Ebola Virus Disease – An Emergent Public Health Threat of the Late 20th Century

Dozie, I.N.S.[1], Nwoke, B.E.B.[2], Amadi, A.N.[1], Chukwuocha, U.M.[1], Dozie, W.U.[1], Ezelote, J[1], Lerum, N.I.[3], Chidebelu, P.E[3], Enweani, E.O.[3], Faro, F.O.[3], Nwabueze, I.C.[3].

1.Department of Public Health Technology, Federal University of Technology Owerri, Owerri.

2.Department of Animal and Environmental Biology, Imo State University Owerri, Nigeria.

3.Department of Microbiology, University of Nigeria Nsukka, Nigeria.

Corresponding author: dozieins@yahoo.com

Abstract

Ebola virus disease is one of the new emerged infectious diseases of the late 20th century. It is a severe, often fatal illness in humans marked by severe bleeding (haemorrhage), organ failure and with fatality rates of between 50% and 90%. Ebola virus is native to Africa and is previously characterized by outbreaks in isolated and remote communities in the rainforest. The 2014 Ebola outbreak is reported in four West African countries namely, Guinea, Liberia, Sierra Leone and Nigeria. Ebola virus disease (EVD) is caused by members of the genus Ebolavirus with five (5) recognized species namely *Zaire Ebolavirus, Sudan Ebolavirus, Ivory Coast Ebolavirus, Reston Ebolavirus* and *Bundibugyo Ebolavirus,* all of which belongs to the family, *Filoviridae*. The transmission of Ebola virus involve two major steps; firstly from suspected natural hosts or reservoir believed to be fruit bats to animals in the wild and secondly, from animals in the wild to humans. Human-to-human transmission occurs through direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other bodily fluids (vomit, faeces, urine, breast milk, semen and sweat) of infected persons. Although the clinical course of infection with an incubation period of between 2 to 21 days is well known, the specific mechanisms underlying the pathogenicity of Ebola virus have not been clearly understood. Several lines of evidence suggest that the viral glycoprotein (GP) plays a key role in the manifestation of Ebola virus infection. EVD can be diagnosed in the laboratory by reverse transcriptase polymerase chain reaction (RT-PCR) assay, antibody-capture enzyme-linked immunosorbent assay (ELISA), antigen detection tests, serum neutralization tests and virus isolation by cell culture. Currently there are no approved drugs or vaccines to treat or prevent Ebola. Treatment consists of supportive therapy to maintain electrolyte balance. However experimental vaccines and antiviral drugs are undergoing development and clinical trials. The potential treatment of Ebola Haemorrhagic fever patients with passive immune therapy (i.e. blood transfusion) from convalescent patients is being explored. Prevention of EVD consists of avoiding close contact with gravely illness patients, improvement of personal hygiene especially hand hygiene, strict barrier nursing techniques including use of personal protective equipment and safe burial of the dead.

Introduction

Infectious or communicable diseases are essential part of humanity, human civilization and history. Infectious disease outbreaks occur from time to time especially in the developing economies of the world including Africa where conditions encourage their prevalence and persistence (Dozie et al., 1999). On the contrary, the non-communicable diseases (NCDs) are more prevalent in the developed economies of Europe and North America where lifestyle and genetics are the most prominent predisposing factors. Examples of NCDs are cancer, diabetes, obesity, high blood pressure, cardiovascular disorders etc.

An infectious disease is defined as, "an illness due to a specific infectious agent or its

toxic product that arises through transmission of that agent or its product from an infected person, animal or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or the inanimate environment". EVD is an example of an infectious disease.

The past forty (40) years have been characterized by the emergence of new infectious diseases of public health significance (Nwoke et al., 2007). Emerging infections account for at least 12% of all human pathogens (Taylor et. al., 2001). Emerging infectious diseases are caused by newly identified species or strains that may have evolved from a known infection or spread to a new population or area undergoing ecological transformation (Lashley, 2004; Fauci, 2005). Examples of newly emerged diseases are Marburg Haemorrhagic Disease or Marburg Viral Disease (MVD) discovered in 1967 in Germany, Lassa Virus discovered in 1969 in Nigeria, Legionnaires' disease discovered in US in 1976, Ebola Haemorragic Fever (now Ebola Virus Diseases, EBV) described in Zaire and Sudan in 1976, Acquired Immune Deficiency Syndrome (AIDS) described in homosexuals in 1981 in USA and Severe Acute Respiratory Syndrome (SARS) described in China in 2002.

