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Statistical Analysis on Yellow Fever Patients in Nigeria: The Risk Factor, Prevention and *Control*

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A B S T R A C T

Yellow fever is an acute haemorrhagic fever caused by a single stranded RNA virus from the Flavivirus genus. It is associated with a wide range of clinical features ranging from entirely asymptomatic to a severe haemorrhagic fever. Symptoms of yellow fever are biphasic which includes the viraemic phase and the toxaemic phase with the toxaemic phase following a temporary period of remission that occurs for 24 hours after the viraemic phase. The yellow fever virus is highly endemic and epidemic in tropical regions of South America and Africa (Angola, Central/East Africa, and West Africa). Three cycles are involved in the transmission of yellow fever; the sylvatic cycle, intermediate cycle and urban cycle. The yellow fever virus is transmitted by the Haemagogus spp. and Aedes africanus mosquito in the sylvatic cycle and Aedes aegypti mosquitoes in the urban cycle. Nigeria has experienced several outbreaks of yellow fever from 1864 to 1969, with outbreaks reoccurring in 2017 till date. Climate change, vegetation, urbanization and encroachment into forest endemic areas are factors that favour the transmission of the yellow fever virus in Nigeria. It is usually difficult to diagnose the yellow fever virus from its clinical features due to the similarity in symptoms with other Flavivirus haemorrhagic fever such as the West Nile Virus, dengue fever, Zika virus and the Chikunguya fever. Virus isolation method, reverse transcription polymerase chain reaction (RT-PCR), serological diagnosis and histopathological analysis are labouratory methods used for the confirmation of yellow fever virus. Yellow fever has no antiviral treatment, symptoms and secondary infections are treated to ease the patient. Effective ways of preventing and controlling the outbreak of yellow fever includes vaccination, vector control programs, disease surveillance and community education. Several public health agencies were established to carry out emergency response to control the outbreak of yellow fever in the country. Low vaccine coverage, poor health care response system, collapse of the vector control programs, inadequate diagnostic labouratory/labouratory technician and poor disease surveillance are factors mitigating the control of yellow fever in Nigeria. Yellow fever is a neglected tropical disease ravaging the South America and Africa, therefore proper sanitation to control the breeding sites of vectors and vaccination should be encouraged among citizens and also improvement of disease surveillance and health care response system by the government would aid in the prevention and control of yellow fever in Nigeria. The study therefore recommends that a comparative study should be conducted in other African countries and globally since this present one is done in Nigeria in other to aid in the prevention and control of yellow fever Globally.

Keywords: Control, Patients, Prevention, Risk Factor, Yellow Fever

1. Main text

Yellow fever is an acute haemorrhagic fever caused by a single – stranded enveloped RNA virus from the family Flaviviridae (Chippaux and Chippaux, 2018). It is associated with a wide range of manifestation ranging from entirely asymptomatic to a highly haemorrhagic fever (Kleinert *et al*., 2019).

The clinical manifestations of yellow fever are usually biphasic; they include the viraemic phase and the toxaemic phase. The viraemic phase is usually mild or moderate while the toxaemic phase is severe. Estimates indicate that only one symptomic case for every 7-12 cases is clinically silent (Kleinert *et al*., 2019). Although most patients with yellow fever are asymptomatic, approximately 15-25% of infected persons with symptoms enter the toxaemic/severe phase with a fatality rate of 20% to 60% (Adogo and Ogoh, 2020). In the majority of the symptomatic cases, the viraemic phase which lasts from 2-4 days is characterized by mild infections with an abrupt onset of fever, headache or backache, muscle pains, nausea, vomiting and red eyes (infected conjunctiva). Though not in all cases, a temporary period of remission follows the viraemic phase which lasts for an average of 24 hours, at this stage; the disease can be rounded up. But in some cases, there could be a resurgence of symptoms following the period of remission, here the virus is said to be in the toxaemic phase. The symptoms following this phase includes jaundice, dark urine, reduced amounts of urine production, bleeding from the gums, nose or in the stool, hiccups and slow pulse in relation to Fever (WHO, 2020). Up to half of the patients in the toxaemic phase progress to death in 10 to 14 days and the rest recover without significant sequale. In the viraemic phase, the viraemic titres are sufficiently high for transmission to biting vectors. Since yellow fever shares the same clinical features at the viraemic phase with other viral haemorrhagic fever such as dengue fever, lassa fever and Crimean Congo Haemorrhagic Fever, it is often difficult to diagnose it at this stage. Yellow fever can only be distinguished from other viruses at the toxaemic phase by the characteristic severity of liver damage and the appearance of Jaundice (Gardner and Ryman, 2010)

