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Ebola: A Synopsis On The Virus In Relation To Food Safety And Health

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Abstract: ***Ebola virus in the last year has been the cause of exceptionally large scale of human diseased cases and mortality in West Africa. This has further deteriorated the already fragile state of food security in this region due to containment measures. Since the unset of the outbreak, a lot of advancements have been made towards the prevention, treatment and diagnosis of the virus. Amongst these are vaccines which are currently undergoing trials, new drugs under development, repurposed drugs and convalescence serum. Some rapid diagnostics tests have also been approved for use to aid in early detection of the virus, however, no drug has been approved for treatment. Most of the progress made towards combating this epidemic has been as a result of foreign interventions. The scale of the Ebola epidemic revealed the lapses in the affected countries in aspects of food safety, education and health care amongst others. Food safety should be made a public health priority of governments of the affected countries as the Ebola Virus Disease is a zoonotic disease that is easily transmissible via consumption of infected animals. Substantial investments should be made towards research and infrastructure intended for the development of African scientists and health personnel to be able to effectively control the disease as well as possible future occurrence of same or other types of epidemics. Training to significantly improve knowledge, behaviour and attitude of the general public to food safety and security would be of great benefit to the affected countries.***

I. INTRODUCTION

The current outbreak of Ebola virus: a lethal filovirus in West Africa has led to high mortality rate in infected humans. Ebola virus and Marburg virus are filoviruses that have been implicated in many fatal cases of viral haemorrhagic fevers (Johansen et al., 2014). Due to this recent epidemic, a lot of restrictions have been placed on communities where this outbreak have occurred as a measure to contain the disease as a result of the extremely high infectious rate associated with the virus. These measures have in turn presented their own set of challenges which include; food unavailability/inaccessibility, loss of income, food ban, inflation in food prices, market closures, shortage of labour and border closures (ACAP, 10/11/2014).

All the above listed challenges increase the severity of the already fragile state of food security in Africa. Food security has defined by Emmanuel K. Boon is providing "safe", nutritious, quantitatively and qualitatively adequate food and also ease of access by all people. This therefore implies that food safety is an integral aspect of achieving food security.

It is important to take into consideration that the first and current Ebola virus disease (EVD) epidemic began as a foodborne illness with the former contracted through water and the later via fruit bat which is generally eaten in some parts of Africa (Larsen, 2014 and Gire et al., 2014).

This further emphasises the need to intensify efforts on accessibility to safe foods as well as alleviation of poverty.

FAO's situation analysis in 2005 has stated that though issues of food security, political stability, communicable

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diseases, natural disasters and other key issues take priority in agendas of government and media of African countries, however, there is an inadequate understanding of the importance of food safety.

The term "Safe Food" implies food that is free from physical (such as dirt, stones, leaves or other foreign objects), chemical (such as detergents, heavy metals, naturally occurring toxins and environmental pollutants) and biological (such as bacteria, viruses, parasites, pests and prions) hazards.

In other to sustain life and promote good health, accessibility to adequate amounts of 'safe' and nutritious food cannot be overstated as foodborne/waterborne illnesses which have been reported to kill up to 2 million people per year have resulted in impairment of socioeconomic development (WHO, 11/2014). This drastic decline in socioeconomic development caused by foodborne diseases is clearly evident in the Ebola virus disease epidemic as there has been severe strain on health care systems in affected countries which also necessitated international food and health care interventions and bans on tourism and trade through closures of country borders, air space and markets, prohibitions on consumption of traditional sources of protein, possibility of devaluation in currency, restriction in movement for fear of contracting the disease and a host of other negative impact caused by the outbreak (WHO, 11/2014 and ACAP, 10/11/2014). Viral infections that have been implicated in foodborne/waterborne related outbreaks include; genera *Norovirus* and *Sapovirus*, genus *Enterovirus*, genus *Hepatovirus*, Genus E virus, *Hepatitis Astrovirus*, genus *Rotavirus*, and family *Adenoviridaenovo*. Other viruses transmissible via food include: genus *Arenavirus*, genus *Flavivirus*, genus *Hantavirus*, Foot-and-Mouth Disease virus *and Aichi* virus (WHO, 10/2014 and Varisckova, Dvorska, Lorencova, and Pavlik, 2005).