A number of older and well known diseases have also re-emerged with greater public health significance. A typical example of a re-emerged disease is drug resistant tuberculosis (TB) (Lashley, 2004; Fauci, 2005). The re-emergence of TB is associated with the advent of HIV/AIDS which is characterized by severe immunodeficiency. These outbreaks are characterized by high mortality and morbidity. They cause much pains, suffering, anxiety, panic and impede socio-economic development and transformation of nation states.

The world once again is witnessing the devastating effects of the Ebola virus outbreak. The theater of the 2014 outbreak is West Africa. This outbreak originated from Guinea and has spread through transportation to neigbouring countries of Liberia and Sierra Leone and most unfortunately to Nigeria (WHO, 2014). The current Ebola outbreak which is reported to be the worst so far in history underscores once again the great importance of rapid travel or transportation in the epidemiology and distribution of infectious diseases (Giesecke, 2002).

Peter Piot, a Belgian and one of the scientists who discovered Ebola virus admits being surprised by the magnitude of the current epidemic which is the 25th in the whole of Africa. According to Piot, "All previous epidemics were quite limited in time and place, generally affecting small villages or small towns and would die out after classic isolation and quarantine, but in this case it's different"

Estimates by the World Health Organization (2014) show that over 3000 people have died from the current Ebola epidemic within a period of nine (9) months. Whereas in the 38 years of Ebola history since its discovery in 1976, a total of 34 outbreaks occurred involving 2,432 human cases with 1,563 (64%) deaths. Daily unfolding statistics shows the seriousness of the current epidemic in West Africa and underscores the urgent need to put in place appropriate measures to check the spread of the virus.

Definition, Origin and Timeline of Ebola Virus Disease

Ebola virus disease is simply defined as a severe, often fatal illness in humans marked by severe bleeding (haemorrhage), organ failure and in many cases death. EVD outbreaks have case fatality rates of between 50% and 90% (i.e. 5 to 9 persons out of 10 infected persons die of the disease) (Peters and Khan, 1999, Sanchez, et al., 2001, CDC, 2014; WHO, 2014). Ebola virus is native to Africa. Ebola was first discovered in two simultaneous outbreaks in Zaire (now called Democratic Republic of Congo, DRC) and Sudan (Bowen et al., 1977, Johnson et al., 1977). The outbreak in Zaire occurred in August/September 1976 in Yambuku located in the Equater Province in the northwest of Zaire. In the Equater Province is a small stream located in the forest called the Ebola River. The disease discovered by Belgian

scientists was named after the river, thus Ebola disease. The virus was isolated and characterized in October, 1976 (Johnson et al., 1977). These initial outbreaks were spread by close personal contact and by use of contaminated needles and syringes in hospitals/clinics. Three hundred eighteen (318) human cases were reported in the Zaire outbreak out of which 280 (88%) died. The Sudan outbreak occurred in Nzara, Maridi and surrounding areas and killed 151 (53%) persons out of 284 reported cases.

According to WHO (2014), a single case of Ebola was reported in Zaire in Tandala village in 1977, and the individual died (100%). Furthermore, in 1979, 34 people in Sudan got infected and 22 (65%) were killed. The outbreak had occurred in the same areas as the 1976 outbreak namely Nzara, Maridi in Sudan.

In 1994, Ebola outbreak occurred in Mekouka, Gabon, and other gold-mining camps located deep in the rainforest. Of the 52 people infected, 31 (60%) died of the disease. Also in 1994, a scientist who performed an autopsy on a wild chimpanzee in Ivory Coast was infected with Ebola virus and survived after supportive treatment in Switzerland.

In 1995, a major outbreak occurred in Kikwit Zaire killing 250 out of 315 infected people. The case fatality rate was 81% which was much higher than the original outbreak in 1976. It is reported that the virus spread through an infected individual working in the forest areas who passed it on to neigbours, family members and healthcare workers.

Between 1996 and 1997, two Ebola outbreaks occurred in Gabon. The first occurred in Mayibout area and was traced to consumption of dead chimpanzee. Nineteen people who were involved in cutting the animal become ill and other cases occurred among family members. Of the 37 people affected, 21 (57%) died. The second outbreak occurred in Booue area of Gabon. 45 (74%) deaths were obtained out of 60 people infected.

