



Zika Virus in Africa: Epidemiology and Determinants

**Nathan Obore^{1*}, Shireen Salome Papabathini¹, Upama Ghimire¹,
Joseph Kawuki¹ and Taha Hussein Musa^{2,3}**

¹Key Laboratory of Environmental Medicine Engineering, Ministry of Education, Global Health School of Public Health, Southeast University, Nanjing, 210009, Jiangsu Province, China.

²Key Laboratory of Environmental Medicine Engineering, Department Epidemiology and Health Statistics, Ministry of Education, School of Public Health, Southeast University, Nanjing, 210009, Jiangsu Province, China.

³Biomedical Research Institute, Darfur College, Nyala, Sudan.

Authors' contributions

This work was carried out in collaboration among all authors. All authors equally contributed to this paper with conception and design of the study, literature review and analysis, drafting and critical revision and editing and final approval of the final version.

Article Information

DOI: 10.9734/JAMMR/2019/v30i1130271

Editor(s):

(1) Dr. Kalpy Julien Coulibaly, Department of Environment and Health, Institute Pasteur of Ivory Coast, Félix Houphouët-Boigny University, Ivory Coast.

Reviewers:

(1) Meer Ahmad Mydin Meera, Malaysia.

(2) Sajitha Weerasinghe, Anuradhapura Teaching Hospital, Sri Lanka.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/52577>

Review Article

Received 25 August 2019

Accepted 31 October 2019

Published 07 November 2019

ABSTRACT

Zika virus (ZIKV) that was less known for decades suddenly became a global health emergency at the beginning of 2016. The virus was first discovered in the Zika forest of Uganda in 1947, and the first confirmed human infection was reported in Uganda between 1962-1963. From its origin in East Africa, ZIKV then spread to West and Central Africa with a limited occurrence in North Africa. ZIKV has been circulating in Africa for over 60 years, but less attention had been given, not until its recent outbreaks outside Africa and its discovered association with adverse congenital disabilities. ZIKV is known to cause several debilitating neurological complications, including microcephaly in newborns and Guillain-Barré Syndrome (GBS) in adults.

This review thus aims to highlight the epidemiological evidence and distribution of ZIKV in Africa with a focus on determinants, complications as well as management. We used literature searched from key databases such as Google Scholar, Web of Science, among others, to collect relevant current information about ZIKV in Africa.

*Corresponding author: E-mail: oborenathan@yahoo.com;

Climate, sociodemographic factors, and increasing human density impact the spread of ZIKV in Africa, as in other areas. Furthermore, ZIKV transmission is affected by several unique factors, including the potential risk of sexual transmission, as well as vast numbers of refugees and other travellers from ZIKA endemic areas across Africa, and all over the world. The review identifies the need to improve surveillance mechanisms and focusing on vector control as critical steps to enable prompt detection and avert potential outbreaks of the disease in the continent.

Keywords: Zika virus; epidemiology of zika; Africa; determinants; microcephaly.

1. INTRODUCTION

ZIKV is an arthropod-borne virus (arbovirus) of the family Flaviviridae and genus Flavivirus, and it is spread by a female *Aedes* mosquito that is a daytime-active [1]. This same family of Flavivirus genus can also cause yellow fever, dengue, Japanese encephalitis, West Nile virus disease [2]. This novel teratogenic infectious agent was first found in a sentinel rhesus macaques monkey showing symptoms of febrile illness in the Zika forest near Entebbe, Uganda, in 1947. The virus was then isolated in *Aedes* mosquitoes in 1948 [3,4]. ZIKV is transmitted generally through mosquitoes but with other non-vector borne modes like sexual transmission, blood transfusion, or other fluid transmissions [5,6]. ZIKV is typically asymptomatic [3] and causes mild infection in humans but is associated with severe neurologic complications like Guillain-Barré syndrome, meningoencephalitis [7] and adverse fetal outcomes such as microcephaly, blindness, placental insufficiency, and fetal demise or even death of newborns [8]. To date, significant laboratory-based evidence suggests that African strains of ZIKV can cause higher rates of infection, viral reproduction, cell death, and antiviral responses [9].

Subsequent epidemiological studies show that ZIKV has a broad geographical distribution in Sub-Saharan Africa and south-east Asia [4]. ZIKV has been continuously circulating across Africa for decades, with at least 25 African countries having widespread human exposure [9]. The first human infection was identified in 1954 in a 10-year-old female Nigerian, although it was misunderstood for Spondweni [10]. However, the first confirmed human infection was reported in Uganda between 1962-1963 [4]. Even though it was known to infect humans, not much research was done about the ZIKV and was often misdiagnosed for other *Aedes* borne infections (Dengue, Yellow fever, Chikungunya) due to similar clinical manifestation and

serological cross-reactivity with closely related viruses [3].

The spread of the virus was silent for 60 years, with less than 20 reported cases in Africa and Asia until its re-emergence in 2007 with the Yap Island and Gabon outbreaks [11]. Ever since this re-emergence, over 800,000 cases had been reported outside Africa; however, this number of cases is believed to be highly underestimated [12]. ZIKV suddenly became a global health emergency at the beginning of 2016 due to its association with GBS, microcephaly, and other congenital disorders [3,4,7]. In 2016, over 7,490 suspected ZIKV disease cases were reported in Cabo Verde [13]. The focus was directed more on the western countries, until neglected Africa came in light after Zika related microcephaly cases were suspected [14] in West Africa, 6 cases from Guinea-Bissau in 2016 [9], and 72 cases from Angola in 2017 and 2018 respectively and other regions of Africa [15]. By 2019, over 87 countries had reported evidence of ZIKV. In Africa, information about ZIKV circulation and specific cases remain limited; this review thus aims to highlight the epidemiological evidence and current situation of ZIKV in Africa with a focus on epidemiology, determinants, complications as well as management.

We used the keywords “Zika,” “ZIKV,” “ZIKV in Africa,” and “Zika virus,” to search in Google Scholar, PubMed, and Web of Science. We reviewed the literature published about Zika Virus especially in Africa over the years until present time, including peer-reviewed journal articles, surveillance reports, and public health websites information and bulletins (such as World Health Organisation (WHO), European Centre for Disease Prevention and Control (ECDC) and US Centers for Disease Control and Prevention (CDC). To capture all information, we cross-referenced the bibliographies of reviewed articles. The search included English-language and foreign-language articles, which were computer translated.