1.1 Global Distribution of Yellow Fever.

Historically, devastating urban yellow fever outbreaks have occurred in Europe, Africa, South and Central America. The yellow fever virus is said to have originated from Africa and was imported to Europe and the Americas as a result of the slave trade between the continents. The first recorded epidemic of yellow fever in the Western Hemisphere was in Yucatan in the year 1648 (Gardner and Ryman, 2010). It is more distributed in south and central as well as Europe and America African due to the presence of ports.

In the absence of sylvatic transmission, sanitation and vector abatement program aided in the eradication of urban yellow fever from North America and European Cities with the last outbreak occurring in New Orleans in 1903. However, yellow fever continues to affect a large number of populations in the tropical regions of Africa, South America and Central America with Forty-four countries in Africa and South and Central America within the modern yellow fever endemic zones with over 900 million people at risk of infections.

1.1.1 Distribution in Americas

Yellow fever is a major epidemic disease ravaging the South and Central America and the Southern United States. The vector abatement program to control and eradicate the domestic vector responsible for the transmission of yellow fever in the 1940s led to the eradication of urban yellow fever. However, in the last few years, the Pan-American Health Organization (PAHO) reported increased circulation of jungle yellow fever in the Americas, affecting Argentina, Paraguay and Brazil in the Southern part of the continent, Colombia and Venezuela in the Andean region and Trinidad and Tobago in the Caribbean (Gardner and Ryman, 2010).

Between January 2017 and December 2018, six countries and territories in Americas reported confirmed cases of yellow fever in Bolivia, Brazil, Colombia, Ecuador, French Guiana and Peru. In December 2016, cases of yellow fever were reported in Minas Gerais in Brazil and the outbreak extended to areas located near the proximity of the states. As of Mid-April 2017, a total case of 2,422 cases were reported. Between December 2018 and January 2019, Brazil and Peru reported confirmed cases of Yellow Fever (Adogo and Ogoh, 2020).

The case of International travel also made it easier for the spread of yellow fever into new areas infested with competent vectors, theoretically placing parts of Asia, Australia, Europe and North America at risk (Gardner and Ryman, 2010). The expansion of the historical area of yellow Fever to areas considered risk free led to waves of transmission; one during the 2016/2017 season with 778 cases and another during the 2017/2018 season with 1,376 cases in Brazil. In the 2018/2019 season, 12 confirmed cases were reported in the municipalities of Eldorado, Jacupiranga, Iporanga and Cananela all of which are located in the Southern part of St. Paulo (Adogo and Ogoh, 2020).

1.1.2 Distribution in Africa

Mass vaccination campaigns in the 1940s helped in controlling urban yellow fever in French - Speaking West African countries. However due to the waning or absence of vaccine coverage in West Africa and Ethiopia, thousands of yellow fever cases were reported. As a result of these, several cities in Africa experienced a resurgence of yellow fever outbreak, these cities include: Abidjan, Cote d'Ivoire (2001); Dakar, Senegal (2002), Touba, Senegal (2002); Conakry, Guinea (2002); and Bobo Dioulasso, Burkina Faso (2004) (Gardner and Ryman, 2010).

In the recent years, many countries in the African region experienced several outbreaks of yellow fever with the most recent outbreak occurring in Viana municipality, Luanda province and Angola in December 2015. The Angolan outbreak was able to spread extensively to the Democratic Republic of Congo (DCR). In July 2016, there were reports of the re- introduction of yellow fever outbreak in 68 countries in Africa.

Several outbreaks of yellow fever were recorded in the past. The first recorded outbreak of yellow fever in Nigeria was reported in Lagos in the year 1864 (Nwachukwu *et al.,* 2017). The 1864 outbreak was followed by other outbreaks in 1894, 1905, 1906, 1925 and 1926 with other set of outbreaks occurring in 1946 in Ogbomosho and in the Eastern part of Nigeria between 1951 to 1953 (Nwachukwu *et al.,* 2017; Adogo and Ogoh, 2020). A major outbreak of yellow fever occurred in 1969 in the Plateau of Jos with over 100,000 infected persons that spread rapidly to other parts of the country. Similarly, 120,000 persons were affected in various parts of Nigeria including Jos, Azare, Ogoja in Cross River State, Oju in Benue state, Ogbomosho in Oyo state in an outbreak that occurred in 1986 and 1987 (Nwachukwu *et al.,* 2017).

