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ABSTRACT

The outbreak of Ebola virus disease (EVD) that raged between 2014 and 2016 in the West African sub-region was one of the global epidemics that spiked international public health concern in the last decade. Since the discovery of ebolavirus in 1976, the 2014-2016 epidemics have been the worst with significant case fatality rates and socioeconomic impact in the affected countries. This review looks at important health determinants that directly accounted for the spatial events of rapid spread and severity of EVD in West Africa, with consequent high fatality rates. It also brings up a time-point health determinant model to conceptualize understanding of this important outbreak with a view to enlightening the public and providing valuable recommendations that may be crucial to preventing or curtailing any future outbreak of the disease.

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Introduction

Ebola virus disease (EVD) also known as viral hemorrhagic fever and hereinafter referred to as Ebola, is a rare but deadly illness which primarily occurs as a result of the transmission of a deadly ebolavirus from wild animals particularly fruit bats, to human pop-
Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Population</th>
<th>Cases</th>
<th>Death</th>
<th>Case Fatality Rate, CFR (%)</th>
<th>Incidence Proportion Per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>&quot;DR Congo&quot;</td>
<td>73,767,447</td>
<td>66</td>
<td>49</td>
<td>74.2</td>
<td>0.09</td>
</tr>
<tr>
<td>2014</td>
<td>Nigeria</td>
<td>176,404,302</td>
<td>20</td>
<td>8</td>
<td>40</td>
<td>0.01</td>
</tr>
<tr>
<td>2014-2015</td>
<td>Mali</td>
<td>16,934,214</td>
<td>8</td>
<td>6</td>
<td>75</td>
<td>0.04</td>
</tr>
<tr>
<td>2014-2016</td>
<td>&quot;Sierra Leone&quot;</td>
<td>7,328,834</td>
<td>14,124</td>
<td>3,956</td>
<td>28</td>
<td>192.7</td>
</tr>
<tr>
<td>2014-2016</td>
<td>&quot;Liberia&quot;</td>
<td>4,243,000</td>
<td>10,675</td>
<td>4,809</td>
<td>45</td>
<td>251.6</td>
</tr>
<tr>
<td>2014-2016</td>
<td>&quot;Guinea&quot;</td>
<td>11,738,441</td>
<td>3,811</td>
<td>2,543</td>
<td>66.7</td>
<td>32.5</td>
</tr>
</tbody>
</table>

Key: *Countries that experienced widespread transmission.

Overall, no less than 20 Ebola outbreaks with about 1,743 reported human cases were recorded in Africa, between 1977 and 2014 [2]. However, an outbreak which began in late 2013 (but spread widely between 2014 and 2016) was the largest and first outbreak that reached epidemic level and it involved a few West African countries (see Table 1). This outbreak was the deadliest and it prompted international public health concern by August of 2014. It resulted in over 28,600 laboratory confirmed cases and nearly 11,300 deaths within a short period in the three worst affected countries – Guinea, Liberia, and Sierra Leone and an economic cost of about $4.3 billion US Dollars [2,7]. Another report documented the death of many health workers in Guinea, Liberia and Sierra Leone [8]. It is important to mention that apart from these epicenters of the disease, minor outbreaks also occurred in other West African countries including Nigeria, Mali and Senegal.

Nigeria recorded the first case of Ebola in July 2014 when an infected Liberian-American flew into Lagos, a highly populated city in the southwest region of the country. Following this, a nurse who attended to the Liberian later died after contracting the disease [9]. Ebola briefly spread to other cities before Nigeria undertook a frantic effort to forestall further spread. Altogether, Nigeria recorded 8 deaths out of 20 cases of Ebola. Four health workers (50% of all infected) were among those that succumbed to the infection. The effort at curtailing the spread of Ebola in Nigeria was regarded as a spectacular success, according to the WHO’s representative who finally declared Nigeria free of Ebola in October 2014, exactly 4 months after the first case was reported. Nigeria became the first African nation to be officially confirmed Ebola free [10,11]. Apart from Nigeria, Mali and Senegal also had a few cases, 8 and 1, respectively [2].