Between 2000 and 2003, Uganda witnessed the first outbreak in the districts of Gulu, Masindi, and Mbarara. The virus infected 425 people and killed 224 (53%) of them. The three most important risk factors associated with this outbreak were attending funerals of Ebola patients, contact with infected family members and provision of care to hospitalized patients without adequate personal protective measures. This was followed by outbreaks in Gabon and Zaire in 2001 and 2003 which had case fatality rates of between 75% to 89%. In 2004, another outbreak occurred in Yambio county of south Sudan and killed 7 (41%) of 17 reported cases.

Similarly between 2007 and 2008, a new strain of Ebola virus called the Bundibugyo virus emerged and infected 149 (25%) people in Bundibugyo District of western Uganda. In 2008, 6 people working in a pig farm developed antibodies against another strain of Ebola (Reston virus). In same 2008, DRC (formerly Zaire) witnessed another outbreak in the Mweka and Luebo Health zones of Kasai Province and killed 15 (47%) out of 32 infected cases.

Between 2009 and 2013, there were few cases reported in Uganda and DRC. This was a crucial period in Ebola timeline as rapid diagnostic testing for Ebola was provided by the new CDC Viral Haemorrhagic Fever Laboratory installed at the Uganda Viral Research Institute (UVRI) (WHO, 2014).

The 2014 outbreak in West African countries is reported to have begun in Guinea in December 2013. The outbreak has spread to Liberia, Sierra Leone and Nigeria. WHO declared it the most severe and deadliest Ebola outbreak till date. Ebola outbreak 2014 was officially notified as a public health emergency on August 8, 2014. As at end of September 2014, an estimated 3000 people have died of the epidemic (WHO, 2014).

Classification and Geographical Distribution of Ebola Virus

Ebola virus disease (EVD) is caused by members of the genus Ebolavirus which belongs to the family, *Filoviridae*. Filovirus are pleomorphic, negative-sense RNA viruses whose genome organization is most similar to the *Paramyxoviridae*. Previously, the genera Ebolavirus and Marburgvirus were classified as species of the now obsolete Filovirus genus. However, in 1998 the International

Committee on Taxonomy of Viruses (ICTV) changed the Filo virus genus to Filo viridae family with two specific genera; Ebola-like viruses and Marburg-like viruses. In 2000, another proposal was made to change the "like virus" to "virus" resulting in the names used today Ebola virus and Marburg Virus (Feldman *et al.,* 2004).

The genus Ebola virus contains five (5) recognized species namely: Zaire Ebola virus, Sudan Ebola virus, Ivory Coast Ebola virus, Reston Ebola virus and Bundibugyo Ebola virus (Feldman *et al.,* 2004). The patterns of outbreak seem to suggest that each filo virus may have a distinct geographical range. For instance, Ivory Coast Ebola virus has been reported only in West Africa, while Sudan Ebola virus appears to occur in East Africa (Sudan and Uganda). The Zaire Ebola virus is reported mainly from Central African in countries like Gabon, Republic of Congo and DRC (formerly called Zaire). Bundibugyo Ebola virus was reported from an outbreak in Uganda. Reston Ebola virus has its origins in the Philippines. The Zaire strain is reported to be the most pathogenic strain (Feldman *et al.,* 1994; Sanchez *et al.*, 1996).

Reservoir of Ebola virus

Very little is known about the natural history of Ebola virus. Several animal reservoirs and arthropod vectors have been studied without successful identification of the reservoir of infection. However, evidence including the finding of high quantity of Ebola virus in fruit bats without showing overt illness suggests that they can be reservoir of infection (Swanepoel *et al*., 1996).

Transmission of Ebola virus

The transmission of Ebola virus involve two major steps; firstly from suspected natural hosts or reservoir (fruit bats) to animals in the wild and secondly, from animals in the wild to humans. It is believed that terrestrial mammals like gorillas, chimpanzees, duikers, antelopes etc get infected when they eat fruits and pulp dropped by fruit bats which are the suspected reservoirs of the virus. This chain of events forms a possible means of transmission from natural host to animal populations, which have led to research towards viral shedding in the saliva of bats (Gonzalez et al., 2007). It is notable that transmission between natural reservoirs and humans is rare.

Ebola is introduced into human population through close contact with the blood, secretions, organs or other bodily fluids of infected animals such as chimpanzees, gorillas, monkeys, antelope etc. Human-to-human transmission occurs through direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other bodily fluids (vomit, faeces, urine, breast milk, semen and sweat) of infected persons.