Global Distribution of Yellow Fever in South America and Africa

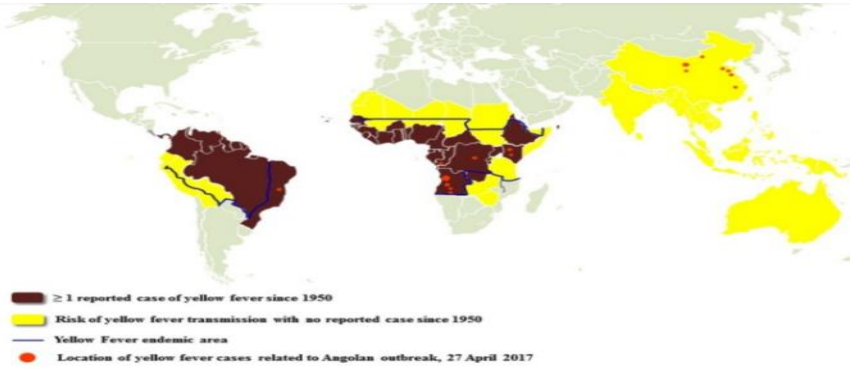


Figure 1: Global distribution of yellow fever in South America and Africa. Source: Swapnil *et al.* (2017).

1.2 Global Impact of Yellow Fever

Yellow fever is affecting over 200,000 people in the tropics of Africa and South America annually with over 30,000 deaths recorded every year (Rogers *et al.*, 2006). In a research carried out by Gaythorpe *et al.*, an estimate of 63,000 to 158,000 severe infection of yellow fever were reported in Africa with over 29,000 to 75,000 recorded deaths while an average of 4000 to 15,000 severe infections with 2000 to 7000 deaths was recorded in South America as at 2018. The highest burden was seen in the Democratic Republic of Congo due to a high force of infection and low vaccine coverage. Brazil is recorded as the fourth highest country experiencing outbreaks of yellow fever due to the high force of infection in the Amazon region rather than low vaccine coverage (Gaythorpe *et al.*, 2021).

1.3 Mode of Transmission

Three cycles are involved in the transmission of yellow fever they include the sylvatic cycle, the intermediate cycle and the urban cycle. *Haemagogus* spp. and *Aedes africanus* are responsible for the transmission of yellow fever in the sylvatic cycle in South America and Africa respectively, while the *Aedes aegypti* and *Aedes albopictus* are responsible for the transmission of the virus in the urban cycle. These mosquitoes require a blood meal for the development of their eggs and as they do so they either take up or deposit the virus in the human body. The yellow fever virus is then transmitted when an infected vector species bites a non-infected person. The *Haemagogus* spp. and *Aedes africanus* transmits the yellow fever virus from infected non-human primates such as the monkeys, chimpanzees and gorillas which are reservoirs in the forest areas to humans that comes into the forest in the sylvatic cycle while the *Aedes aegypti* and *Aedes albopictus* transmits the yellow fever virus from these infected persons from the forest to non-infected persons in the urban areas. In the intermediate cycle, some of the *Aedes* species bites indiscriminately by feeding on both non-human primates from the forest and humans living in savanna areas around the forest, thus transmitting the virus from infected non-human primates to humans (Gardner and Ryman, 2010).