Although, the 2014-2016 Ebola epidemics were initially believed to be caused by Zaire ebolavirus [12], investigations later linked this outbreak with two viruses, Sudan and Zaire ebolaviruses [1]. In addition, far from West Africa, cases of Reston ebolavirus were linked with monkeys imported to the United States from the Philippines [1]. Even though, the 2014-2016 Ebola epidemics appears to have fully put under control, yet since 2016, cases of Zaire ebolavirus have not ceased to occur. In 2017, 8 cases and 4 deaths of Ebola were reported in Likati town, D.R Congo. Again, in 2018 34 cases and 33 deaths were recorded in Bikoro, another town in D.R Congo. Worse still, during 2019, Ebola cases were still being reported in both D.R Congo and Uganda despite several interventions by international aid agencies [2].

Outbreaks of Ebola Virus in Africa: Epidemic Timeline and Impacts

Ebola virus was first documented in 1976, with two concurrent outbreaks in Nzara town, South Sudan (Sudan ebolavirus) and Yambuku town, the neighborhood of a river called Ebola river in D.R Congo (Zaire ebolavirus). Following these cases, within some weeks of the first incidence, about 318 Ebola cases were reported with a fatality rate of 88% [6]. In 1994, another 52 cases of Zaire ebolavirus were reported in Mekouka town, Gabon, with 31 deaths recorded. In the same year, one case of new specie (Taire Forest ebolavirus) was recorded in Côte d’Ivoire, although it was later successfully treated.

Ebola and Other Infectious Diseases: Differential Diagnoses

Ebola is commonly associated with high death risk which is largely due to the severity of body fluid loss and dehydration, leading to hypovolemic shock on account of low blood pressure. It is noteworthy that low blood pressure is generally associated with clinical symptoms such as diarrhea and vomiting in other infectious diseases, like cholera [12]. Other symptoms of Ebola include fever, sore throat, muscular pain, and headaches and these are all common early signs and symptoms of Ebola (from first few days up to first three weeks after ebolavirus infection) but are also common.
with other health conditions. Hence, it is important to note that body rash and internal and external bleedings (haemorrhages) are important symptoms of EBOV that help to differentiate it clinically from other infectious diseases, such as meningitis, malaria, typhoid fever, and cholera [12]. Confirmatory diagnosis of early infection with ebolavirus may involve testing for viral RNA and assays for Ebola-specific immune antibodies, to urgently save the patient and the public from the spread of the disease.

The Key Health Determinants Associated with High Mortality Rate of 2014-2016 West African Ebola Epidemics

Generally speaking, a number of factors could determine the rapid spread of Ebola in several African populations. These factors may include social and economic factors, poverty, malnutrition, poor sanitation, intercurrent diseases, individual health status, health literacy, and other education-related factors, among others. In the 2014-2016 West African epidemics, some of these factors were prevalent and occurred concurrently with others that are well established, to determine the transmission, spread, and outcomes such as degree of morbidity and mortality rates. These factors can be categorized as micro- and macro-determinants and modeled into a conceptual prism to indicate how they interconnect, for a better understanding of the epidemic (see fig.1). Critical health determinants, which militated against the control of 2014-2016 Ebola outbreaks, are discussed below;

Medical Attention and Government Policy: Combinatorial Effects

Ebola is an emergency that requires quick and urgent reactions. It was in reverse that many western African countries where the epidemics of Ebola struck really lacked rapid response and were aback from the use of adequate resources to combat the emergency. In addition, majority of these countries had relaxed immigration policies which worsened the spread across the regional boundaries, apart from common vector-agent migration [2,13].