2. MOLECULAR EPIDEMIOLOGY

There are two major lineages of ZIKV according to Phylogenetic analysis, known as the Asian and African lineages [16]. Previous research has shown that ZIKV has circulated in Africa for decades, but no case reports or human studies have yet investigated in-depth the effects of the African lineage on pregnancy and birth outcomes. Studies of the African lineage in-vitro and in animal models suggest an increased severity in pregnancy compared with the Asian lineage, causing foetal loss rather than birth defects [17]. The differences in the pathogenicity and epidemic potential of these viral lineages and strains are not yet fully understood [9]. Fayol et al. reported two independent recombinant strains of ZIKV that were introduced into West Africa from East Africa. The first viral introduction into Côte d'Ivoire in 1995 and Senegal around 1985 was related to the strain which possibly moved from Uganda around 1940. The second introduction was associated with a Nigerian strain when ZIKV probably moved from Uganda to Nigeria and the Central African Republic around 1935. From Nigeria, the virus spread to and circulated within Senegal between 1950 and 1965. After which it spread to Burkina Faso around 1980 and back to Senegal around 1985. Moreover, an additional ZIKV lineage from Uganda probably spread to Malaysia around 1945, and from there, the virus reached Micronesia around 1960, forming the Asian strain [18].

3. EPIDEMIOLOGICAL DISTRIBUTION OF ZIKV IN AFRICA

ZIKV was identified in Uganda in the Zika forest in 1947 during Yellow fever surveillance; Zika Virus was later discovered in humans in 1952 [3]. Numerous serological studies since the discovery of ZIKV have enabled the mapping out of the geographic distribution of human infections with the virus, spanning the tropical regions in Africa to Asia [18]. With a total of 87 countries and territories showing evidence of autochthonous mosquito-borne transmission of Zika virus (ZIKV) as of July 2019, and affecting four of the six WHO Regions (Africa, Americas, South-East Asia, and Western Pacific Region) [19].

4. PATHOGENESIS

ZIKV belongs to; Group: IV ((+) ssRNA), Family: Flaviviridae, Genus: Flavivirus, Species: Zika

virus [57]. It is an icosahedral, enveloped, non-segmented, positive-sense, single-stranded RNA virus which has a diameter of 40nm, with an outer coating and dense inner core [58]. ZIKV RNA comprises 10,794 nucleotides coding 3,419 amino acids, which are similar to the Spondweni virus [4,59]. This virus can quickly be adopted from arthropods to vertebrates. Cellular receptors are transmitted by E (envelope) glycoprotein, and this is followed by endocytotic uptake and uncoating of the nucleocapsid, which helps to release viral RNA into the cytoplasm. There is a production of modified viral polyprotein followed by the collection of the immature virions in secretory vesicles and endoplasmic reticulum before being released [58,59]. Zika virus antigens are found entirely in the nuclei of infected cells, suggesting a location for replication that makes it different from other flaviviruses. The incubation period is about 10 days in mosquitoes while 4 to 5 days in the human host [60]. The virus starts with an infection of dendritic cells near the site of inoculation and spreads to lymph nodes, where it is amplified, resulting in viraemia and haematogenous distributions to visceral organs and peripheral tissues. Following the spread of the virus within the body, antibody and cell-mediated immune response are induced, leading to mild symptoms. After infection, specific IgM antibodies against ZIKV appear approximately 4-7 days after onset of the symptoms followed by the appearance of IgG antibodies after 2-3 days. One week post-infection, the virus is highly excreted in the urine, saliva, and other body fluids [4,57].

ZIKV infection has been demonstrated in both in vitro and in vivo. The virus can replicate in the villus cytotrophoblasts from the 1st trimester. The peak of ZIKV infection is observed in amniotic epithelial cells in the mid gestational placenta. ZIKV can also infect and replicate in macrophages isolated from the full-term human placenta, where it leads to the induction of antiviral immune response in the infected macrophages [57]. Research has shown that infection of Human induced pluripotent stem cell (iPSC) with ZIKV induced a marked cytopathic effect (CPE) and cell apoptosis via caspase-3 activation. Further studies in a model of forebrain organoids, ZIKV infection, led to reduced organoid size and thickness and enlarged lumen, in accordance with dilated ventricles seen in microcephalic fetuses. The virus also infected human neural progenitor cells (hNPCs) and induced cell apoptosis [17,57].

Table 1. Summary of African countries by region with reported evidence of ZIKV

Region/Country	Year
East Africa	
Uganda	1948 (Isolated in mosquito) [3] 1952 (First human case) [20] 1967, 1969, 1984 (Neutralizing antibodies detected) [21,22]
Tanzania	1945, 1947-1948 [23]
Ethiopia	1960-1964 [24] 2018 [25]
Kenya	1964, 1966 (Antibodies detected) [26]
Somalia	1966 [21]
Djibouti	1991-1992 [27]
Zambia	2013 (Zika IgM antibodies detected) [28]
Other East African Countries	Mozambique in 1957 [29], Burundi [30], Djibouti in 1991-1992 [27], Sudan [31], Seychelles [32] and Madagascar in 1977 and 1986 [33].
West Africa	
Nigeria	1950s-1980s (Zika antibodies in human samples) [34,35]
Angola	1960 (ZIKV detected in human sera in different localities) [36] 1971, 1972 (ZIKV was again detected) [37] 2016 (2 cases confirmed in Luanda and Bengo) [38]
Central African Republic	1961, 1962 (High sero-prevalences documented) [39,40]
Senegal	1962-1990 (Initial detection of virus) [41,42] 2000, 2008, 2013 (Recent cases reported) [43]
Ivory Coast	1963-1965 (suspected ZIKV in circulation) [39,40,44] 1997-1998 (ZIKV antibodies detected in Abidjan) [45]
Guinea Bissau	1964-1965 (positive human sera samples reported) [39,46] 2016 (4 cases confirmed) [47]
Gabon	1967, 1975, 1979-1980 (Libreville exposed to ZIKV) [39,48] 2007 (ZIKV circulation detected) [11]
Cameroon	1984, 2010 (ZIKV was detected) [49,50] 2015 (ZIKV detected in blood donors sample) [51]
Cabo Verde	2016 (The most extensive urban outbreak with over 7000 human cases notified and 18 ZIKV-associated microcephaly) [19,52]
Others West African countries	ZIKV circulation was suspected in Burkina Faso [18], Mali, Benin, Chad, Togo, Niger [39], Republic of Congo [53], Liberia [39,54] and Sierra Leone [55].
North Africa*	
Egypt	1950s (ZIKV detected in human samples) [56]
Morocco	1968-1969 (ZIKV detected in human and birds) [39]

* North Africa has seen lesser of the Zika disease cases compared to other African regions probably due to the unfavourable conditions for mosquito breeding

5. TRANSMISSION

uninfected person, the virus enters into the bloodstream and causes infection [57].

