

# Strengthening Integrated Zika Virus Epidemics Prevention and *Aedes* Mosquito Management and Containment Programs Innovations in Africa

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## Abstract

With over 62 countries and territories affected worldwide with *Aedes* mosquito-transmitted Zika virus disease and estimated over 2 million people are at high risk including pregnant women in these *Aedes* mosquito-prone settings. The recent epidemic events further stress the ever-increasing need and value of national public health evidence-based decision-making policy, budget allocation and programs in protecting vulnerable communities. This paper highlights *Aedes* vector ecological determinants and impacts mitigation and adaptation approaches in strengthening and in scaling-up integrated *Aedes* mosquito management programs and Zika virus epidemics prevention and containment measures across *Aedes*-prone African countries. We supported the view of WHO urgency to establish and strengthen effective and robust local/national public health laboratories surveillance, port of entries and inter-sectorial monitoring capabilities, scaling-up proven vector management programs and Zika virus preparedness-response activities. This paper provides the prerequisite in scaling-up integrated cost-effective *Aedes* vectors community awareness and empowerment in risk alertness and communication strategies, and Zika virus population-based detection, diagnosis and reporting systems in guiding evidence-based epidemiologic, clinical and environmental programs implementation innovations at all levels in vulnerable countries such as Africa. Moreover, improving shared responsibility and participation are vital. Furthermore, instituting robust, effective and sustainable local/national preparedness and emergency response systems capabilities is crucial in averting future arthropod-borne threats and epidemics.

**Keywords:** Zika virus; *Aedes*; Arboviruses; Climate; Surveillance; Adaptations

## Introduction

*Aedes* mosquito-transmitted arboviral diseases and particularly Zika epidemic continues to ravage the Western hemispheres and has been reported in over 62 countries worldwide since 2014; [1]. Recent expansions into the western coast of Africa-Cape Verde and Senegal. Zika virus (ZIKV) was first isolated in Zika forest in Uganda in 1947 and until its epidemics in Yap island in 2007 [2]. Efforts in mapping the geographical distribution of *Aedes* and related diseases epidemiology and risk factors are sparse and require urgent field surveillance and cross-borders operational research in elucidating the existing and/or future threats in Africa.

Contemporary evidence of Zika presence in Senegal, Nigeria and lately in Cape Verde is of great concern to African leaders, policy-makers, programs implementers and all stakeholders to act proactively and call for urgency on practical and innovative solutions in quelling the ecological and geographical expansion of *Aedes* mosquito-transmitted Zika virus in Africa. Equally, pending in-depth investigation and confirmation of potential associations between ZIKV and microcephaly (congenital littleness of the head and incomplete brain development) to stillbirth, Guillain-Barré syndrome (an autoimmune nerve disorder), and other neurological or cognitive disorders that led to the World Health Organization (WHO) declaration of Zika as a Public Health Emergency of International Concern (PHEIC) on 1 February 2016, [3].

More importantly, scaling-up timely and innovative integrated Aedes mosquito smart management programs, research and development (R&D) in novel vaccines and drug discovery is vital [3-5]. Moreover, evidence-based development and application of efficient and reliable operational diagnostics and therapeutics approaches and tools to quell Zika epidemics expansion effects are critical [2-4]. Furthermore, upgrading local and national laboratories in cutting-edge diagnostics and surveillance systems coupled with intensifying community-based engagement and participation projects, as well as setting-up mechanistic quarantine at various entry ports for Zika surveillance are needed.

This paper highlights impact mitigation and adaptation strengthening and scaling-integrated Aedes vector management and emerging Zika virus epidemics prevention and containment programs innovations across Aedes-prone African countries.