Infection can also occur indirectly if broken skin or mucous membrane of a healthy person comes in contact with environments contaminated with an Ebola person's infectious fluids such as soiled clothing, bed lining, or used needles. Burial ceremonies in which mourners or mortuary attendants have direct contact with the body of the deceased person (i.e. corpse) can also play a role in the transmission of Ebola virus. Persons who have died of Ebola must be handled using strong protective clothing and gloves and must be buried immediately.

Exchange of body fluids appears to be necessary before infection can occur. It is notable that transmission among humans is almost exclusively among caregiver family members or healthcare workers tending to the very ill (CDC, 2014). Many healthcare workers have been exposed to the virus while caring for Ebola patients. This happens because they may not have worn personal protection equipment or were not properly applying infection control measure.

There is no documented evidence that the virus can be transmitted by air. Evidence from Kikwit, DRC which has the custom of children not touching ill adults showed that children who lived in small one room huts with parents who died from Ebola did not become infected (CDC, 2014). This strongly supports the view that direct contact with sick patients is a means of transmission while air is not a means of transmission. However, the potential transmission of Filoviruses as aerosols under laboratory conditions have resulted in their

classification as Category A biological weapons (Leffel and Reed, 2004).

Ebola Virus disease progression

Although the clinical course of infection is well known, the specific mechanisms underlying the pathogenicity of Ebola virus have not been clearly understood. According to Sullivan *et al*., (2003) this is due, partly to the difficulty in obtaining samples and studying the disease in the relatively remote areas in which outbreaks occur. In addition a high degree of biohazard containment is required for laboratory studies and clinical analysis. Isolation of the viral cDNAs and the development of expressive systems have allowed the study of Ebola virus gene products under less restrictive conditions and facilitated an understanding of the mechanisms underlying virally induced cell damage.

The incubation period (i.e. from time of infection to onset of clinical symptoms) is 2 to 21 days with an average period of 5 to 9 days. Infected people can transmit the virus as long as their blood and secretions contain the virus. People who are gravely ill are highly infectious and contact with their blood and secretions/bodily fluids result in infections (CDC, 2014). It is notable that infected people are NOT CONTAGIOUS until they are acutely ill. Only when ill does the viral load express itself first in blood and then in other bodily fluids (including vomit, faeces, urine, breast milk, semen and sweat).

Infection initially presents nonspecific flu-like symptoms such as fever, myalgia and malaise. As infection progresses, patients exhibit severe bleeding and coagulation abnormalities, including gastrointestinal bleeding, rash, and a range of hematological irregularities, such as lymphopenia and neutrophilia (Sullivan *et al*., 2003). Cytokines are released when reticuloendothelial cells encounter virus, which contribute to exaggerated inflammatory response that are not protective. Damage to the liver, combined with massive viremia, leads to disseminated intravascular coagulopathy. The virus eventually infects microvascular endothelial cells and compromises vascular integrity. The terminal stages of Ebola virus infection usually include diffuse bleeding, and hypotensive shock accounts for many Ebola virus fatalities (Colebunders & Borchert, 2000; Sanchez *et al*., 2001).

Several lines of evidence suggest that the viral glycoproteins (GP) play a key role in the manifestation of Ebola virus infection (Sullivan *et al*., 2003). The transmembrane form of GP targets the Ebola virus to cells that are relevant to its pathogenesis. Specifically, GP allows the virus to introduce its contents into monocytes and/or macrophages, where cell damage or exposure to viral particles may cause the release of cytokines (Stroher et al., 2001) associated with inflammation and fever, and into endothelial cells, which damages vascular integrity (Yang *et al*., 2000). Thus sGP may alter the immune response by inhibiting neutrophil activation, while the transmembrane GP may contribute to the haemorrhagic fever symptoms by targeting virus to cells of the reticuloendothelial network and the lining of blood vessels.

Diagnosis

EVD is clinically indistinguishable from other haemorragic fever especially Marburg haemorrahgic fever. Furthermore, EVD can be confused with many other infectious diseases prevalent in sub-Saharan Africa such as malaria, typhoid fever, shigellosis, cholera, leptospirosis, plague, relapsing fever, meningitis, hepatitis (WHO, 2014). Non-infectious conditions that can be confused with EVD include leukemia, hemolytic uremic syndrome, snakeenvenomation, clotting factor deficiencies/platelet disorders.