5.1 Vector-borne Transmission

ZIKV is a mosquito-borne Flavivirus and is usually transmitted by *Aedes* mosquitoes [1]. This is the primary mode of transmission in the tropical and subtropical areas of Africa and other regions around the world that are infested with *Aedes aegypti*, *Aedes albopictus*, and other variety of *Aedes* mosquitoes [61]. When the mosquito bites an infected person with ZIKV, the virus enters into the mosquito, and when it bites

In Africa, *Ae. africanus*, *Ae. furcifer*, *Ae. vittatus*, *Ae. taylori*, *Ae. luteocephalus*, *Ae. albopictus* and other *Aedes* species mosquitoes have been identified to carry ZIKV, while in Asia, it has been detected in *Ae. aegypti*, which is considered the main ZIKV epidemic vector outside Africa. Both *Ae. albopictus* and *Ae. aegypti* are competent vectors for ZIKV but transmission from *Ae. Aegypti*, due to its longer extrinsic incubation period, is more efficient than *Ae. Albopictus* [57].

5.2 Non-Vector Borne Transmissions

Sexual transmission: substantial evidence confirms that ZIKV can be transmitted through unprotected sex with an infected person. Laboratory evaluation of the cases reported in 2008 and 2013, stated that ZIKV was detected in semen [62]. Zika virus sexual transmission has been reported through sexual contact between people coming from endemic areas and those in the non-endemic areas [63]. The virus is also transmitted in both symptomatic and asymptomatic infections and through oral, anal, and genital intercourse between male and female, or similar sex [4,57].

Blood transmission: ZIKV is a new challenge for blood transfusion, especially during ZIKV outbreaks. In 2016 a case of transfusion-transmitted infection was detected in Brazil. ZIKV RNA was detected in most of the blood donors from Florida and Texas in 2017 [4,57].

Other body fluid transmissions: current evidence shows that ZIKV RNA has been isolated in blood, amniotic fluid, semen, urine, saliva, breast milk [5,64], and cerebrospinal fluid, indicating the significant potential of fluid transmission [2,5,65]. ZIKV in saliva has been documented to be twice as much as that in blood, implying the enormous possibility of ZIKV transmission. Saliva transmission plays a role in sporadic outbreaks in non-endemic areas [66]. ZIKV can be transmitted through tears and sweat, because eyes are the site of virus replication, increased tear secretion during conjunctivitis or uveitis can be a mode of shedding of the virus [5,6]. The virus is also present in urine samples of ZIKV patients even after the onset of symptoms. Current evidence suggests that kidney tissue is a suitable environment for the replication of the virus [66,67].

Maternal-fetal transmission: Pregnant mothers suffering from ZIKV have higher chances to spread the infection to the fetus. The virus enters through the placenta and damages the growing brain of the fetus, especially for mothers infected during their first trimester [4]. The intrauterine transmission was confirmed during the Brazil outbreak [68], and also perinatal transmission was reported in France in 2013 [4,57]. Viral RNA was spotted in the amniotic fluid of pregnant mothers, although not all pregnant women infected with ZIKV may transmit the infection to the fetus [68]. In some clinical cases, ZIKV was detected in breastfeeding children, although

ZIKV transmission from breast milk is suggested, breastfeeding is still considered safe for all newborns [66].

6. DETERMINANTS

Based on the current understanding, most people without previous exposure to ZIKV are susceptible to infection [69]. Inhabitants of areas with ongoing transmission of ZIKV from mosquitos to humans are at an increased risk of infection, as well as individuals with sexual partners who are infected [5,6,70]. Recent studies link sexual transmission, particularly to people or travellers from endemic areas returning to areas without mosquito transmission [70,71,72]. The vector usually breeds in contaminated aquatic environments, for example, stagnant wastewater, and others, thus people living in homes with such breeding sites are prone to mosquito transmission of ZIKV. *Aedes* mosquito larvae and pupae can acquire ZIKV from contaminated aquatic systems, including urine, resulting in ZIKV infected adult females [73,74]. In contrast with other mosquito species, *Aedes* mosquitoes are often distributed in urban areas and usually breed in indoor and outdoor settings in a wide variety of natural and artificial water-holding containers such as plastic tanks, cement tanks, flower vases, water storage jars, and rubber tires, among others [75]. Homes with open or unscreened doors and windows, especially in areas with ongoing mosquito transmission, increase the risk of ZIKV infection [76]. Pre-existing herd immunity is also a key determinant for the future population at risk, especially among the newborns as the immunity determines the likelihood of ZIKV infection in women of childbearing age [77,78].

Human social factors may determine ZIKV infection, for example, human density and poverty, among others, are related to higher rates of transmission of *Aedes*-borne pathogens amongst humans [73]. More impoverished African rural areas have lower quality housing and poor drainage, without window screens [74], leading to higher mosquito abundance and biting rates [79]. Besides, population movements among African countries, primarily as refugees, determine the rate of spread of infection into pathogen-free areas [76,77]. Environmental factors such as temperature and humidity favour breeding of mosquitoes and thus play a critical role in sustaining the mosquito population carrying the ZIKV [73,74]. Given the warm tropical climate in most parts of Africa, *Aedes*

mosquitoes easily thrive, presenting a significant risk of transmitting not only ZIKV but also other mosquito-borne infections.

7. DIAGNOSIS

Clinically, Patients with ZIKV infection often are asymptomatic in initial stages, with about 20% [80] showing clinical symptoms after 3 to 10 days of infection [81]. Patients usually present with fever, maculopapular rash, arthralgia, myalgia, conjunctivitis, headache, retro-orbital pain, and emesis, as seen in Cabo Verde [52], but these can often be misunderstood for chikungunya virus (CHIKV) or dengue virus (DENV) [3,4]. Usually, the fever subsides in 3-7 days, while arthralgia can persist for a month [82].