## Upgrading Integrated Aedes Vector Management Programs in Susceptible Countries

Upgrading integrated Aedes vector prevention and control programs remains the most proactive, practical and pragmatic preventive and containment approach against Zika virus epidemics at all levels [3-7]. Most previous local and national anti-Aedes vectors traditional policies and programs implementation have aimed at deploying insecticides across vulnerable settings to interrupt transmission, with little efforts on monitoring the changing pattern of susceptibility of vectors to various social and ecological determinants over time [6,7]. Still, quite a lot of Aedes-prone zones lack tangible data on the existence, nature, trend and behavioural adaptations of these vectors to social and migration dynamics, climatic and environmental stressors management in relation to ZIKV epidemics and other arbovirus co-infections [6-8]. Improving upon lessons learnt (e.g. urban planning and environmental modifications, outdoor/indoor spraying of pyrethroids and/or carbamates, organophates, the experiences (e.g.: targeted larvicides or adulticides) from decades of local/ national dengue and Chikungunya control programs, or the use of genetically-engineered mosquitoes, lack and limited drug options in clinical case management is paramount to avert vectors emergence and reduction or interruption of transmission and mainly ZIKV complication impact and costs [2,3,5-7].

Accordingly, it is essential that vulnerable populations and communities be educated on the applications of appropriate and effective measures, effectiveness in implementation of arboviruses vector educational and behavioural education in awareness and resilience outreach. The implications and costs of widespread use of pesticides against Aedes, and potential Zika-related neonates born with microcephaly are staggering, and the potential stigmatization and discrimination against affected children and families require further longitudinal research.

Furthermore, scaling-up the local and national malaria vector control programs including improving environmental

management, structured urbanization, and mechanization of agriculture irrigation is needed. While controlling arboviruses-related vectors using insecticide impregnated treated bednets (ITNs), the use of safe and appropriate mosquito repellents in self-protection, residual spraying of houses, can further upscale mosquito larval breeding source-reduction and control activities [4,7,9]. Besides, raising community-based programs including participation and alertness are urgently needed in fostering Aedes ecological and climate changes adaptation and mitigation strategies implementation in minimizing rural and urban suburbs to household mosquito breeding sites, competence and potential future impacts.

## Enhancing Community Engagement and Surveillance and Participative Communication Mechanisms

Community engagement through social mobilization, education awareness is needed to boost the effective participation and resilience, in minimizing speculation and conjecture, dissipate rumors, and correct inaccurate information, confusion and erroneous perceptions considering that most tropical diseases with most virus carriers being asymptomatic hosts or reservoirs [1,10,11]. Particularly appropriate community-driven Aedes or Zika and other arboviral diseases prevention and management approaches and strategies underscore the potential impacts on millions of vulnerable communities and populations [9,10]. Besides to ensure inter-institutional and trans-disciplinary consistency of Zika virus and vector information or messages to respond rapidly to concerns and specific needs on the part of the public, health care providers, climatic and environmental mitigation tactics [1,10].

Timely, leveraging on advances in information communication such as social media and internet-based is crucial in providing coordinated and transparent dissemination of accurate and accessible evidence-based information prioritization on Aedes-related ZIKV epidemics. These innovative and interactive platforms for dialogue, communication and timely feedbacks are needed to scale-up access to and use of preventive measures, uptake and coverage of public health interventions in meeting up with vulnerable population needs, in regaining public assurance, trust and resilience. This is particularly important on ethical, legal and medical concerns related ZIKV infection effects/complications in neonates and mothers sexual and reproductive health, which is new and/or persistent to some regions compared to previous vector-borne diseases limited in its geographic and demographic scope and still not fully elucidated [1-3,11]. Community-shared responsibility and participation for vigilance to control the Aedes mosquito larval breeding sites or ZIKV in both public and private places [6-8]. Optimizing on rapid and appropriate risk communication new technologies strategies against the traditional channels are essentially needed to convey accurate information, guidelines and instructions, and to take collective communities engagement and voices in putting forward solutions and action plans to address possible social, cultural and ecological

challenges or issues on contextual and effective community-based vector management programs [10,11].

