et al., 2021. Economic impact of dengue in Singapore from 2010 to 2020 and the cost-effectiveness of Wolbachia interventions. PLOS Global Public Health 1(10): e0000024.

Srisawat N et al., 2022. World Dengue Day: A call for action. PLOS Neglected Tropical Diseases 16: e0010586.
Steele SG et al., 2021. Towards One Health clinical management of zoonoses: A parallel survey of Australian general medical practitioners and veterinarians. Zoonoses and Public Health 68: 88–102.
Trewin BJ et al., 2022. Extensive public health initiatives drive the elimination of *Aedes aegypti* (Diptera, Culicidae) from a town in regional Queensland: A case study from Gin Gin, Australia. PLOS Neglected Tropical Diseases 16(4): e0010243.
Villar L et al., 2015. Efficacy of a Tetravalent Dengue Vaccine in Children in Latin America. New England Journal of Medicine 372: 113–123.
Wilder-Smith A, 2022. Dengue vaccine development: challenges and prospects. Current Opinion in Infectious Diseases 35: 390–396.
World Health Organization (WHO) 2023. Dengue: Dengue and severe dengue.
Xiang BW et al., 2022. Dengue virus infection modifies mosquito blood-feeding behavior to increase transmission to the host. Proceedings of the National Academy of Sciences 119(3): e2117589119.
Yang X et al., 2021. Global burden for dengue and the evolving pattern in the past 30 years. Journal of Travel Medicine 28: 1–11.
Zerfu B et al., 2023. Epidemiology, biology, pathogenesis, clinical manifestations, and diagnosis of dengue virus infection, and its trend in Ethiopia: a comprehensive literature review. Tropical Medicine and Health 51(1): 11.