2. Transmission Cycle between the Yellow Fever Virus and Its Vector

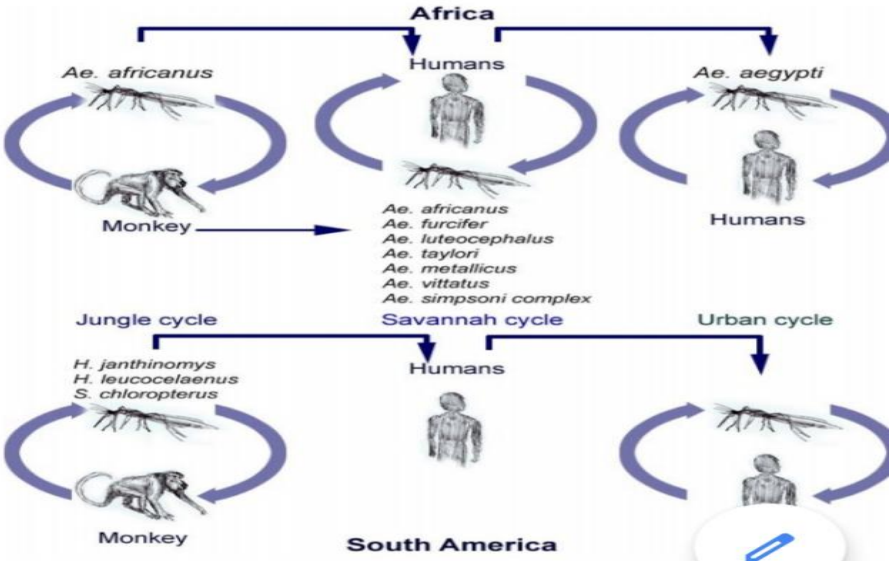


Figure 2: Transmission cycle between the yellow fever virus and its vector. Source: Abdullahi *et al.* (2021).

2.1 History of Yellow Fever in Nigeria

Several outbreaks of yellow fever were recorded in the past. The first recorded outbreak of yellow fever in Nigeria was reported in Lagos in the year 1864 (Nwachukwu *et al.,* 2017). The 1864 outbreak was followed by other outbreaks in 1894, 1905, 1906, 1925 and 1926 with other set of outbreaks occurring in 1946 in Ogbomosho and in the Eastern part of Nigeria between 1951 to 1953 (Nwachukwu *et al.,* 2017; Adogo and Ogoh, 2020). A major outbreak of yellow fever occurred in 1969 in the Plateau of Jos with over 100,000 infected persons that spread rapidly to other parts of the country. Similarly, 120,000 persons were affected in various parts of Nigeria including Jos, Azare, Ogoja in Cross River State, Oju in Benue state, Ogbomosho in Oyo state in an outbreak that occurred in 1986 and 1987 (Nwachukwu *et al.,* 2017).

The 1969 epidemic was first evident in September, with the peak of the outbreak occurring in October 1969. Between 1969 and 1987, numerically limited outbreak occurred in the last three months of 1970 in Okwogu district in Nigeria. The onset of the epidemic was in October and its peak in November with few or no cases in January with over 21 to 41 affected persons in every 100 persons (Monath, 1982). A case was confirmed in Ifelodun Local Government Area of Kwara State in 2017, 21 years after the major outbreak in 1969 (Adogo and Ogoh, 2017).

2.2 Current Situation of Yellow Fever in Nigeria

In November 2018, a cluster of suspected yellow fever outbreak was recorded in Edo state, Nigeria. A total of 146 suspected case, 42 presumptive positive and 32 confirmed cases, including 26 deaths were reported across 15 of 18 Local Government Area of the state from September to December 2018. Between January I and May 31 2019, 1,255 suspected cases were reported in 424 Local Government Area in Nigeria. Three cases were tested positive in Izzi Local Government Area of Ebonyi state as at 31 July 2019 (Adogo and Ogoh, 2017). According to the Nigeria Center for Disease Control (NCDC), 2 cases were recorded in Kano, 10 in Gombe, 109 in Borno and 110 in Bauchi states as at September 2019 with 6 deaths reported from Alkeri LGA in Bauchi state (Abdulkadir *et al.,* 2019). Cumulatively from January I to May 31 2021, a total of 626 suspected cases have been reported from Adamawa (13 cases), Akwa Ibom (2 cases), Anambra (47 cases), Bauchi (25 cases), Bayelsa (14 cases), Delta (14 cases), Ebonyi (2 cases), Edo (28 cases, Ekiti (2 cases), Enugu (32 cases), FCT Abuja (6 cases), Imo (16 cases), Jigawa (23 cases), Kano (14 cases), Kastina (52 cases), Kebbi (15 cases), Kogi (7cases), Kwara (18), Lagos (3 cases) Nasarawa (11 cases), Niger (32), Ogun (11 cases), Ondo (13 cases), Osun (14 cases), Oyo (19 cases), Plateau (8 cases), Rivers (5 cases), Sokoto (4 cases), Taraba (7 cases), Yobe (56 cases) and Zamfara states (9 cases). A total of presumptive positive and inconclusive samples was recorded from CPHL Lagos (33 samples), NEL Abuja (11 samples), YOMH Kaduna (1 sample), MDH Abuja (1 sample). These cases were reported from Anambra (7 cases), Bauchi (1 cases), Benue (2 cases), Borno (6 cases), Delta (5 cases), Ebonyi (1 case), Enugu (14 cases), Imo (1 case), Kano (1 case), Kastina (1 case), Niger (1 case), Ondo (1 case), Oyo (4 cases), Yobe states (1 case). Eighteen confirmed cases were reported from IP Dakar from: Anambra (2 cases), Delta (3 cases), Enugu (9 cases), lmo (1 case), Niger (1 case), Oyo (1 case) and Ondo states (1 case). Two deaths were recorded from Anambra (1 case) and Imo (1 case) (NCDC, 2021).