## Strengthening Local and National Public Health Laboratories Surveillance and Monitoring Capabilities

The capacity of national public laboratories to test for Zika and investigate the transmission competence/capacity of its associated mosquito vector(s) and evolution for competence and virulence is very limited to leading laboratories. Recently, strengthened laboratories were also able to rapidly identify, respond to and contain West Africa Ebola outbreaks [2,12]. Strengthening local and public health laboratories capacities to detect, diagnose and track Zika, Ebola and other emerging pathogen threats highlights the ever-increasing role and value of national public health evidence-decision making policy, budget allocation and programs in protecting vulnerable communities. Simple and inexpensive point-of-care (POC), more readily accessible and mass screening of Zika nano-diagnostics in achieving early, rapid, timely diagnosis is needed. As well, strengthening multi-sectorial responses to emerging threat and epidemic drivers, while recognizing that health vulnerability is shaped by access, availability, coverage and policies in environment, international trade and travel, mechanization of agriculture, housing or education coupled with coordinated smart actions during outbreaks [1,7,9,12].

## Establishing Robust and Effective Preparedness and Emergency Response Systems Capacity

To date, no vaccine or cure exists for Zika emergence in the region where populations lack immunity to the virus. Investing in research and development (R&D) through fostering public-private partnerships and collaboration is needed. This is essential to fast-track different pipelines of effective actions, ranging from development of a human vaccine to genetic modification of mosquitoes to curb multiple gaps, unknowns and uncertainties surrounding the Zika epidemics [1,4,8,9,11,12]. There is an urgent need for new, accessible and available Zika diagnostic test kits as critical steps to early detection and confirmation, and prompt information dissemination [10,12].

Proactive and smart community preparedness and alertness provide support to public health laboratories for clinical with diagnostic investigations; confirmation and reporting of both domestically and internationally-acquired or transmitted cases should be established at all levels. Proactive determination to investigate and establish the determinants and predictors of Zika and other emerging outbreaks is essential in spatio-temporal early-warning signals. Hence, generating data and database in modeling of potential threats and epidemics in guiding evidence-based knowledge and decision-making policies and mitigation strategies [2,12].

There is an urgent need to develop and implement sustainable digital surveillance systems as well as cross-borders and entries ports monitor to track Zika and other emerging viral diseases. Strengthening communities' adaptations of proven effective educative approaches and targeted preventive strategies are needed in fostering vulnerable populations mainly maternal-child health and citizenry [13,14]. Moreover, adoption and adaptation of CDC Pregnancy Risk Assessment Monitoring System in improving tracking and monitoring Zika-related foetal development and birth defects, Guillain-Barre syndrome and related motherhood and childhood complications in all endemic countries are advisable [1,2,5,7,12,15,16]. Building public health preparedness and emergency response capacity in line with the WHO declaration announced on 5 February, 2016 at the opening of the Emergency Use Assessment and Listing Procedure (EUAL) for new ZIKV in vitro diagnostics (IVDs) and established during the 2014 Ebola outbreak, together with African institutions platforms in fast-tracking and boosting long-term local and regional interactive and digitally-integrated vector-borne disease surveillance and early-warning systems [2,12,14,16-19], and strategic programs and applications innovations are imperative in mosquitoes and vector-borne diseases prevention and control in African countries.

## Conclusion

Understanding the contemporary *Aedes* mosquito larval and adult ecology and biology, risk factors and determinants is critical in prevention and control of Zika epidemics. There is a need to strengthening community-shared responsibility and participation, vigilance capabilities in scaling-up innovative and integrated *Aedes* vector management programs at all levels in susceptible African countries. Furthermore strengthening community and public health laboratories surveillance and monitoring systems capacity including port of entries are needed in generating evidence to boost political commitment and new resources to the establishment of robust and effective preparedness and emergency response systems capacity is crucial in African countries and worldwide.

## Competing Interest

Authors declare no conflict of interest.

## Author's Contributions

ET conceived the idea and prepared the primary draft of the manuscript. ET, CKW, OAO, JYN and EIMK provided additional information from literature. ET and EIMK critically revised the manuscript. All authors read and approved the final version of the manuscript.

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