7.1 Laboratory Diagnosis

For laboratory confirmation of ZIKV, various specimens can be used, such as; serum, saliva, tissues, urine, and whole blood [80], while in pregnant women, amniotic fluid can be used for diagnosis [4,83]. Some investigations found the detection of ZIKV RNA within a week in saliva and thus recommend both blood and saliva for better sensitivity in acute stages and use urine for later stages of the disease [6]. Using the specimens above, ZIKV can then be confirmed through laboratory investigations of ZIKV RNA or antigen or IgM and IgG antibodies [6,82,84]. To detect ZIKV-RNA, viral proteins (NSI) and live virus, Reverse transcription polymerase chain reaction (RT-PCR), IgM-capture enzyme-linked immunosorbent assay (MAC-ELISA), and virus isolation can be used respectively [80,85]. These methods are used for both mosquito surveillance and the diagnosis of the patient.

For suspected ZIKV infection among people living in areas with no ZIKV activity, if the patient is tested within two weeks of presentation of symptoms or after possible exposure, ZIKV RNA can be tested in blood and urine samples using RT-PCR test. A positive result confirms recent ZIKV infection. If ZIKV RNA is negative, testing for ZIKV IgM in serum confirms no recent ZIKV infection. For the patients tested between 2-12 weeks after the onset of symptoms or possible exposure, we can test for ZIKV IgM and IgG in serum using the ELISA test. If it is positive, we conduct a plaque reduction neutralisation test (PRNT). A positive PRNT result confirms recent ZIKV infection, while a negative result confirms no recent infection. Additionally, if ZIKV IgM is

positive, a RT-PCR test can also be used to confirm recent ZIKV infection [57].

In countries with advanced laboratory capacities, a ZIKV RT-PCR assay should be the first-line test due to its high specificity and sensitivity even in the early stages of infection [84,85]. Since the timing of infection is hard to establish, a negative RT-PCR does not exclude infection [80]. However, it is the most accurate and rapid test used worldwide. In endemic countries, due to lack of laboratory facilities, IgM ELISA or rapid tests using blood samples are used to test for recent exposure [4,84]. When laboratories are using rapid tests, combined NS1 antigen and IgM or IgG antibodies should be considered to rule out cross-reaction with “dengue-like disease.” With this test, IgM antibodies are detected as early as 4–5 days and up to 12 weeks or more after the start of symptoms [85]. Positive or questionable IgM ELISA results are confirmed by PRNT; however, this technique is limited to a few laboratories; it is labour-intensive and expensive involving handling of live virus and requires standardised reagents that often are not available [84,85]. Viral Isolation is used to isolate the virus from body fluids and tissues, but it is poorly sensitive and time-consuming. It is used mainly for research purposes and not routine diagnosis [57,86]. When using ELISA and PRNT, the major limitation is the cross-reactions with a previous history of flavivirus infection or immunization against another Flavivirus [4,84,86].

Pregnant women must be screened for a travel history to ZIKV-affected areas. Symptomatic pregnant women who have travelled to Zika-affected areas should undergo RT-PCR or serological testing for the detection of ZIKV infection. They should also undergo fetal ultrasonography to evaluate for microcephaly or intracranial calcifications. Detection of any fetal anomalies must be followed by amniocentesis for the evaluation of intrauterine ZIKV infection [87].

8. TREATMENT AND MANAGEMENT

Treatment is focused mainly on supportive care and management of symptoms as there is no known treatment available for ZIKV infection or some of its complications [4]. ZIKV infection can often be asymptomatic, but when symptoms are present, they are usually mild. Symptoms such as fever, rash, or arthralgia are managed with plenty of rest, staying well hydrated by drinking plenty of fluids [88]. Pain and fever are treated

with acetaminophen; however, diagnosis of Dengue fever should first be ruled out to avoid hemorrhage associated with the use of NSAIDs and aspirin when ill with dengue. If symptoms worsen, further medical care should be considered [87]. Aspirin is contraindicated for use in children below the age of 12 years due to the risk of Reye syndrome [89]. Pregnant women with fever must be treated with acetaminophen [57,90]. Antihistamines may also be prescribed for an itchy rash [87]. Pregnant women in areas with ongoing Zika transmission or who develop symptoms of ZIKV infection should seek prompt medical attention for laboratory testing and additional clinical care. Consultation with an experienced obstetrics and gynecology specialist in conjunction with an infectious disease specialist is vital in the management of possible ZIKV infection [90]. Some of the care includes repeated ultrasonography for fetal evaluation, amniocentesis, postnatal management in the testing of placental tissues, and newborns should be tested and evaluated for congenital ZIKV infection following CDC guidelines [57,88]. Follow-up care of children born to mothers with probable exposure to ZIKV during pregnancy is critical for appropriate intervention [88].

9. PREVENTION

There are several DNA vaccines currently at different phases of trials in the hope of using prevention as the main alternative to combat the disease [91]. There are four types of vaccines that have been evaluated in Zika naive populations and are subsequently being assessed in areas where there is flavivirus activity in phase 1 clinical trials: three DNA, one modified RNA, four purified formalin-inactivated virus (PIV), and one live measles-vectored. Moreover, one of the PIVs is being assessed in subjects who have previously received YF (YF Vax™ - live attenuated) or JE (Ixiaro™ - inactivated) vaccines. Clinical trials in the small number of volunteers showed the vaccines were safe, well-tolerated, and all induced neutralizing antibodies. These trials involved candidate DNA and purified inactivated virus vaccines, although the trials varied by dosing regimen and vaccine candidate. These results imply that a Zika vaccine can be developed and that phase 2 clinical trials are warranted. This gives hope for possible future protection of the high-risk populations against ZIKV infection, especially in endemic areas. It would also help to reduce the incidences of microcephaly,

GBS and related costs of caring and treating victims of such complications [57, 91].

The current WHO strategic Response plan recommends Community engagement, integrated vector management, and Public health risk communication to aid the prevention of Zika adverse outcomes [92]. Currently, avoiding mosquito bites is critical in endemic regions and places with active outbreaks, or where *Aedes* species mosquitoes are active. The community should be involved in community drives such as the elimination of mosquito breeding sites, and aim towards control of the vector. Wearing long-sleeved clothes and pants to cover as much of the body as possible, and the use of mosquito repellents is recommended [87,92]. The mosquito breeding cycle can be broken by the use of larvicides, insecticides, and ovitraps, including the regular use of safe household insecticide sprays. Families have to be educated in the proper use of mosquito-nets and mosquito-repellents [75]. Also, the use of window and door screens when indoors is essential in areas of mosquito transmission. Pregnant women and children should even sleep under mosquito nets if sleeping during the day or early evening. Sexually active men and women, as well as pregnant women, should practice safe sex with the correct use of condoms. During ZIKV outbreaks, couples should be counselled and offered a full range of contraceptive methods after considering potential adverse pregnancy and fetal outcomes of ZIKV [57].