Map of Nigeria Showing the Distribution of Yellow Fever in Different Parts of the Country

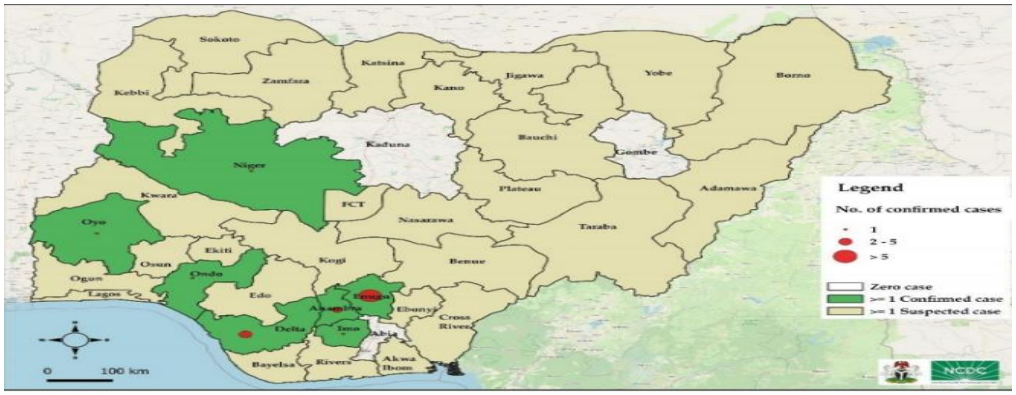


Figure 3: Map of Nigeria showing the distribution of yellow fever in different parts of the country. Source:Yellow Fever Situation Report, NCDC (2021).

2.3 Factors Favouring the Distribution of Yellow Fever in Nigeria

Availability of reservoirs (i.e. infected non-human primates and infected persons from the forest) and high vector density are prerequisites for the outbreak of yellow fever (Gardner and Ryman, 2010). Various factors are responsible for the transmission of yellow fever in Nigeria.

2.3.1 Climate

The lifecycle of a mosquito and the replication of the yellow fever virus in the body of the mosquito is highly dependent on climate most particularly temperature and rainfall (Hamlet *et al.,* 2018). Global warming and increased rainfall intensity in Nigeria are one of the factors favouring the transmission of the yellow fever virus in Nigeria (Abdullahi *et al.,* 2021). Like all insects *Aedes aegypti* is poikilothermic and ectothermic. The increase in temperature

below temperature induced mortality leads to the increase in metabolism, speed of pupation and the frequency of blood meal of the mosquito. It also reduces the extrinsic incubation period of the yellow fever virus thus increasing the risk of transmission of yellow fever (Hamlet *et al.,* 2018). It is noted that climate change in Nigeria are in the form of change in temperature and rainfall. It has been observed that the recent period is characterized by a generally hotter temperature than normal (Akamigbo, 2011). An analysis which was presented to study the potential impact of climate change on the transmission of yellow fever showed strong evidence that projected climate change may alter the distribution of *Aedes aegypti* and the disease it transmits (Gaythorpe *et al.,* 2020). Increased intensity in rainfall also affects the transmission of the yellow fever virus as these vectors depend on water for breeding and the development of their eggs (Hamlet *et al.,* 2018).