This paper gives a brief insight on Ebola virus; the disease, transmission, mechanism of action, effect on animal/public health and recent advancements in control and also evaluates the food safety systems including policies and measures available in the affected countries and how they may be improved to prevent future outbreaks.

II. EBOLA VIRUS (EBOV): BRIEF HISTORY, MECHANISM OF ACTION AND RECENT ADVANCEMENT IN CONTROL

Ebola virus (EBOV) of the family filoviridae has over the years been linked to intervallic occurrences of fatal haemorrhagic fever in Central Africa with the most recent outbreak in West Africa, although there have also been transported cases to the United States and Spain. The first outbreak caused by the virus was reported in the Democratic Republic of Congo in 1976. The mortality rate of the virus has been reported to range from 50% to 90% although new specie of the organism found in Uganda has a lower fatality rate of about 25% (Giebert et al., 2010, Pandey et al., 2014, and ECDC, 2014). The five main species of the virus that have been identified include: *Zaire EBOV, Sudan EBOV, Reston EBOV, Tai EBOV and Bundibugyo EBOV*. EBOV is transmitted via contact with bodily fluids (i.e. blood, sweat, vomit, semen, secretions, breast milk etc), tissues and organs of both dead and living persons and animals with an incubation period of 4-10 days but could vary from 2-21 days (Lewnard et al., 2014 and ECDC, 2014). It can also be transmitted via direct contact with skin of an infected person, although there is a lower risk of developing infection through this type of exposure as compared to that of the bodily fluids.

Although EBOV released into the air has shown a high infectious rate on rodents and non-humans in experiments, there has been no proof of human infection with the virus via inhalation from the environment (Bray and Chertow, 2014).

The preliminary symptoms of the EBOV include fever, malaise, myalgia and headache after which symptoms such as: pharyngitis, vomiting, diarrhoea and maculopapular rash follows. Haemorrhagic diathesis and multiple organ dysfunction follows during the fatal stage of the disease (Pandey et al., 2014).

The virus can stay alive in liquid or dried material for some days. UV radiation, gamma irradiation, heating for 60 minutes at 60 °C or boiling for five minutes, sodium hypochlorite and disinfectants have all been found to inactivate the organism. Refrigeration and freezing, on the other hand has been shown to be of non-effect on the virus (ECDC, 2014).

The length of the EBOV genome is about 19000 nucleotides long. It is an encapsulated single-stranded negative RNA that encodes seven structural proteins: nucleoprotein (NP), polymerase cofactor (VP35), (VP40), GP, transcription activator (VP30), VP24, and RNA polymerase (L) and one non-structural protein (GP) (Nanbo et al., 2013).

Research has shown that cells infected with EBOV escape destruction by the immune system as a result of steric shielding and functional inactivation of certain surface proteins of the cells it infects leading to a continued propagation of the virus (Francica et al., 2010).

The human immune response to viral infections is normally triggered by the recognition of infected cells that invade the genetic replication process to produce more copies of themselves after which the cell undergoes necrosis and releases the new viral replicates that infect other cells (Bray and Chertow, 2014). The EBOV have however developed an unknown mechanism to prevent normal immune response by repressing proteins that are critical for immune recognition. The inability of the immune system to recognize infected cells hinder the destruction of such cells by the immune system and consequently the virus. EBOV infected cells showed a reduced number of cell surface proteins when analysed using flow cytometry, however, using the western blot technique there were no observed notable changes in levels of protein. These observed discrepancies have been speculated to be either as a result of over detection of non-present proteins by the western blot technique which has been deemed very unlikely or non-detection of relevant proteins by the flow cytometry technique which is most likely. Subsequent analysis using flow