In the laboratory, EVD can be diagnosed by reverse transcriptase polymerase chain reaction (RT-PCR) assay, antibody-capture enzyme-linked immunosorbent assay (ELISA), antigen detection tests, serum neutralization tests and virus isolation by cell culture. These tests can be performed in field or mobile hospitals and laboratories.

Epidemiology

Ebola is undoubtedly zoonotic i.e. transmission is from animals to man and the disease appears to be more severe in primary than secondary cases. Outbreaks of Ebola

have mainly been restricted to Africa (Colebunders and Borchet, 2000). Previous outbreaks have occurred mostly in remote locations in the rainforest. Besides quarantine measures to contain these outbreaks, lack of access roads and poor transportation helped in localizing or containing these outbreaks. The index cases in these outbreaks are usually people who live in the forest or whose occupations take them to the forest. The secondary cases are often family members and healthcare workers who contracted the infection by close personal contact and by use of contaminated needles and syringes. Nosocomial (i.e. hospital associated infection) spread is common, particularly affecting nurses and doctors (CDC, 2004). Transmission by sexual intercourse has been described from one case to his wife, 83 days after initial infection. It is notable that both males and females and people of all age categories are equally susceptible to infection.

Treatment of EVD, Vaccine and Antiviral Therapy Development

Currently there are no approved drugs or vaccines to treat or prevent Ebola. The US Centre for Disease Control (CDC) recommends supportive therapy for patients as the primary treatment for Ebola. This includes balancing the patient's fluids and electrolytes, maintaining their oxygen status and blood pressure and treating them for any complicating infections. The hallmark of treatment of Ebola is supportive care and rigorous infection control (CDC, 2014; WHO, 2014).

It is noteworthy that there are experimental Ebola vaccines and antiviral therapy under development. This is due to an understanding of the mechanisms underlying Ebola virus-induced cytopathic effects. Several animal models have been developed to study the pathogenesis of Ebola virus infection and to assess the efficacy of various vaccine approaches. Guinea pigs and nonhuman primates represent the primary animal models for vaccine development because the progression and pathogenesis most closely resemble those of the human disease (Xu *et al*., 1998, Connolly et al., 1999, Wyers *et al.,* 1999). It is noteworthy that live attenuated viruses and recombinant proteins have been used successfully in a variety of vaccines, but the safety and immunogenicity of gene-based vaccines have proven increasingly attractive (Sullivan *et al*., 2003).

However, these investigational products are in the earliest stages of product development and have not yet been fully tested for safety or effectiveness. Small amounts of some of these experimental products have been manufactured for clinical trials. It is the expectation of the US Food and Drug Administration (FDA) that these investigational products will one day serve to improve clinical outcomes for Ebola patients.

The potential treatment of Ebola Haemorrhagic fever patients with passive immune therapy (i.e. blood transfusion) from convalescent patients have been reported (Mupapa *et al*., 1999). Of the 8 patients in Kikwit, DRC who met Ebola haemorrhagic fever case definition and tansfused with blood donated by 5 convalescent patients, only one patient (12.5%) died. This number is significantly lower than the overall case fatality (80%) for Ebola haemorrhagic fever epidemic in Kikwit. The reason for this low case fatality remains to be explained.

Prevention and Control

The prevention of EVD presents a significant challenge. The ideal thing would be to eliminate the suspected reservoir of infection (i.e. fruit bats). Also the rapid progression of Ebola virus infection has further complicated the control of this disease, affording little opportunity to develop acquired immunity. What is fundamental in prevention is to understand the nature of the disease, how it is transmitted and how to prevent it from spreading further.

While initial cases of EVD are contracted by handling infected animals or carcasses, individuals should reduce contact with high-risk animals (i.e. fruit bats, monkeys, apes, gorillas, antelopes etc). Animal products (blood and meat) including bush meat must be thoroughly cooked before consumption.

Close physical contact with Ebola

patients should be avoided. Appropriate personal protective equipment (PPE) including gloves, impermeable gowns, boots/covered shoes, masks and goggles (to protect against splashes) must be worn when taking care of ill patients at home or in the hospital (WHO, 2014). Strict infection-control measures must be applied including regular hand washing with soap especially after visiting patients in hospital, or after taking care of patients at home and sterilization of equipment used in hospitals/clinics. Suspected cases should be reported immediately to health authorities for immediate quarantine while confirmed cases should be isolated. It is recommended that isolated persons should be kept alone in single isolation rooms. Access to these areas should be restricted and equipment for treatment dedicated to isolated patients. Occasionally access may be given to individuals who are necessary for the patient's wellbeing and care, such as a child's parent.