2.3.2 Human activities

Aedes aegypti breeds on both artificial and natural containers. They breed in natural containers such as tree holes, plant axils (e.g. banana axils, pineapple axils etc.), rock pools and other natural water holding surfaces. They also breed in artificial containers such as cans, bottles, barrels, abandoned swimming pools, tires and flower pots containing rain water deposit (Lima-camara *et al.,* 2016).

In rural areas, container like open drums and buckets are used to store water outside the house for a long period of time. This habit led to a large number of water-holding containers that preserves standing water for a long period of time, thus creating a suitable breeding habitat for the *Aedes* mosquitoes (Wijayanti *et al.,* 2020).

Due to overcrowding, poor housing systems and poor sanitation in urban areas, the dumping of artificial containers such as tires, cans, bottles, flower pots, barrels and other artificial water holding containers which are suitable breeding sites for *Aedes* mosquitoes influences the presence of *Aedes aegypti* thus creating conditions ideal for the transmission of yellow fever in urban areas (Abdulkadir *et al.,* 2019; Abdullahi *et al.,* 2021; Lima-camara *et al.,* 2016; Hamlet *et al.,* 2018). Travelling to areas endemic to yellow fever also increases the risk of transmission to unvaccinated travellers. In August 2019, an individual with suspected yellow fever from Kano state was traced to have travelled to the Yankari game reserve in Bauchi state which was experiencing an outbreak of yellow fever (Gardner and Ryman, 2010; Abdullahi *et al.,* 2021).Activities such as deforestation, resource derivation, agricultural activities and forest encroachment exposes humans to *Aedes africanus* leading to the sylvatic transmission of yellow fever (Abdullahi *et al.,* 2021).

2.3.3 Vegetation

Vegetation is a key factor determining the habitat of non-human primates (Gaythorpe *et al.,* 2020). The tropical rainforest in Nigeria provides a stable environment for the *Aedes africanus* mosquitoes which breeds on tree holes and cervices and the non-human primates thus sustaining the sylvatic transmission of yellow fever in Nigeria (Gaythorpe *et al.,* 2020).

Tree Holes, Natural Breeding Site of *Aedes Aegypti*

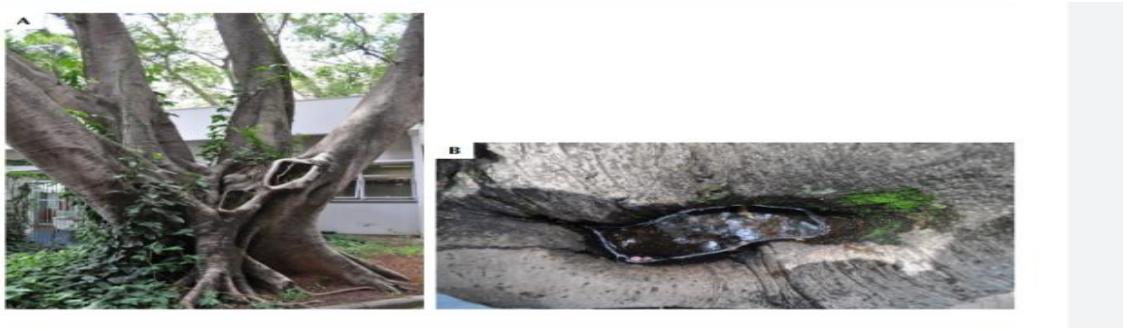


Figure 4: Tree holes, natural breeding site of *Aedes aegypti.* Source: Lima-Camara *et al.* (2016).

3.0 Diagnosis and Treatment of Yellow Fever

3.1 Diagnosis of Yellow Fever

Case definition can be defined as a suspected case if the patient displays an acute onset of fever which is followed by jaundice that occurs within 2 weeks after the onset of the first symptoms and a confirmed case if the case is confirmed using labouratory methods. Yellow fever could be suspected in persons living in endemic areas or in persons with recent travels to endemic areas presenting symptoms characterized by an abrupt onset of fever, relative bradycardia and jaundice (Gardner and Ryman, 2010).