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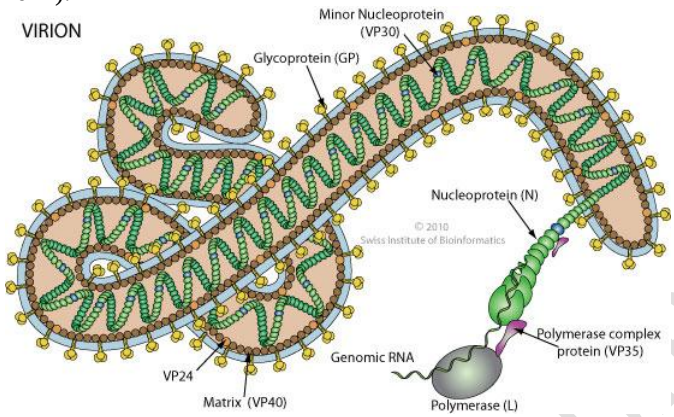
cytometry carried out on the infected cells that underwent standard histological treatment which causes permealization of the cell membrane showed the sterically shielded cell surface proteins that were initially undetected. Once entrance is gained into the system, it is disseminated to regional lymph nodes, the blood stream, dendritic cells and fixed and mobile macrophages in the liver, spleen, thymus and other lymphoid tissues.

Extensive tissue damage observed in infected animals is evidence that endothelial cells, fibroblasts, hepatocytes, adrenal cortical cells and epithelial cells are infected (Bray and Chertow, 2014).

Gastrointestinal dysfunction (which can be caused by either infection of the tract or circulating cytokines), systemic inflammatory response (which occurs through the release of cytokines, chemokines and other pro inflammatory mediators), coagulation defects (induced by the inflammatory response of the host) and impaired adaptative immunity are the typical conditions observed in infected persons (Bray and Chertow, 2014).



Source: http://conorhearn.com/the-deadly-ebola-virus/
Figure 1: The Ebola Virus Structure

ADVANCEMENT

Researches on ways to curb the EBOV epidemic has been on-going since its most recent outbreak and certain promising advancements have been made. Giesbert et al. (2014), were able to completely protect guinea pigs that have been exposed to fatal doses of ZEBOV by using small interfering RNAs (siRNAs) to target the virus' RNA polymerase L protein formulated in stable nucleic acid-lipid particles (SNALPs). These findings indicated that RNA interference could potentially be used as a treatment for EBOV infected people as well as for other emerging infections caused by viruses.

Johansen et al. (2013), carried out in vitro screening of Food and Drug Administration (FDA) and ex US – approved drugs with selected molecular probes so as to detect drugs that possess antiviral capabilities against ZEBOV and it was discovered that certain selective estrogen receptor modulators (SERMs) such as clomiphene and toremiphene effectively inhibited EBOV infection in mouse when tested in vivo. It was then suggested that these SERMs can be repurposed for treating infections caused by filoviruses.

Cocktails of monoclonal antibodies have also been proven by recent research to be efficient for the prevention of morbidity and mortality in non-human primates after 1-2 days of post exposure to EBOV. The result revealed that 43% of the post exposed animals survived the challenge (Pettitte et al., 2013).

Zmab administered in combination with adenovirus-vectored interferon α (Ad-IFN) showed an efficacy of up to 75% in cynomolgus and 100% in rhesus macaques after detection of viremia at 3 dpi, which was an improvement as compared to the 50% efficacy observed when Zmab was used alone for the treatment of (NHP) (Qui et al., 2013).

Zmapp has also been administered in humans with 100% efficacy.

Cohen and Kupferschmidt reported that an American freelance camera man infected with EBOV was preliminarily treated by administering intravenous replacement of fluids and electrolytes and antibiotics to treat secondary infections and medications to reduce diarrhoea and vomiting. Further treatment was carried out by using serum from EVD survivor containing antibodies together with brincidofovir (a drug that was produced to combat other viral infections but has shown efficacy against EBOV in vitro). The patient recovered although the actual cause of recovery could not be verified since the patient was given multiple experimental treatments all at once. Table 1 shows some medications undergoing development for the treatment of EBOV.

TKM – Ebola which is one of the drugs under development has been observed to have side effects such as triggering over production of certain dangerous inflammatory hormones called cytokines which is a response also triggered by the EBOV.

Favipiravir (influenza medication) also showed potency against Ebola when tested on mice after six days post exposure to infection. The mice used were genetically engineered to lack immune response against viruses (Cohen and Kupferschmidt, 2014).

Researches in areas of rapid diagnostic tests for EBOV aside the polymerase chain reaction (PCR) molecular test and ELISA as reported by Vogel et al 2014, includes Senova and Corgenix rapid diagnostic test kits.