Nigeria, though abundant in vector agents of Ebola never experienced any case between 1976 and 2014 when there were consistent records in the neighboring West African countries [14]. The disease was eventually imported by an infected individual who traveled from Liberia, without any evidence of adequate screening of his health status at the port of entry in Lagos. However, the public health system involving Emergency Operations Center, National Public Health Institute and Incident Management System had been in place two years before the epidemic of Ebola struck. Nigeria had earlier declared public health state of emergency against polio, another viral disease, and the structures and mechanisms that were in place already were promptly activated in mitigating the spread of Ebola within the country [6,13]. In other words, rapid health interventions, healthcare quality, political commitment, operational and strategic changes helped Nigerian public health system with Emergency Operation Centers and Incident Management System, among others, and greatly contributed to the rapid response to Ebola and its effectiveness. This limited the epidemic to twenty cases, as established from the laboratory results of confirmatory tests performed on the suspected victims (Table 1). In addition, it restricted the increase and spread of the virus due to stable public health institutions, apart from the rapid interventional method [13].

Notwithstanding, the epidemic itself was not without any consequence. Despite the apparent quality health and rapid intervention, apprehension of Ebola led to misconceptions in some parts of the country. The fear of Ebola and poor health education resulted in various health problems and challenges, down to self-prescribed preventive measures such as the drinking and bathing with salty water, among others [15]. It was indeed an aftermath of the Ebola threat that predisposed many Nigerians to hypertension, cardiac challenges, and kidney problems, and worsened the plight of those that were on dialysis. Furthermore, many Nigerians, particularly those residents in the rural areas, failed to adhere to government and expert recommendations against contracting the disease, even though public campaigns were intense.

In contrast to the health systems in Nigeria, those in some other western African countries including Sierra Leone, Liberia and Guinea, were inadequate and the few functional health systems that were crucial to preventing the spread of Ebola failed to perform optimally. Health workers, particularly the skilled ones, were also insufficient in number [16]. Government infrastructure, government-enforced quarantine, health record, and drug supply were practically inadequate [16]. In addition, government response which was expected to be central to reducing the rate of transmission and preventing the spread of Ebola, was weak in many West African countries [17,18].

An important micro-determinant of the rapid and extensive spread of Ebola in West Africa was the occurrence of the infection in medical settings. Such infections otherwise termed nosocomial infections were largely due to failures in established procedures of infection control and breach of standard barrier precautions [19,20], attributable to poor safety orientation, inexperience and lack of skilled workers, and poor financing of healthcare systems and infrastructure. These inadequacies may be attributed to poor government policies, poor medical attention, and weak economic state of almost all of the affected countries (fig. 1).

Social factors

Social factors, such as culture, tradition, and occupational hazard also played significant roles in the spread of 2014-2016 Ebola outbreaks in West Africa. According to a report, many people through attendance of funerals in Sierra Leone contracted the disease and helped in the spread to their families and friends [21]. Similarly, in Guinea, traditional burial method which is a common practice in which dead bodies are washed and touched unprotected or sometimes unsuitably protected, resulted in the spread of Ebola and the high death rates recorded [22]. The modern practice of embalment of corpses could also have contributed to the spread of Ebola in parts of West African countries [23]. Occupational risks also contributed to the increased Ebola mortality rate and was the main risk of transmission of the virus to healthcare workers who attended to Ebola patients [23]. The imported case of Ebola in Nigeria was first transmitted by the attending nurse who later died [11]. It is believed that some occupations are more contributory to the transmission than the other. Although, the risk becomes higher when proper use of the protective, such as gloves, masks, and eye-protection is disregarded, as was the situation in many of the African countries where the disease struck [24]. In other words, one may conclude that social factors including occupational hazard and safety failures involving the use of personal protective equipment were instrumental to the rapid and widespread transmission of Ebola in West Africa, 2014-2016 (fig. 1).

Seasonal and Climatic Factor

It has been reported that the annual dry season, which runs between December to May (longest period of the year) is a breeding season for fruit bats, a reservoir of ebolavirus with high potential to replicate and thus enhances transmission [25]. An increase in the number of bats (species) is said to influence viral load and interspecies fighting which may both enhance viral transmission. It is believed that a favourable climate indirectly leads to more spillovers from swarming Ebola reservoirs and may also force inter-
Fig. 1. A Model of Eight Cardinal Health Determinants Associated with Epidemic of Ebola Outbreak in West Africa from 2014 to 2016. (A: Determinant categories; B: Macro-determinants; C: Micro-determinants).