3.1.1 Clinical diagnosis

This is done by first carrying out a presumptive diagnosis which is based on the clinical features observed from the patient. It is then followed by a complete blood count test, urinalysis, liver function test, coagulation test, viral blood culture and serological test (Adogo and Ogoh, 2020; Gardner and Ryman, 2010). Clinical diagnosis of yellow fever in the field is usually difficult due to the case by case differences in severity. The clusters of symptoms observed could sometimes be mistaken for dengue fever, Lassa fever, Ebola fever, malaria, typhoid, hepatitis and other haemorrhagic viral fever. In some cases, mild diseases often escape diagnosis while in the severe case; jaundice could be absent thus limiting diagnosis (Gardner and Ryman, 2010).

3.1.2 Labouratory diagnosis

Labouratory diagnosis is carried out using any of the following method

1. Virological detection method through the isolation of the yellow fever virus from sera or through the detection of the yellow fever virus genomic sequence in blood or organs using the reverse transcription polymerase chain reaction method.
2. Serological diagnosis which detects the presence of yellow fever specific IgM or IgG antibodies in acute and covalscent sera in the absence of recent vaccination.
3. Postmortem liver histopathology.
4. The detection of yellow fever virus in tissues using the immunohistochemical method. (Swapnil *et al.*, 2018; Gardner and Ryman, 2010).

3.2 Treatment of Yellow Fever

There is no specific treatment for yellow fever. Although several compounds with in-vitro antiviral activities such as Ribavirin and Interferon have been described, it is however no longer in use due to the yielding conflicting results (Gardner and Ryman, 2010). Studies have shown that yellow fever is susceptible to sofosbuvir suggesting that this drug may represent a novel therapeutic option for the treatment of yellow fever. However, symptoms including haemorrhage, renal and hepatic dysfunction and possible secondary infections are treated. Severely ill patients are admitted in the intensive Care unit and provided with vasoactive medications, fluid resuscitation and ventilator support. Fresh frozen plasma and vitamin K are administered to replenish clotting factors (Adogo and Ogoh, 2020).

4.1 Prevention and Control of Yellow Fever

Quite true that yellow fever cannot be eradicated; outbreaks can be controlled and prevented. Detection and control of the yellow fever depends on a strong surveillance system (WHO, 2020).

4.1.1 Surveillance

Surveillance aids in the early detection of outbreaks and in the identification of vulnerable populations with high risk of infection (WHO, 2020). Early detection of suspected case using the 'syndromic surveillance' approach (Chippaux and Chippaux, 2018), reporting, analysis and confirmation of yellow fever are steps involved in the surveillance of yellow fever outbreak (WHO). Vector surveillance targeting *Aedes aegypti* and other *Aedes* species helps to identify area with high risk of yellow fever transmission (Abdulkadir *et al.*, 2019). In order to control the outbreak, the investigation team must respond to outbreak with both emergency measure and long-term immunization plan (Swapnil *et al.*, 2017).

4.1.2 Vaccination

This is the best way of preventing and controlling an outbreak of the disease (Abdulkadir et al., 2019). The 17D-live attenuated vaccine developed in 1936 offers a long-lasting protection against the virus. The 17D vaccine was created after the 1935 vaccine used in the treatment of yellow fever in French speaking countries in West Africa. The use of the 1935 vaccine was reduced due to the high risk of encephalitis reactions observed in children following its use (Swapnil *et al.*, 2017). Its production was stopped in 1980 (Rogers *et al.*, 2011). The 17D vaccine is however considered safe with low adverse effect rate (Garythorpe *et al.*, 2021). Routine infant immunization and mass vaccination campaigns are designed to increase coverage in areas at risk of outbreaks and also to control outbreaks in epidemic areas. Travellers going to endemic areas should be vaccinated to prevent the spread of the disease (Abdulkadir *et al.*, 2019).

4.1.3 Vector control programs

Continued host to host transmission of yellow fever is possible only in geographical areas with competent vector species (Kleinert *et al.*, 2019). The different vector control strategies include:

- Application of chemical insecticides, toxins and insect growth regulator to the breeding sites in order to reduce the number of vectors reaching the adult stage.