WHO advises families or communities not to care for individuals who may present with symptoms of Ebola virus disease in their homes. Such families or communities should seek treatment in a hospital or treatment center staffed by doctors and nurses qualified and equipped to treat Ebola victims. If they chose otherwise, WHO strongly advises them to notify local public health authorities and receive appropriate training, equipment (gloves and personal protective equipment, PPE) for treatment, instructions on proper removal and disposal of PPE, and information on how to prevent further infection and transmission of disease to oneself, other family members, or the community. Hospitals and other health facilities that have hosted Ebola cases should be decontaminated periodically. Decontamination should include surfaces and equipment and management of soiled linen and of waste (WHO, 2014).

Furthermore, people who died of Ebola should be promptly and safely buried. It is recommended that the deceased be handled and buried by trained case management professionals (such as environmental health officers) who are equipped to properly bury the dead. Furthermore, it is recommended that cremation which is the application of high temperature to reduce bodies to basic chemical components (ashes) is ideal for safe disposal of bodies of persons or animals who die during outbreaks of highly infectious diseases such as Ebola virus. This is to minimize further transmission. It is notable that in 2013 the Lagos State Government introduced its Voluntary Cremation Law under which a person may signify interest to be cremated at death or a deceased's family member who must attain the age of 18 years can decide to have the corpse cremated.

It is noteworthy too that the virus is easily killed by heating at 60^0C for 30 minutes, ultraviolet (UV) and gamma radiation, formalin (1%), lipid solvents, hypochlorite or phenolic disinfectants and bleach. It is believed that exposure to sunlight, contact with soap as well as use of washing machine even for clothing saturated with infected body fluids will kill virus.

Ebola Virus Disease (EVB) in Nigeria-Current Status

It is now history that Nigeria is witnessing her first Ebola disease outbreak. The disease was imported into Nigeria by Patrick Sawyer, a Liberian-American who flew into the country on July 20, 2014. He was treated at the First Consultant Medical Center, Lagos where he died and infected the doctors and nurses who cared for him. The cities currently affected by EVD or its scare are Lagos, Port Harcourt and Enugu.

Statistics by the Federal Ministry of Health show that the total number of Ebola Virus Disease cases so far reported in Nigeria is nineteen (19). The number of deaths is seven (7), while the number of those successfully managed and discharged stand at twelve (12). It is noteworthy that all 19 cases include the index case (Patrick Sawyer), the primary contacts of the index case who are mostly medical personnel and the secondary contacts who are mainly spouses of the primary contacts. It is significant that all cases under surveillance in Nigeria especially in the cities of Lagos, Port Harcourt and Enugu have all been released following completion of the 21-day incubation period and non developed

active disease.

Notwithstanding this cheering development, the Federal Government is working relentlessly with all stakeholders, particularly the World Health Organization and the Lagos State Government to maintain surveillance and strengthen containment activities by setting up isolation and treatment wards as well as the public enlightenment campaigns.

Challenges about EVD Prevention and Optimism for Containment/Control

Many challenges exist about EVD. One of these challenges include circulating false information about prevention of EVD. In Nigeria for instance, it is widely rumoured that eating bitter kola or drinking salt water or bathing with salt can prevent Ebola disease. Indeed, undocumented reports showed that many people drank salt water or bathed with salt water or ate bitter cola as a preventive strategy. It is known that such practices such as drinking salt water can aggravate a diseased condition as hypertension.

Like every epidemic, scientists are optimistic that the 2014 EVD outbreak will be contained. This is especially now that affected governments and indeed the international community have adopted proactive measures towards its containment such as massive enlightenment campaigns, setting up of isolation centers for treatment of the sick and quarantine of suspected cases for strict observation etc.

Secondly, the pattern of infection especially means of transmission is fairly known to put in place appropriate preventive measures. Of significance is the fact that, there is no evidence that the virus can be transmitted by air (i.e. it is not an air-borne infection) (CDC, 2014).

Thirdly, the infective virus as a natural agent will continue to lose its power of pathogenicity (i.e. attenuation) as it is transmitted from one person to another. This is partly the reason index cases have more severe infections than primary and secondary contacts.