The later test works by direct collection of blood from a finger-prick onto one extreme of the test strip followed by the addition of a disinfecting chemical solution to prepare the sample for the test. The sample then travels through the strip which contains dye-tagged antibodies that attach to a specific protein of the EBOV. A second antibody latches onto the antibody-virus complex showing a dark line which is indicative of infection as the sample travels up the strip. In the former test, a mini pipette is used for collection of blood sample from a pricked finger followed by mixing it with the disinfecting chemical solution before application to the strip. Every other step in the test is similar to that of the corgenix test. The availability of a reliable and affordable rapid diagnostic test would go a long way in the early detection and treatment of the virus which would invariably lead to reduced transmission, quicker treatment before onset of symptoms, ease of traceability and better control of the virus in general.

Pandey et al. 2014, developed a stochastic model of EBOV transmission and discovered that in order to reverse the continuous exponential increase of the epidemic, a collective approach of case isolation, tracing and quarantine of contact and hygienic burial practices must be urgently effected.

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Four main rapid diagnostic tests have only been recently approved by WHO for use in the affected countries. These are namely; Real star Filovirus Screen RT-PCR kit 1.0, antigen rapid test kit Re EBOV™, Lifeviver™ Ebola virus real-time RT-PCR kit, and Xpert Ebola Test (WHO, 2015).

An estimated fifteen (15) vaccines are currently undergoing development in North America, Europe, Russia and China. VSB-EBOV and ChAd 3-ZEBOV are the two most advanced ones yet. Johnson and Johnson also developed a prime boost regime of Ad26- and MVA-EBOV. Novavax – a biotech company also developed a recombinant particle made of EBOV glycoprotein produced in tobacco plants (WHO, 2015).

Substance	***Producer***	***Function***	***Result of trials***
TKM-Ebola	*Tekmira Pharmaceuticals (Vancouver, Canada)*	*RNA inhibitor in lipid nanoparticle*	*Solid protection in monkeys*
ZMapp	*Mapp Biopharmaceutical (San Diego, California)*	*Ebola antibody cocktail*	*Solid protection in monkeys*
Brincidofovir	*Chimerix (Durham, North Carolina)*	*Small molecule with broad antiviral activity*	*Blocks Ebola in test tubes*
AVI-7537	*Sarepta Therapeutics (Cambridge, Massachusetts)*	*Antisense oligonucleotide that cripples Ebola mRNA*	*Partial protection in monkeys*
Favipiravir	*Fujifilm (Tokyo)*	*Small molecule; influenza drug. Broadly targets RNA polymerase enzyme*	*Solid protection in mice*
Convalescent serum	*None*	*Antibodies recovered from blood or plasma*	*Failed in monkeys; may have helped patients' in small human study*

Source: Cohen and Kupferschmidt, 21/11/2014

Table 1: Substances presently under development for the treatment of Ebola

III. EFFECTS OF EVD ON ANIMAL AND PUBLIC HEALTH

EVD has been considered as a zoonotic disease since it is an infection that is easily transmissible from vertebrate animals to people. Zoonosis can be triggered by various microorganisms including viruses. Certain species of fruit bats in Africa are believed to be the natural reservoirs for EBOV. Infection could be transmitted to other animals via close contact with tissues, organs, or body fluids of living or dead bats. At risk animals include non – human primates, antelopes, shrews, porcupines, agouti and other rodents which are popularly eaten as "bush meat" in Africa. This source of protein is considered as a treat to some and a main source of food to others. Once the infection is transmitted to a human, it can easily spread from human to human (LaMorte, 2014 and CDC, 2014).

Concerns have arisen recently on the transmissibility of EBOV from pets to humans. A research carried out by Allela et al. (2005), showed that 57 out of 337 samples collected from dogs in EBOV epidemic area that had been exposed to the virus via consumption of infected dead animals, contained EBOV immunoglobulin G (IgG). The study suggested that there is a possibility of dogs getting infected by the virus, though the alleged infections were asymptomatic.

Although according to AVMA (2014), there has been no evidence of dogs or cats becoming sick with the virus or possibly transmitting the virus to humans and animals, it is however, important to note that dogs and cats are also eaten as a source of meat in some African cultures.

There is currently no approved routine testing for EBOV in pets (AVMA, 2014).