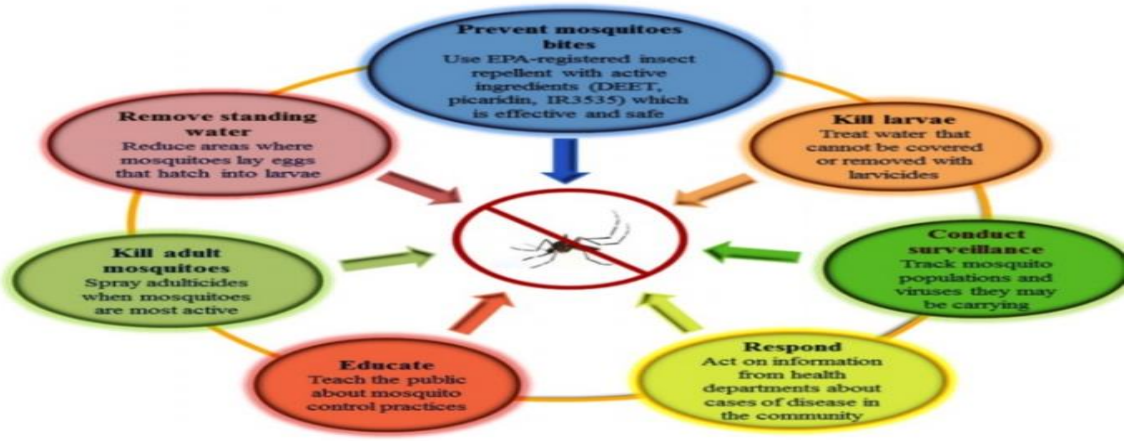
- Eliminating the potential breeding sites of *Aedes* mosquitoes by discarding containers that can hold standing water.
- Controlling of Adults through the application of long-lasting insecticides in the inner walls of houses and the use of long-lasting insecticides treated nets so as to kill or repel them. (Swapnil *et al.,* 2017).

4.1.4 Community education

Information on proper sanitation and disposal of waste items that can act as containers for standing water should be communicated to communities, storage of water in open drums and buckets for a long period of time should be discouraged so as to eliminate the breeding sites of *Aedes* mosquitoes (Swapnil *et al.,* 2018). Wearing of long-sleeved clothes, long trousers and socks and the use of EPA registered insect repellent when outdoors should be advised to reduce the number of vectors biting them (Abdulkadir *et al.,* 2019).

Diagrammatic Representation for the Prevention and Control of Yellow Fever Virus Transmission

Figure 5:



Diagrammatic representation for the prevention and control of yellow fever virus transmission.Source: Swapnil *et al.* (2017)

4.2 Public Health Response to the Outbreak of Yellow Fever in Nigeria

Various agencies such as the National yellow fever Emergency Operation Center (EOC), National Incident Management System (IMS), National Rapid Response Team (RRT), National Center for Disease Control (NCDC) and the National Primary Health Care Development Agency (NPHCDA) were established to coordinate response activities such as case finding, risk finding and case management (Abdulkadir *et al.,* 2019). The yellow fever reactive immunization was launched in collaboration with the World Health Organization and other collaborators, funded by Gavi, the vaccine alliance to carry out the immunization program in 13 LGAs of Edo state where cases have been confirmed. The international Coordination Group (ICG) on vaccine provision approved the release of 3.1 million doses of yellow fever in Nigeria. The world Health Organization pledged to donate 12 million doses of yellow fever vaccine in 2018 and 19 million in 2019 to support the Nigerian campaign against yellow fever (Adogo and Ogoh, 2020).

4.3 Challenges Mitigating the Eradication of Yellow Fever in Nigeria

Inadequate disease surveillance, poor state of labouratory facilities for diagnosis, collapse of the health care delivery systems, low vaccine coverage and collapse of the vector control program are factors inhabiting the prevention and control of yellow fever in Nigeria. Despite the mandate to support the states and Local Government in their immunization programs, the supply of vaccines have always been problematic for Nigeria due to insufficient funds and the politicization of health issues, leading to the frequent appointment of inappropriate qualified staff has led to low and differential routine immunization coverage that allowed for the persistence of the virus in some sub-groups of the population. In some cases, some of the citizen refused to get immunized from fear that the vaccine might be used as a weapon of destruction against them. This is seen mainly n the Northern part of Nigeria (Abdulkadir *et al.,* 2019)

Conclusion

Yellow fever continues to represent an epizoonotic disease ravaging South America and Africa. Proper sanitation, good laboratory equipments, trained personnels, good health care systems and the implementation of good control measured presented in this study would aid in the prevention and control of outbreaks in the country. The study therefore recommends that a comparative study should be conducted in other African countries and globally since this present one is done in Nigeria in other to aid in the prevention and control of yellow fever globally.

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