Fig. 2. Effect of Climatic Changes and Human Activities on Ebolavirus Transmission.
action of the bats with other wildlife species, especially under high forage and wildlife distributions [25]. Ebola is mainly found within 10^- equator where the climatic condition in conjunction with other factors, favoured the intensity of spread of the virus from 2014 to 2016[26]. Another factor is human activities such as, deforestation. Habitat destruction through human activities such as tree felling, bush clearing and burning, could lead to the wider dispersion of wildlife reservoirs of Ebola. This coupled with the usual practice of hunting of wildlife animals(Fig. 2).

**Physical Environment**

Physical environment is an important determining factor in the spread of ebolavirus. It may include closeness of residential sites to the harbouring forest where wildlife with potential influence of transmission are located. Aside from location as a determinant of Ebola transmission, residential quality is a possible enabling determinant for the spread of ebolavirus (Fig. 1). It is reported that poor structural housing quality, poor access to safe water, overcrowding, sanitation, and insecure residential status, among other infrastructural inadequacies are favourable stimuli for transmission of Ebola. Again, data shows that outbreaks of Ebola took place in rural and among the geographically isolated populations riddled in poor residential quality [27].

In addition, interaction or closeness with animals, such as; animal petting and domestication are possible ways for animal-to-human transmission. Also, most times, different animals are found in the farm feeding on agricultural products and transmit the virus on leftovers. Although, there is a debate whether ebolavirus can be transmitted through food, ebolavirus can spread through ingestion of fruit already contaminated with ebolavirus-infected saliva or faeces of the reservoirs. Thus, some habits of local food processing or preservation such as open silos method or traditionally store silage in the rural areas could be a potential route of transmission (Fig. 1). In addition, fruit bat spillovers could also be a different route in transmitting the virus to other wildlife species (such as duiker, nonhuman primates) or even humans [28].

**Health Status and Human Biology**

Human biology and nutritional status are two important determinants that may determine the transmission of Ebola. It is understood that ebolavirus may remain protected from host immunity in the body by penetrating immune-privileged sites. In this way, some organs including testicles, eyes, fetus, placenta, among others, are immune-protected, and thus referred to as immune-privileged in the body. In other words, this means that they tolerate any inflow of antigens without eliciting immune response. This pathway is an opportunity for ebolavirus antigen to be free from host immunity and may be the reason why semen of male patients suffering from Ebola may subject them to high risk of transmission of the virus after recovery [29].

In addition, report (after follow-up) from the 2014 Ebola epidemic establishes that survivors who recover can harbour the viral RNA in their semen for minimum of 2.5 years, with high chance of transmitting the virus by sexual intercourse during that time [30]. This brings Ebola to the limelight of sexually transmission diseases. Keita and coworkers [31] reported that in Guinea, many survivors of Ebola were found with persistence of the viral RNA in semen (men) and breast milk (female) after several months.

**Individual risk behaviour**

Unfortunately, sexual violence and exploitation are common habits that pose high risk of transmission in the three major countries (Guinea, Liberia and Sierra Leone) with reported widespread cases [32,33]. Sexual exploitative relationship is a common basic means of survival among many people including the refugees for a long period of time, and it involves many agency staff like NGO’s workers. This is grossly attributed to poverty, and lack of livelihood option to survive. According to a report through a sexually exploited woman in Guinea, indiscriminate sexual involvement has no ugly meaning. Likewise in Liberia, another place with rampant spread of Ebola, sex-for-money activities are common practices [32]. Strong association between Ebola transmission and sexual behaviour has been reported [33,34]. Therefore, there is indication that persistent recurrence of Ebola in some of these notable West African countries could be as a result of viral persistence and sexual risk behaviour.