Fourthly, a major suspected factor that resulted in quick spread of the virus in the 2014 outbreak was inability of affected local communities to respond quickly with barrier nursing techniques and strict infection control measures since the clinics in these local settings maybe ill-equipped to manage such outbreaks.

Fifthly, the level of awareness about the importance of hygiene, especially hand hygiene and environmental sanitation is very high even among the local and uneducated people in villages and communities.

Proactive Measures against EVD

Some proactive measures in the containment of EVD will include sustained massive enlightenment campaign including staying informed as an individual and keep others informed too. The degree of panic occasioned by the epidemic can be stemmed down with adequate information about EVD. Necessary precautionary measures should be taken by reporting suspected cases for quarantine, isolation and treatment. Unnecessary travels especially to countries currently experiencing outbreaks must be avoided. It is absolutely important to wash hands regularly with soap and water or use of hand sanitizers**.** Information must be made available to everyone, since everybody is susceptible to infection with virus. Where ever the virus is present, it represents danger to all. The directives issued the Ministry of Health or any other agency involved in keeping updates on EVD must be adhered to.

World Health Organization (WHO) and Response to EVB

WHO provides technical advice to countries and communities to prepare and respond to Ebola outbreaks such as: disease surveillance and information sharing across regions, technical assistance to investigate and contain outbreaks, advice on prevention and treatment options, deployment of experts and distribution of health supplies (such as personal protection equipment) to countries upon request, communications to raise awareness of the nature of the disease and protective health measures to control transmission of the virus, activation of regional and global networks of experts to

provide technical assistance, if requested and mitigate potential international health effects and disruptions of travel and trade.

Conclusion

West Africa is experiencing her first Ebola virus disease outbreak on a devastating scale. The fatality rate within a period of 8 months of the outbreak is over 50% which is quite significant and underscores the declaration of the outbreak as a Public Health Emergency by the World Health Organization. The Nigeria Ebola disease was imported into the country on July 20, 2014 by the Liberian-American, Patrick Sawyer. The death toll is 7 out of 19 confirmed cases giving an approximate case fatality rate of 37%. The modes of transmission are fairly well known to implement effective preventive measures. It is notable that the Federal Government of Nigeria and international agencies and governments are sparing no efforts to contain the disease in West Africa. In the absence of an approved antiviral drug for treatment and vaccine for prevention, the sustenance of preventive information on EVD and education of the citizenry remains key to the control of EVD in West Africa.

References

Bowen, E.T., Lloyd. D., Harris, W.J., Platt, G.S., Baskerville, A., and Vella, E.E. (1977). Viral haemorrhagic fever in southern Sudan and northern Zaire. Preliminary studies on the etiological agent. *Lancet* : 571-573

CDC (2014). Ebola Haemorrhagic Fever: Chronology of Ebola Haemorrahagic fever outbreaks. CDC Fact Sheet. (Unpublished).

Colebunders, R., and Borchert, M. (2000). Ebola haemorrhagic fever – a review. *J. Infect.* 40: 16-20.

Connolly, B.M., Steele, K.E., Davis, K.J., Geisbert, T.W., Kell, W.M., Jaax, N.K. and Jahrling, P.B. (1999). Pathogenesis of experimental Ebola virus infection in guinea pigs. *J. Infect. Dis*. 179: S203-S217.

Dozie, I.N.S., Iwuagwu, F.O., Nwoke, B.E.B. (1999). HIV/AIDS epidemic and its speculated African origin: A re-appraisal. *Negro Educ. Rev*. L (3-4): 79-87.

Fauci, A.S. (2005). "Emerging and reemerging infectious diseases: the perpetual challenge". *Academic Medicine* 80 (12): 1079–85.

Feldman, H., Nichol, S.T., Klenk, H.D., Peters, C.J., and Sanchez, A. (1994). Characterization of filoviruses based on differences in structure and antigenicity ofn the virion glycoprotein. *Virology*, 199: 469-473.

Feldman, H., Geisbert, T.W., Jahrling, P.B., Klenk, H.D., Netesov, S.V., Peters, C.J., Sanchez, A., Swanepoel, R., and Volchkov, V.E. (2004). In Virus Taxonomy. Viiith Report of the International Committee on Taxonomy of Virus, pp 645-653. Elsevier/Academic Press, London.

Giesecke, J. (2002). Modern Infective Disease Epidemiology. Arnold publications, London.