10. COMPLICATIONS AND OUTCOMES OF ZIKV INFECTION

Usually, Zika fever clears on its own in 2 to 7 days, and rarely some people develop Guillain-Barré syndrome (GBS). Some studies estimated the risk of acquiring GBS to be 0.24 per 1000 ZIKV infections [4,57]. However, Zika fever, especially during the first trimester, has severe effects on the fetus, such as miscarriages and increases the risk of congenital disabilities [2,4], for example, infants born with congenital central nervous system deformities [7]. It is also associated with other complications of pregnancy, including IUGR (intrauterine growth retardation), preterm birth, stillbirth, eye abnormalities, and neonatal death [47].

Microcephaly, the most typical form of ZIKV related birth defects, is often associated with developmental delays as well as intellectual,

visual, and hearing impairment and epilepsy [7,68]. Recent studies indicate that the risk of ZIKV related congenital disabilities is the same whether the pregnant woman experiences symptoms on ZIKV infection or not [57,93]. Considerable evidence has linked GBS to ZIKV infection, a condition resulting from neurological damage (inflammation of the brain and spinal cord) [7,94]. GBS patients are reported to usually present with bilateral paresthesias, peripheral muscle weakness, and facial palsy. Approximately 25% of GBS patients require intensive care, and the mortality is 3-5%, even with appropriate supportive care. This is mainly due to complications related to paralysis of respiratory muscles, Cardiac arrest, or blood clots [94,95]. A specific study reported 50% of GBS patients having lasting paralysis with difficulty in walking three months after discharge [57]. Besides, ZIKV infection in older children and adults may lead to other neurological conditions such as encephalomyelitis, acute myelitis, encephalitis, meningoencephalitis, and sensory polyneuropathy [94,96].

Complications of ZIKV in Africa are less documented, and its outcomes had been undetected [97] not until the recent outbreaks outside Africa that drew more attention to ZIKV complications and outcomes in Africa. In the 2016 Cabo Verde outbreak, 50% of confirmed microcephaly cases were linked to ZIKV infection [52], and the first case of congenital Zika syndrome (a unique pattern of birth defects including severe microcephaly, decreased brain tissue, damaged focal retina, congenital contractures, and hypertonionia found among newborns infected with ZIKV during pregnancy) in Africa was recently reported in 2018, in a newborn from Angola [98].

11. CONCLUSION

ZIKV being a disease relatively silent because of its asymptomatic nature and lesser-known outcomes on the continent, calls for a targeted response for its early detection, prevention, care, and support of affected populations. Despite its origin in Africa, there is still limited information on the Trends, distribution, and transmission of ZIKV in Africa due to a lack of awareness and weak surveillance mechanisms. Thus there is considerable potential for future outbreaks in the continent, especially in regions without herd immunity posing an enormous global health challenge if it is not addressed. There is a need to develop cost-effective and easy to use

diagnostic tests for prompt detection of ZIKV in endemic regions. Without medical development such as a vaccine, or unique pest control, Zika seems destined to start spreading again in African countries. In addition, more research on the missing gaps is required as well as Policy strengthening, especially on refugee surveillance. Nevertheless, the current efforts in developing new vaccines have provided hope for better prevention and control of the virus.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Abushouk AI, Negida A, Ahmed H. An updated review of Zika virus. *J. Clin. Virol.* 2016;(84):53-58.
2. Malone RW, Homan J, Callahan MV, Glasspool-Malone J, Damodaran L, Schneider ADB, et al. Zika virus: medical countermeasure development challenges. *PLoS Negl Trop Dis.* 2016;10(3):e0004530.
3. Sampaio GDS, Brites C, Drexler JF, Moreira-Soto A, Miranda F, Martins Netto E. Expansion of Zika virus circulation from Africa to the Americas, 1947-2018: A literature review. *Epidemiol. Serv. Saúde.* 2019;28:e2018411.
4. Baud D, Gubler DJ, Schaub B, Lanteri MC, Musso D. An update on Zika virus infection. *The Lancet.* 2017;390(10107):2099-2109.
5. Liu R, Wang X, Ma Y, Wu J, Mao C, Yuan L, et al. Prevalence of Zika virus in blood donations: a systematic review and meta-analysis. *BMC Infectious Diseases.* 2019; 19(1):590.
6. Musso D, Roche C, Nhan T-X, Robin E, Teissier A, Cao-Lormeau V-M. Detection of Zika virus in saliva. *J. Clin. Virol.* 2015; 68:53-5.