**Conclusion**

It is very obvious that many factors mitigated against the control of 2014-2016 Ebola epidemic, involving poverty, failed government policies, individual risk behaviours, poor health system, among others. In the hardest hit countries, the situation went downheartedly evoking economic impacts in spite of many international aids for logistic supplies and other response activities. Unfortunately, today Ebola outbreak remains unabated in some of these affected countries, although with limited resources. Importantly, evidences show that Ebola is a sexually transmitted disease and tend to persist long among the survivors, even after recovery, thus the chance of re-transmission is still highly probable especially with indiscriminate sexual activities. It is therefore important for every country involved to focus inwards on some health determinants associated with Ebola outbreak in other to eradicate the disease and to prevent future recurrence.

**Recommendations**

From the previous lessons of outbreaks in West African countries, some health determining factors may need to be addressed, to finally put the continual outbreak of Ebola to rest.

I As a policy tool and an important check-up, screening of immigrant health status with detailed health condition should not be taken for granted before visa approval, especially in an Ebola-free zone, not even within the region where visa is abolished. It is believed that a detailed health screening plan will prevent importation of deadly disease agents. Some viral diseases including Ebola, COVID-19, and others have become global health threats and causes for concern with high risk of morbidity and/or mortality rates through contact transmission. Thus, enforcing immigration regulation on detailed health screening policy will prevent case importation and forestall epidemic especially through the port of entry.

II Apart from enforcing immigration regulation, physical environment favouring the transmission of Ebola in West African sub-regions is an important factor to handle properly. In many areas, where there are flocks of vector-agent reservoirs in the neighbourhood, ecological interventions may be considered necessary to check and manage zoonotic pathogen spillovers. This may be achieved if the habitat is preconditioned unfavourable for the reservoirs and by disconnecting the food chain, particularly against the fruit bats that are common host for many viral pathogens, to prevent spillovers and transmission to other wildlife species.

III Also, to foster the degree of preparedness and prevention control, vaccination is an important measure that should be made available, especially in the prone areas where media campaign and other awareness programs may not totally prevent human risk behaviours. Likewise, funding of research on emerging
communicable viral diseases of much global concern including Ebola, and other haemorrhagic fevers such as Lassa fever, among other relatively neglected and under-reported diseases, should receive more attention in national budgets.

IV In addition, pathogens have been reported to be spread in the body through massive lymphohematogenous dissemination [35]. Ebolavirus is a blood borne pathogen and may as well be disseminated in the same way. There is high plausibility that body fluids may be affected in Ebola. Hence, detailed studies of the viral persistence in the vital body fluids such as semen and breast milk will be an important area to explore to assess the length of time in shedding the virus and the extent of detection of RNA in survivors, for preventive measures. In other words, neglecting survivors after recovery may be a ticking time bomb for resurgence. More so, blood transfusion involving survivors with recent Ebola experience should be disregarded. Therefore, knowledge of viral persistence in the body milieu and due follow-ups after recovery are considered key areas to prevent re-explosion and recurrent outbreaks.

V Moreover, improvement on emergency preparedness and response operations are vital strategies to prevent spread of Ebola and many similar diseases of public health concern, particularly when an incident is recorded. Of recent, reports show the level of emergency preparedness and response operations in Nigeria against COVID-19 [36] and polio [13], and how this has greatly helped Nigeria in combating the spread of COVID-19 through strategic response management and improved technical and human resources. An important area of emergency preparedness is provision of health facilities at every quarantine center. This will greatly help in rapid response to contain new case record. Similarly, emergence of new cases of Ebola in zero-record areas should be rapidly restricted from spreading while contact tracing should be immediately activated.

VI Furthermore, interrupting the chain or transmission pathways of ebolavirus would be an important target to combat the wild spread via preventive measures and surveillance approaches. By blocking the portals of entry and exit of the virus as well as preventing contact with body fluid of an infected patient, will help interrupting possible transmission.

VII In the meantime, Ebola should be treated as a sexually transmitted disease to prevent fruitless efforts from preventive interventions against other routes of transmission. The knowledge and awareness campaigns against indiscriminate sexual activities and with adequate follow-ups may prevent future resurgence from previous epidemics.

VIII Finally, training and retraining of public health and other health practitioners will expose them to better handling.

References