Gonzalez, J.P., Pourrut, X., Leroy, E. (2007). Ebolavirus and other filoviruses. *Curr. Top. Microbiol. Immunol*. 315: 363-387.

Johnson, K.M., Lange, J.V., Webb, P.A., and Murphy F.A. (1977). Isolation and partial characterization of a new virus causing acute haemorrhagic fever in Zaire, *Lancet* : 569-571.

Lashley, F.R. (2004). Emerging infectious diseases: vulnerabilities, contributing factors and approaches. *Expt. Rev. Anti-infect. Ther*. 2(2): 299-316.

Leffel, E.R. and Reed, D.S. (2004). Marburg and Ebola viruses as aerosol threats. Biosecurity and Bioterrorism: Biodefense strategy, *Practice and Science*, 2(3): 186-191.

Mupapa, K., Massamba, M., Kibadi, K., Kuvula, K., Bwaka, A., Kipasa, M., and Colebunders, B. (1999). Treatment of Ebola Haemorrahgic fever with blood transfusions from convalescent patients. *J. Infect. Dis*. 179 (supplement 1): S18-S23.

Nwoke, B.E.B.; Nwoke, E.A.; Ukaga, C.N.; Anosike, J.C.; Dozie, I.N.S.; Ajero, C.M.U. The impact of changing human environment and climate change on emerging and re-emerging parasitic diseases. *Nig. J. Parasitol*. 28 (2): 135-145 (2007).

Peters, C.J. and Khan, A.S. (1999). Filovirus diseases. *Curr. Top. Microbiol. Immunol.* 235: 85-95.

Sanchez, A., Trappier, S.G., Mahy, BW.J., Peters, C.J. and Nichol, S.T. (1996). The virion glycoproteins of Ebola viruses are encoded in two reading frames and are expressed through transcriptional editing. *Proc. Natl. Acad. Sci. USA* 93: 3602-3607.

Sanchez, A., Ksiazek, T.G., Rollin, P.E., Miranda, M.E.G., Trappier, S.G., Khan, A.S., Peters, C.J. and Nichol, S.T. (1999). Detection and Molecular Characterization of Ebola viruses causing disease in human and nonhuman primates. *J. Infect. Dis*. 179: S164-S169.

Sanchez, A.A., Khan, A.S., Zaki, S.R., Nabel, J.B., Ksiazek, T.G. and Peters, C.J. (2001). Filoviridae: Marburg and Ebola viruses, p. 1279-1304. In D.M. Knipe and P.M. Howley (ed.), Fields Virology. Lippincott, Williams & Wilkins, Philadelphia, PA.

Stroher, U., West, E., Bugany, H., Klenk, H.D., Schittler, J., and Feldman, H. (2001). Infection and activation of monocytes by Marburg and Ebola viruses. *J. Virol*. 75: 11025-11033.

Sullivan, N., Yang, z., and Nabel, G.J. (2003). Ebola virus pathogenesis: implications for vaccines and therapies. *J. Virol.* 77 (18): 9733-9737.

Swanepoel, R.L., Leman, P.A., Burt, F.J., Zachariades, N.A., Braack, L.E., Ksiazek, T.G., Rollin, P.E., Zaki, S.R. and Peters, C.J. (1996). Experimental inoculation of plants and animals with Ebola virus. *Emerg. Infect. Dis*. 2(4): 321-325.

Taylor, L. (2001). Risk factors for human disease emergence *Phil. Trans. Roy. Soc. B*, 356(1411):983-9.

Wyers, M., Formenty, P., Cherel, Y., Guigand, L., Fernandez, B., Boesch, C., and Le Guenno B. (1999). Histopathological and immunohistochemical studies of lesions associated with Ebola virus in a naturally infected chimpanzee. *J. Infect. Dis.* 179: S54-S59.

Xu, L., Sanchez, A., Yang, Z., Zaki, S.R., Nabel, E.G., Nichol, S.T. and Nabel, G.J. (1998). Immunization for Ebola virus infection. *Nat. Med*. 4: 37-42.

Yang, Z.H., Duckers, H.J., Sullivan, N.J., Sanchez, A., Nabel, E.G. and Nabel, G.J. (2000). Identification of the Ebola virus glycoprotein as the main viral determinant of vascular cell cytotoxicity and injury. *Nat. Med*. 6: 886-889.

WHO (2014). Ebola viral disease. WHO Fact Sheet No.103. (Unpublished).