- Available:<http://www.sciencedirect.com/science/article/pii/S138665321500133X>
7. World Health Organization. Situation report: Zika virus, microcephaly, Guillain-Barre syndrome.
Available:<https://apps.who.int/iris/bitstream/handle/10665/253604/zikasitrep20Jan17-eng.pdf;jsessionid=CFC3E2AF93469963F516A1E782A9A3D5?sequence=1>
(Accessed 1st October 2019)
 8. Widman DG, Young E, Yount BL, Plante KS, Gallichotte EN, Carbaugh DL, et al. A reverse genetics platform that spans the Zika virus family tree. *MBio*. 2017;8(2): e02014-16.
 9. Nutt C, Adams P. Zika in Africa—the invisible epidemic?. *The Lancet*. 2017; 389(10079):1595-6.
 10. Wikan N, Smith DR. First published report of Zika virus infection in people: Simpson, not MacNamara. *Lancet Infect Dis*. 2017; 17(1):15-17.
 11. Grard G, Caron M, Mombo IM, Nkoghe D, Ondo SM, Jiolle D, et al. Zika virus in Gabon (Central Africa)—2007: a new threat from *Aedes albopictus*?. *PLoS Negl Trop Dis*. 2014;8(2):e2681.
 12. World Health Organization. Countries and territories with current or previous Zika virus transmission.
Available:<https://www.who.int/emergencies/diseases/zika/countries-with-zika-and-vectors-table.pdf>
(Accessed 17th September 2019)
 13. European Center for Disease Control and Prevention (ECDC). Zika virus transmission worldwide.
Available:<https://ecdc.europa.eu/sites/portals/files/documents/zika-risk-assessment-9-april-2019.pdf>
(Accessed 20th September 2019)
 14. Health news. Zika in Africa: Rare birth defect on the rise of Angola; 2018.
Available:<https://www.reuters.com/article/us-health-zika-insight/zika-in-africa-rare-birth-defect-on-the-rise-in-angola-idUSKCN1MR0F7>
(Accessed 22nd September 2019)
 15. The New York Times. The Zika Virus Is Still a Threat. Here's What the Experts; 2019.
Available:<https://www.nytimes.com/2019/07/02/health/zika-virus.html>
(Accessed 11th August 2019)
 16. Song BH, Yun SI, Woolley M, Lee YM. Zika virus: history, epidemiology, transmission, and clinical presentation. *J Neuroimmunol*. 2017;308:50-64.
 17. Duggal NK, Ritter JM, McDonald EM, Romo H, Guirakhoo F, Davis BS, et al. Differential neurovirulence of African and Asian genotype Zika virus isolates in outbred immunocompetent mice. *Am J Trop Med Hyg*. 2017;97(5):1410-7.
 18. Faye O, Freire CC, Iamarino A, Faye O, de Oliveira JV, Diallo M, et al. Molecular evolution of Zika virus during its emergence in the 20th century. *PLoS Negl Trop Dis*. 2014;8(1): e2636.
DOI: 10.1371/journal.pntd.0002636.
 19. WHO. Zika epidemiology update 2019.
Available:<https://www.who.int/emergencies/diseases/zika/zika-epidemiology-update-july-2019.pdf>
(Accessed 30th September 2019)
 20. Smithburn KC. Neutralizing antibodies against certain recently isolated viruses in the sera of human beings residing in East Africa. *J. Immunol*.1952;69(2):223-34.
 21. Henderson BE, Metselaar D, Cahill K, Timms GL, Tukei PM, Williams MC. Yellow fever immunity surveys in northern Uganda and Kenya and eastern Somalia. *Bull World Health Organ*.1968;38:229e37.
 22. Rodhain F, Gonzalez JP, Mercier E, Helynck B, Larouze B, Hannoun C. Arbovirus infections and viral haemorrhagic fevers in Uganda: a serological survey in Karamoja district, 1984. *Trans R Soc Trop Med Hyg*. 1989; 83:851e4.
 23. Henderson BE, Kirya GB, Hewitt LE, Sekyalo E, Mukuye A. Serological surveys in East Africa and Somalia. *Entebbe, Report*. 1969;18:35-47.
 24. Serie C, Casals J, Panthier R, Bres P, Williams MC. Studies on yellow fever in Ethiopia. 2. Serological study of the human population. *Bull World Health Organ*. 1968;38:843e54.
 25. Tsegaye MM, Beyene B, Ayele W, Abebe A, Tareke I, Sall A, et al. Sero-prevalence of yellow fever and related Flavi viruses in

- Ethiopia: a public health perspective. BMC Public Health. 2018;18(1):1011.
26. Geser A, Henderson BE, Christensen S. A multipurpose serological survey in Kenya. 2. Results of arbovirus serological tests. Bull World Health Organ. 1970;43:539e52.
 27. Rodier GR, Gubler DJ, Cope SE, Cropp CB, Soliman AK, Polycarpe D, et al. Epidemic dengue 2 in the city of Djibouti 1991e1992. Trans R Soc Trop Med Hyg. 1996;90:237e40.
 28. Babaniyi OA, Mwaba P, Mulenga D, Monze M, Songolo P, Mazaba-Liwewe ML, et al. Risk assessment for yellow fever in Western and north Western provinces of Zambia. J Glob Infect Dis. 2015;7:11e7.
 29. Kokernot RH, Smithburn KC, Gandara AF, McIntosh BM, Heymann CS. Neutralization tests with sera from individuals residing in Mozambique against specific viruses isolated in Africa, transmitted by arthropods. An Institut Med Trop. 1960;17: 201e30.
 30. Rodhain F, Carteron B, Laroche R, Hannoun C. Human arbovirus infections in Burundi: results of a seroepidemiologic survey, 1980-1982. Bull Soc Pathol Exot Filiales. 1987;80(2):155-61.
 31. Omer AH, McLaren ML, Johnson BK, Chanas AC, Brumpt I, Gardner P, et al. A seroepidemiological survey in the Gezira, Sudan, with special reference to arboviruses. J Trop Med Hyg. 1981;84: 63e6.
 32. Posen HJ, Keystone JS, Gubbay JB, Morris SK. Epidemiology of Zika virus, 1947–2007. BMJ global health. 2016; 1(2):e000087.
 33. Fontenille D, Mathiot C, Rodhain F, Coulanges P. Arboviruses in the region of Nosy-Be, Madagascar. Serologic and entomologic data. Bull Soc Pathol Exot. 1988;81:58e70.
 34. Boorman JP, Draper CC. Isolations of arboviruses in the Lagos area of Nigeria and a survey of antibodies to them in man and animals. Trans R Soc Trop Med Hyg. 1968;62:269-77.
 35. Fagbami AH. Zika virus infections in Nigeria: virological and seroepidemiological investigations in Oyo state. J Hyg. 1979;83:213-9.
 36. Kokernot RH, Casaca VM, Weinbren MP, McIntosh BM. Survey for antibodies against arthropod-borne viruses in the sera of indigenous residents of Angola. Trans R Soc Trop Med Hyg. 1965;59:563-70.
 37. Filipe AR, De Carvalho RG, Relvas A, Casaca V. Arbovirus studies in Angola: serological survey for antibodies to arboviruses. Am J Trop Med Hyg. 1975; 24:516-20.
 38. WHO Africa Health Emergencies Programme. Weekly bulletin on outbreaks and other emergencies. Week 48; 2017. Available: <http://apps.who.int/iris/bitstream/10665/259557/1/OEW48-2504122017.pdf> (Accessed 10th October 2019)
 39. Bres P. Recent data from serological surveys on the prevalence of arbovirus infections in Africa, with special reference to yellow fever. Bull World Health Organ. 1970;43:223-67.
 40. Chippaux-Hyppolite C, Chippaux A. Yellow fever antibodies in children in the Central African Republic. Bull World Health Organ. 1966;34:105-11.
 41. Bres P, Lacan A, Diop I, Michel R, Peretti P, Vidal C. Arboviruses in Senegal. Serological survey. Bull Soc Pathol Exot. 1963;56:384-402.
 42. Monlun E, Zeller H, Le Guenno B, Traore-Lamizana M, Hervy JP, Adam F, et al. Surveillance of the circulation of arbovirus of medical interest in the region of eastern Senegal. Bull Soc Pathol Exo. 1993;86:21-8
 43. Herrera BB, Chang CA, Hamel DJ, Mboup S, Ndiaye D, Imade G, et al. Continued transmission of Zika virus in humans in West Africa, 1992-2016. J Infect Dis. 2017; 215:1546-50.
 44. Robin Y, Brès P, Lartigue JJ, Gidel R, Lefèvre M, Athawet B, et al. Les arbovirus en Cote-D'Ivoire. Enquête sérologique dans la population humaine. Bull Soc Pathol Exot Filiales. 1968;61(6):83345. French. PMID: 4313384.
 45. Akoua-Koffi C, Diarrassouba S, Benie VB, Ngbichi JM, Bozoua T, Bosson A, et al. Investigation surrounding a fatal case of yellow fever in Cote d'Ivoire in 1999. Bull Soc Pathol Exot. 2001;94:227-30.
 46. Pinto MR. Survey for antibodies to arboviruses in the sera of children in Portuguese Guinea. Bull World Health Organ. 1967;37(1):101–8. PMID:5300043