According to UNICEF (2015), many children have suffered loss of one or both of their parents as a result of the EBOV outbreak. Due to the unprecedented scale of the outbreak, the affected countries have suffered; devastated health care systems, loss of education, and social structures that are distressed. Table 2 and figure 2 below shows the EBOV reported cases and deaths in the 2014 EVD affected African countries.

Countries	**Cases**	**Deaths**
Guinea	3652	2429
Liberia	10666	4806
Sierra Leone	12827	3912
Mali	8	6
Nigeria	20	8
Senegal	1	0

Excerpted from: http://apps.who.int/ebola/ebola-situation-reports

Table 2: WHO Ebola Situation Report Data up till 31st of May 2015

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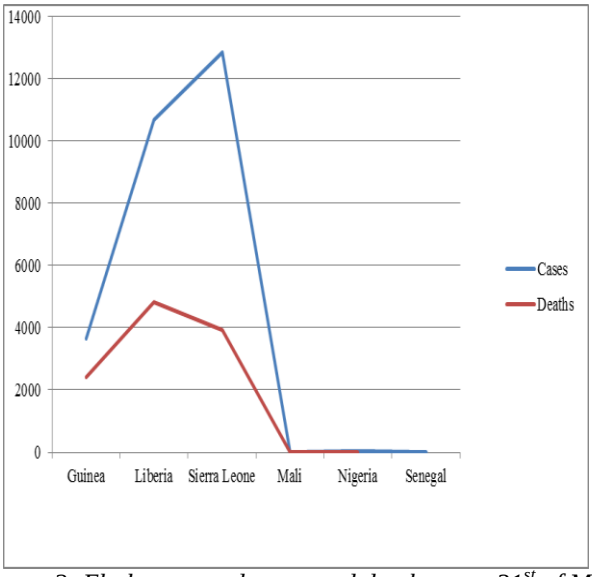

Figure 2: Ebola reported cases and deaths as at 31st of May 2015

IV. ROLE OF EVD IN IMPAIRMENT OF FOOD SECURITY

According to ACAPS (2014), the real extent of EVD outbreak is underrated due to the number of registered cases and mortalities. The three main countries affected by the epidemic have an estimated number of 22 million people that are at serious risk of food insecurity resulting from the aftermath of the epidemic.

An additional estimated 173 million people in Nigeria could have also been exposed to this risk if not for the prompt precautionary measures taken by the government to quickly curtail the spread of the virus.

The most agriculturally buoyant areas of Guinea, Liberia and Sierra Leone were the most affected which could lead to a protracted negative impact on the livelihoods and economies of individuals (ACAPS, 2014).

The situation reports from these areas have brought to light the following issues:

- ✓ Reduced levels of crop production and labour availability.
- ✓ Restrictions on movement as a result of official and self-imposed curfews.
- ✓ Reduced purchasing power resulting from inflation in food prices in some areas.
- ✓ Trade restrictions.
- ✓ Restricted access to devastated areas due to logistical, monetary and climatic constraints.
- ✓ Inadequate intervention response from international sources aimed at the containment of the epidemic.

All of the above stated prevailing issues have been highlighted by FEWSNET (08/10/2014) to be the driven forces of food insecurity.

According to FAO (05/09/2014), there is an anticipated down plunge in local produces due to the abandonment of farms and food stock by farmers in the most affected areas, as they migrate to areas that are perceived to be safer from EVD transmission. This may lead to endangerment of the food security of an enormous population of people.

V. COMPARATIVE ANALYSIS OF FOOD SAFETY SYSTEMS IN AFFECTED COUNTRIES

Food safety is critically essential to Africa as a result of its aggravating impact on food insecurity (FAO/WHO, 2005). Some of the impact of inadequate food safety measures includes food borne illnesses that contribute to the following: reduced productivity of workers, disability and even untimely death leading to reduction in income and food accessibility. Foodborne illnesses are a key factor that contributes to human suffering in the African region. Measures targeted at the improvement of food safety results in reduced food losses and increased food availability. Furthermore, international trade opportunities are open to countries that are able to enforce food safety, consequently leading to a rise in income levels. In Africa, inaccessibility to safe food, low levels of income, and a sense of injustice in trade issues are important contributory factors in increased political turmoil which further emphasises the importance of food safety for the African region (FAO/WHO, 2015).

