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

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Received date: Aug 31, 2016; Accepted date: Sep 23, 2016; Published date: Oct 03, 2016

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Citation: Tambo E, Khayeka-Wandabwa C, Olalubi OA, et al. Strengthening integrated Zika virus epidemics prevention and *Aedes* mosquito management and containment programs innovations in Africa. J Mol Pathol Epidemiol. 2016, 1:1.

Abstract

With over 72 countries and territories affected worldwide with *Aedes* mosquito-transmitted Zika virus disease and estimated over millions of people are at high ZIKV 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 ZIKV epidemics prevention and containment measures across *Aedes*-prone African countries. The paper advocates for the urgency to establish and strengthen effective and robust local and national public health laboratories surveillance and inter-sectoral monitoring capabilities in scaling-up evidence-based and integrated *Aedes* vector management programs and Zika virus (ZIKV) preparedness and emergency response capacity and 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 capacity is crucial in existing and future arthropod-borne threats and disasters.

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 72 countries worldwide including recent expansion into the western coast of Africa-Cape Verde and *Aedes* persistence in most parts of Africa [1]. Zika virus (ZIKV) was first isolated from 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 ZIKV 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 drug 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 *Aedes* vector ecological determinants and impact mitigation and adaptation strategies in strengthening and scaling-up integrated *Aedes* vector management and emerging ZIKV epidemics prevention and containment programs innovations across *Aedes*-prone African countries.

Upgrading Integrated *Aedes* Vector Management Programs in Susceptible Countries

Over 72 countries and territories have reported evidence of mosquito-borne Zika virus transmission since 2007. Interestingly, 20 countries or territories have reported microcephaly (reduction of head circumference) and other central nervous systems (CNS) anomalies potentially associated with ZIKV infection or suggestive of congenital infection. Only, 4 of the 20 countries reported microcephalic babies born from mothers in countries with no endemic ZIKV transmission but who reported recent travel history to Zika affected countries. Upgrading integrated *Aedes* vector prevention and control programs remains the most proactive, practical and pragmatic preventive and containment approach against ZIKV 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 arboviral 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 complications 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 ZIKV 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 to ZIKV infection effects/complications in neonates and mothers sexual and reproductive health, which is (microcephaly, neurological and cognitive disorders, etc) 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 *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 the increasing insecticides resistance and 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 health laboratories to test for Zika and investigate the transmission competence/capacity of its associated mosquito vector(s) and evolution of competence and virulence is very limited to leading laboratories in the western world. 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 to improve surveillance strategy of Zika and other arboviral diseases. 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 drugs exists against 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 with reported new cases in Singapore, Philippines, Malaysia, Viet Nam and Thailand in the South-East Asia Region. 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 Zika epidemics as result of enhanced surveillance, monitoring, public awareness and resilience [1,4,8,9,11,12]. There is an urgent need for new, accessible and affordable Zika diagnostic test kits as critical steps for 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 entry ports monitor to track Zika and other emerging viral diseases. Strengthening communities' adaptations to 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 and its complications on maternal and child health. 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 in establishing robust and effective preparedness and emergency response systems to reduce the risk of onward transmission 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.

Acknowledgments

No funding support was received.

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