47. World Health Organization. Situation report: Zika virus, microcephaly, Guillain-Barré syndrome. WHO; 2016.
Available:<https://apps.who.int/iris/handle/10665/251811>
(Accessed 4th October 2019)
48. Saluzzo JF, Ivanoff B, Languillat G, Georges AJ. Serological survey for arbovirus antibodies in the human and simian populations of the South-East of Gabon (author's transl). *Bull Soc Pathol Exot.* 1982;75:262-6.
49. Tsai TF, Lazuick JS, Ngah RW, Mafiamba PC, Quincke G, Monath TP. Investigation of a possible yellow fever epidemic and serosurvey for flavivirus infections in northern Cameroon. *Bull World Health Organ.* 1987;65:855-60
50. Fokam EB, Levai LD, Guzman H, Amelia PA, Titanji VP, Tesh RB, et al. Silent circulation of arboviruses in Cameroon. *East Afr Med J.* 2010;87(6):262-8. et al.
Available:<https://www.ajol.info/index.php/amj/article/view/63085>
(Accessed 10th October 2019)
51. Gake B, Vernet MA, Leparc-Goffart I, Drexler JF, Gould EA, Gallian P, et al. Low seroprevalence of Zika virus in Cameroonian blood donors. *Braz J Infect Dis.* 2017;21:481-3
52. Lourenço J, de Lourdes Monteiro M, Valdez T, Rodrigues JM, Pybus O, Faria NR. Epidemiology of the Zika virus outbreak in the Cabo Verde Islands, West Africa. *PLoS currents.* 2018;10.
53. Nurtop E, Moyon N, Dzia-Lepfoundzou A, Dimi Y, Ninove L, Drexler JF, et al. A Report of Zika Virus Seroprevalence in Republic of the Congo. *Vector Borne Zoonotic Dis;* 2019.
54. Van der Waals FW, Asher DM, Goudsmit J, Pomeroy KL, Karabatsos N, Gajdusek DC. Post-encephalitic epilepsy and arbovirus infections in an isolated rainforest area of central Liberia. *Trop Geogr Med.* 1986;38:203-8.
55. Robin Y, Mouchet J. Serological and entomological study on yellow fever in Sierra Leone. *Bull Soc Pathol Exot.* 1975; 68:249-58.
56. Smithburn KC, Taylor RM, Rizk F, Kader A. Immunity to certain arthropodborne viruses among indigenous residents of Egypt. *Am J Trop Med Hyg.* 1954;3:9-18.
57. Luisa Barzon, Marta Trevisan, Alessandro Sinigaglia, Enrico Lavezzo, Giorgio Palù. Zika virus: From pathogenesis to disease control, *FEMS Microbiology Letters.*2016;363(18):fnw202,
Available:<https://doi.org/10.1093/femsle/fnw202>
58. Shehu NY, Shwe D, Onyedibe KI, Pam VC, Abok I, Isa SE, et al. Pathogenesis, diagnostic challenges and treatment of Zika virus disease in resource-limited settings. *Niger Postgrad Med J.* 2018; 25(2):67.
59. Navalkele BD. "Zika Virus." *Medscape;* 2018.
Available:<https://emedicine.medscape.com/article/2500035-overview - a2500034>
(Accessed 23rd September 2019)
60. Info.com, m. 2019. "Zika Virus- Structure, Genome, Symptoms, Transmission, Pathogenesis, Diagnosis."
Available:<https://microbiologyinfo.com/zika-virus-structure-genome-symptoms-transmission-pathogenesis-diagnosis/>
(Accessed 30th August 2019)
61. Boyer S, Calvez E, Chouin-Carneiro T, Diallo D, Failloux AB. An overview of mosquito vectors of Zika virus. *Microbes Infect.* 2018;20(11-12):646-60.
62. Ferdousi T, Cohnstaedt LW, McVey DS, Scoglio CM. Understanding the survival of Zika virus in a vector interconnected sexual contact network. *Scientific reports.* 2019;9(1):7253.
63. World Health Organization. Prevention of sexual transmission of Zika virus: interim guidance update. *World Health Organization;* 2016.
(Accessed 25th August 2019)
Available:https://apps.who.int/iris/bitstream/handle/10665/204421/WHO_ZIKV_MOC_16.1_eng.pdf?sequence=1
64. Mann TZ, Haddad LB, Williams TR, Hills SL, Read JS, Dee DL, et al. Breast milk transmission of flaviviruses in the context of Zika virus: a systematic review. *Paediatr Perinat Epidemiol* 2018;32:358e68.
Available:<https://doi.org/10.1111/ppe.12478>
65. Kurscheidt FA, Mesquita CS, Damke GM, Damke E, Analine RD, Suehiro TT, et al. Persistence and clinical relevance of Zika virus in the male genital tract. *Nat. Rev. Urol.* 2019;16(4):211.