The food safety systems in most African countries have however, been reported to be generally weak, fragmented and inadequately coordinated (FAO/WHO, 2015).

The tables below compares the food laws, enabling regulations/ministries, departments and agencies, food safety awareness, capabilities, codex memberships and notifiable foodborne diseases involved in the 2005 to 2014 EBOV affected countries.

Country	***Legislation***	***Ministries, Departments and Agencies involved in enforcement and monitoring***
Congo, DR	*Decree no.364 of September 2000 establishing the list of the authorized additives in the fishery sector*	
Guinea	*Decree D/2003/4/PRG/SGG on the establishment of a national commission on food safety and quality (CNSSA)*	*CNNSSA*
Liberia	*N/A*	
Mali	*Decree n°01-175/pm-rm on capacity building against poverty*	*Ministry of Agriculture, Ministries of Heath, Trade*
	Decree n°00-183/p-rm on the ruling of the public services of the water for consumers	*Ministry of Public Health*
	Counterfeit and Fake Drugs and Unwholesome Processed Food Decree, (Act No. 25 of 1999)	*Federal Ministry of Health*

Nigeria		
	National Agency for Food and Drug Administration and Control (Amendment) Decree 1999 (No. 19 of 1999)	*Food and Drug Agency*
	Food and Drugs (Amendment) Decree 1999 (No. 21 of 1999)	*Food & Drug Administration & Control (NAFDAC)*
	National Agency for Food and Drug Administration and Control Decree 1993 (No. 15 of 1993)	*Standards Organization of Nigeria (SON)*
	Public Health Ordinance Cap 164 of 1958	*National Codex Committee*
	The Standards Organisation of Nigeria Decree, No. 56 of 1971	*Standards Organization of Nigeria (SON)*
	The Animal Disease Control Decree, No. 10 of 1988	*Federal Ministry of Agriculture*
	The Marketing of Breast Milk substitute Decree, No. 41 of 1990	
	Others	
Uganda	*Public Health Act, 1964*	*Ministry of Health, Tourism, Trade & Industry*
	Plant Protection Act 1962	*Ministry of Agriculture, Animal Industry & Fisheries*
	Fish Quality Assurance Rule	*Uganda National Bureau of Standards*
	Import/Inspection of Clearance Rules, 2002	*Uganda Revenue Authority (Chemist)*
	Standard Act, 1983, Registration on Food	*Establishment Ministry of Agriculture*

Table 3: Food laws, regulations and ministries in the 2005 to 2014 EBOV affected African countries

Country	***Food Standards System***	***Inspection Mechanism***	***Laboratory Support Services***	***Capability of Food Industries to Provide Safe Food***
Congo, Demo. Rep.	*N/A*	*N/A*	*N/A*	*N/A*
Guinea	*Technical Commission for Agricultural and Food Standards coordinates all actors involved in elaborating Food standards.*	*N/A*	*Requires strengthening*	*N/A*
Liberia	*N/A*	*N/A*	*N/A*	*N/A*
Mali	*N/A*	*N/A*	*N/A*	*N/A*
Nigeria	*N/A*	*N/A*	*N/A*	*N/A*
Sierra Leone	*Established NCC is to handle standards development in connection with the SLBS. Adopting Codex standards as national food standards.*	*Standards Bureau to start import and export and certification procedures in February 2005.*	*Rudimentary laboratory support service by the Public Health Laboratory. No Accreditation.*	*No established system for building capacity*
Uganda	*A fairly good system in place*	*Established system for imports clearance, including food*	*Food laboratories of UNBS provide basic lab support. The Microbiology Lab is accredited for selected tests.*	*As a result of the ban on fish exports to EU in 1997&2000, the fishing industry has been assisted to develop the capacity to meet the safety requirements of the market*

Table 4: Food standards systems and food safety capabilities of the 2005 to 2015 EBOV affected African countries

Country	***Creation of Food Safety Consciousness among Consumers***	***Information Network on Food Safety***	***Coordination of Food Safety Activities at the National Level***	***Membership in Codex and establishment of National Codex Committees (NCC) and National Codex Contact Points (NCCP)***	***Notifiable food-borne diseases in the African Region***	
					Food-borne diseases	***Incidence of diseases***
Congo DR	*N/A*	*N/A*	*N/A*	*Member. Ministry of Agriculture serves as NCCP*	***N/A***	***N/A***
Guinea	*Two consumer associations, ALCO and HYCOV are active in NCC.*	*N/A*	*A National Food Safety Commission has existed since 2003 but is not yet functional because of a lack of funds. Activities are poorly coordinated.*	*Member. The National Standardization and Metrology Institute (INNM), serves as the NCCP. Requests assistance in establishing a NCC*	*Diseases caused by: Staph. aureus, Salmonella, Shigella & Bacillus cereus*	*Cholera:44 %;*
Liberia	*N/A*	*N/A*	*N/A*	*Member- Ministry of Commerce serves as NCCP.*	*N/A*	*N/A*

Mali	*N/A*	*N/A*	*N/A*	*Member. Ministry of Health serves as NCCP.*	*N/A*	*N/A*
Nigeria	*Consumer Protection Council is an active member of the NCC and educates consumers.*	*N/A*	*N/A*	*Member. NCC was re-activated in August 2000, with representation of all identifiable stakeholders. Technical sub-committees have been established, and plans are being made to strengthen and empower the NCC and the NCCP. The Standards Organization of Nigeria is the NCCP and also the Secretariat of the NCC, chaired by the National Agency for Food and Drug Administration and Control.*	*Diseases caused by Salmonella, Botulinum, Shigella, Listeria, pesticides and natural toxins*	*No data*
Uganda	*Two consumer associations are active in NCC and undertake some consumer training and advocacy.*	*No Network exists*	*National Food Safety Strategic Plan has been drafted to support the stakeholders in implementing the proposed Food Safety Law.*	*Member. NCCP located in National Bureau of Standards. NCC established in June 2002 comprising Government ministries, the industry and trade associations, academia, research institutions, and consumer organizations.*	*N/A*	*N/A*

Key: N/A = Not available
Excerpted from: FAO/WHO2005

Table 5: Food safety awareness, codex memberships and notifiable foodborne diseases in the 2005 to 2014 EBOV affected countries.

VI. POSSIBLE CONSIDERATIONS FOR IMPROVEMENT

Below are some recommendations to be considered for the improvement of food safety/security and public health management systems in the affected African countries:

- ✓ Food safety should be made a public health priority of governments in the EVD affected countries as they are fundamentally responsible for the establishment, improvement, and implementation of policies, regulatory frame works and food safety systems that are effective in order to enable effective prevention, early detection, and timely response to unsafe food related threats to public health(http://www.who.int/mediacentre/factssheet/fs399/en/).
- ✓ Substantial investments should be considered on research and infrastructure aimed at developing African scientists and health personnel to effectively prevent, manage and respond to public health epidemic to reduce potential damage of exponential magnitude as seen during the EVD outbreak instead of depending majorly on foreign interventions for management and control of such situations.
- ✓ Training to significantly improve knowledge, behaviour and attitude of individuals to food safety and security should not be limited to academic institutions only. Effective training programs (e.g. seminars/workshops) which focus on educating rural populations of the EVD affected African countries should be considered from time to time on issues of food security and food safety.

VII. CONCLUSION

Most of the EVD affected countries have one or more food safety management systems in place at the national level. However, in the face of the unprecedented scale of the Ebola epidemic that occurred between 2013 and 2014, the degree of ineffectiveness of these management systems was exposed alongside weaknesses in the health care systems of these African countries. There has been an enormous dependence on international intervention to help manage the challenge. Whilst many foreign bodies have contributed in one way or the other to helping Africa fight this deadly disease, urgent attention needs to be given by the affected countries to investing in disease containment/ isolation facilities, research, training and retraining of health personnel. It was evident in the situation report of the affected countries that a lot of transmission occurred from patient to medical personnel as a result of non-availability or improper use of protective gears. EVD has tremendously lowered the already brittle state of food security as a result of: labour loss due to mortality thereby leading to reduction in household income; national, international and self-imposed restrictions on population movement; trade restrictions; border closures; and reduced access to some of the most agriculturally productive regions as they were the most devastated. Promising advancements have been made in the areas of development of rapid diagnostic tests and experimental treatments in order to eradicate the EVD epidemic.

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