66. Khaiboullina SF, Ribeiro FM, Uppal T, Martynova EV, Rizvanov AA and Verma SC. Zika Virus Transmission Through Blood Tissue Barriers. *Front microbiol.* 2019;10(1465):1465.
67. Borges ED, Vireque AA, Berteli TS, Ferreira CR, Silva AS, Navarro PA. An update on the aspects of Zika virus infection on male reproductive system. *J Assist Reprod Genet.* 2019;30:1-1.
68. Vermillion MS, Lei J, Shabi Y, Baxter VK, Crilly NP, McLane M, et al. Intrauterine Zika virus infection of pregnant immunocompetent mice models transplacental transmission and adverse perinatal outcomes. *Nature communications.* 2017;8:14575.
69. Clapham H. Determinants of Zika transmission and control. *J Infect Dis.* 2019;220(6):917.
70. Harrower J, Kiedrzyński T, Baker S, Upton A, Rahnama F, Sherwood J, et al. sexual transmission of Zika virus and persistence in semen, New Zealand, 2016. *Emerg Infect Dis.* 2016;22(10):1855
71. Musso D, Lanteri MC. Zika virus in Singapore: unanswered questions. *Lancet Infect Dis.* 2017;17:782–3.
72. Tham HW, Balasubramaniam V, Ooi MK, Chew MF. Viral determinants and vector competence of Zika virus transmission. *Front Microbiol.* 2018;9.
73. Lourenco J, de Lima MM, Faria NR, Walker A, Kraemer MU, Villabona-Arenas CJ, et al. Epidemiological and ecological determinants of Zika virus transmission in an urban setting. *Elife.* 2017;6:e29820
74. Du S, Liu Y, Liu J, Zhao J, Champagne C, Tong L, et al. Aedes mosquitoes acquire and transmit Zika virus by breeding in contaminated aquatic environments. *Nat. Commun.* 2019;10(1):1324.
75. Ferede G, Tiruneh M, Abate E, Kassa WJ, Wondimeneh Y, Dامتie D, et al. Distribution and larval breeding habitats of Aedes mosquito species in residential areas of northwest Ethiopia. *Epidemiology and health.* 2018;40.
76. Nah K, Mizumoto K, Miyamatsu Y, Yasuda Y, Kinoshita R, Nishiura H. Estimating risks of importation and local transmission of Zika virus infection. *PeerJ.* 2016;4:e1904.
77. Weaver SC, Costa F, Garcia-Blanco MA, Ko AI, Ribeiro GS, Saade G, et al. Zika virus: History, emergence, biology, and prospects for control. *Antiviral research.* 2016;130:69-80.
78. Pierson TC, Graham BS. Zika Virus: immunity and vaccine development. *Cell.* 2016;167:625–31
79. Hotez PJ, Murray KO, Buekens P. The Gulf Coast: a new American underbelly of tropical diseases and poverty. *PLoS Negl Trop Dis.* 2014;8:4–6
80. Hasan S, Saeed S, Panigrahi R, Choudhary P. Zika virus: A global public health menace: A comprehensive update. *J Int Soc Prev Community Dent,* 2019; 9(4):316
81. Paixão ES, Teixeira MG, Rodrigues LC.. Zika, chikungunya and dengue: the causes and threats of new and re-emerging arboviral diseases. *BMJ global health,* 2018;3(Suppl 1):000530.
82. Zammarchi L, Stella G, Mantella A, et al. Zika virus infections imported to Italy: Clinical, immunological and virological findings, and public health implications. *J. Clin. Virol.* 2015;63:32–35.
83. Baud D, Van Mieghem T, Musso D, Truttmann AC, Panchaud A, Vouga M. Clinical management of pregnant women exposed to Zika virus. *Lancet Infect Dis.* 2016;16(5):523.
84. Landry ML, St. George K. Laboratory diagnosis of Zika virus infection. *Arch Pathol Lab Med,* 2016;141(1):60-67.
85. Centers for Disease Control and Prevention. Revised diagnostic testing for Zika, chikungunya, and dengue viruses in US Public Health Laboratories. Atlanta, GA: Centers for Disease Control and Prevention; 2016.
Available:<https://www.cdc.gov/zika/pdfs/den-chikv-zikv-testing-algorithm.pdf>
(Accessed 2nd september 2019)
86. Shan C, Xie X, Barrett AD, Garcia-Blanco MA, Tesh RB, Vasconcelos PFDC, et al. Zika virus: Diagnosis, therapeutics, and vaccine. *ACS Infect Dis.* 2016;2(3):170-172.
87. Centers for Disease Control and Prevention. Zika Virus. Centers for Disease Control and Prevention. 2016.
Available:<https://www.cdc.gov/zika/index.html>
(Accessed 1st September 2019)

88. Falcao MB, Cimerman S, Luz KG, Chebabo A, Brigido HA, Lobo IM, et al. Management of infection by the Zika virus. *Ann Clin Microbiol Antimicrob.* 2016;15(1): 57
89. Schrör K. Aspirin and Reye Syndrome. *Paediatr. Drugs.* 2007;9(3):195-204.
90. ACOG. Management of Patients in the Context of Zika Virus: Acog Committee Opinion, Number 784. *Obstetrics & Gynecology.* 2019;134(3):e64–e70.
DOI:10.1097/AOG.0000000000003399
Available:<https://insights.ovid.com/crossref?an=00006250-201909000-00046>
(Accessed 4th September 2019)
91. Barrett AD. Current status of Zika vaccine development: Zika vaccines advance into clinical evaluation. *npj Vaccines.* 2018; 3(1):24.
92. WHO. ZIKA strategic response plan Quarterly Update. 2016.
Available:<https://www.who.int/emergencies/zika-virus/quarterly-update-october/en/>
(Accessed 5th September 2019)
93. European Center for Disease Control and Prevention (ECDC). Zika virus transmission worldwide; 2019.
Available:<https://ecdc.europa.eu/sites/port al/files/documents/zika-risk-assessment-9-april-2019.pdf>
(Accessed 5th September 2019)
94. Honein MA, Dawson AL, Petersen EE, Jones AM, Lee EH, Yazdy MM, et al. Birth defects among fetuses and infants of US women with evidence of possible Zika virus infection during pregnancy. *Jama.* 2017;317(1):59-68.
95. World Health Organization. Assessment and management of Guillain-Barré syndrome in the context of Zika virus infection: interim guidance update. World Health Organization; 2016.
Available:<https://www.who.int/csr/resources/publications/zika/guillain-barre-syndrome/en/>
(Accessed 29th October 2019)
96. Ferreira ML, de Brito CA, Moreira ÁJ, de Morais Machado MÍ, Henriques-Souza A, Cordeiro MT, et al. Guillain-Barré syndrome, acute disseminated encephalomyelitis and encephalitis associated with Zika virus infection in Brazil: Detection of viral RNA and isolation of virus during late infection. *Am. J. Trop. Med. Hyg.* 2017;97(5):1405-9.
97. Nutt C, Adams P. Zika in Africa—the invisible epidemic? *The Lancet.* 2017; 389(10079):1595-6
98. Sasseti M, Zé-Zé L, Franco J, Cunha JD, Gomes A, Tomé A, et al. First case of confirmed congenital Zika syndrome in continental Africa. *Trans R Soc Trop Med Hyg.* 2018;112(10):458-62.

© 2019 Obore et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/52577>