Handbook of Global Urban Health

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Publication details
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Published online on: 20 May 2019

Accessed on: 24 Aug 2023

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AFRICAN CITIES AND EBOLA

Zacchaeus Anywaine and Ggayi Abubaker Mustapher

Introduction

Ebola virus disease (EVD), formerly known as Ebola hemorrhagic fever (EHF), is a severe viral illness caused by infection with one of the five known Ebola virus species (Zheng et al. 2015). The first cases of EVD occurred in 1976 in two simultaneous outbreaks, one in Nzara, Sudan (currently South Sudan) and the other in Yambuku, Zaire (currently the Democratic Republic of Congo (DRC)). The Zaire cases were mainly from Yambuku, a small village near the Ebola River, from which the disease takes its name. Similarly, the virus species have taken the names of places where subsequent outbreaks have happened, and these are: Zaire ebolavirus (ZEBOV), Sudan ebolavirus (SEBOV), Tai Forest ebolavirus (TAFV) (formerly known as Côte d’Ivoire ebolavirus), Bundibugyo ebolavirus (BEBOV) and Reston ebolavirus (REBOV). Of the five species, ZEBOV is the most pathogenic in humans, followed by SEBOV, BEBOV and lastly TAFV. REBOV is known only to be pathogenic to non-human primates (Feldmann and Geisbert 2011).

EVD is a zoonotic disease spread from animals to humans. Fruit bats are highly suspected to be the natural reservoirs of the virus (Biek et al. 2006; Yuan et al. 2012; Olival et al. 2013). Ebola has a high case fatality rate ranging between 25% and 90%, with an average of 50% (Lefebvre et al. 2014). The case fatality rate depends on a number of factors (Garske et al. 2017), including the viral species, the epidemic setting (Gatherer 2015) and time during the epidemic. Mortality is likely to be high in areas with a high population density, poverty and inaccessible health services and where rituals are performed on the dead. The case fatality rate can be decreased through improved medical management, reporting of probable cases and immunization of the exposed populations.

The 2014–2016 West Africa epidemic was the largest and most complex since 1976. It involved very many cases and deaths, in both rural and urban settings, and occurred in countries with poor health infrastructure. The epidemic also spread between countries, starting in Guinea, then Liberia, Sierra Leone and Mali, and limited transmission to Nigeria, Senegal, Spain, Italy, the United Kingdom (UK) and the United States of America (USA) (Gatherer 2015).

In this chapter, we provide an overview of Ebola outbreaks in Africa, with emphasis on the urban dimension in African cities, starting with a brief discussion of how the various epidemics evolved over time. We also give a concise summary of how the urban face of Ebola became a global emergency, the lessons learned therein, and the success stories, particularly regarding the global response, which has led to the development of several vaccines and drugs. The chapter relies primarily on existing published peer reviewed literature, as well as grey literature, mainly from reports by the World Health Organization (WHO) and the Centers for Disease Control (CDC). In addition, the
chapter draws from the experiences of the authors working in Ebola vaccine clinical trials in Uganda, where Ebola outbreaks have happened in the past.

### Epidemiology of Ebola

Ebola was first recognized in 1976 in two outbreaks that occurred nearly simultaneously in Nzara, South Sudan and Yambuku, Democratic Republic of Congo. Several outbreaks have occurred since

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Ebola species</th>
<th>Number of cases</th>
<th>Number of deaths</th>
<th>Case fatality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018 (up to June 7)</td>
<td>DRC (ongoing)</td>
<td>Zaire ebolavirus</td>
<td>59</td>
<td>27</td>
<td>47%</td>
</tr>
<tr>
<td>2017</td>
<td>DRC</td>
<td>Zaire ebolavirus</td>
<td>8</td>
<td>4</td>
<td>50%</td>
</tr>
<tr>
<td>2015</td>
<td>Italy</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2014</td>
<td>DRC</td>
<td>Zaire ebolavirus</td>
<td>66</td>
<td>49</td>
<td>74%</td>
</tr>
<tr>
<td>2014</td>
<td>Spain</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2014</td>
<td>UK</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2014</td>
<td>USA</td>
<td>Zaire ebolavirus</td>
<td>4</td>
<td>1</td>
<td>25%</td>
</tr>
<tr>
<td>2014</td>
<td>Senegal</td>
<td>Zaire ebolavirus</td>
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<td>0</td>
<td>0%</td>
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<tr>
<td>2014</td>
<td>Mali</td>
<td>Zaire ebolavirus</td>
<td>8</td>
<td>6</td>
<td>75%</td>
</tr>
<tr>
<td>2014</td>
<td>Nigeria</td>
<td>Zaire ebolavirus</td>
<td>20</td>
<td>8</td>
<td>40%</td>
</tr>
<tr>
<td>2014–2016</td>
<td>Sierra Leone</td>
<td>Zaire ebolavirus</td>
<td>14,124*</td>
<td>3,956*</td>
<td>28%</td>
</tr>
<tr>
<td>2014–2016</td>
<td>Liberia</td>
<td>Zaire ebolavirus</td>
<td>10,675*</td>
<td>4,809*</td>
<td>45%</td>
</tr>
<tr>
<td>2014–2016</td>
<td>Guinea</td>
<td>Zaire ebolavirus</td>
<td>3,811*</td>
<td>2,543*</td>
<td>67%</td>
</tr>
<tr>
<td>2012</td>
<td>DRC</td>
<td>Bundibugyo ebolavirus</td>
<td>57</td>
<td>29</td>
<td>51%</td>
</tr>
<tr>
<td>2012</td>
<td>Uganda</td>
<td>Sudan ebolavirus</td>
<td>7</td>
<td>4</td>
<td>57%</td>
</tr>
<tr>
<td>2012</td>
<td>Uganda</td>
<td>Sudan ebolavirus</td>
<td>24</td>
<td>17</td>
<td>71%</td>
</tr>
<tr>
<td>2011</td>
<td>Uganda</td>
<td>Sudan ebolavirus</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>2008–2009</td>
<td>DRC</td>
<td>Zaire ebolavirus</td>
<td>32</td>
<td>14</td>
<td>44%</td>
</tr>
<tr>
<td>2007–2008</td>
<td>Uganda</td>
<td>Bundibugyo ebolavirus</td>
<td>149</td>
<td>37</td>
<td>25%</td>
</tr>
<tr>
<td>2007</td>
<td>DRC</td>
<td>Zaire ebolavirus</td>
<td>264</td>
<td>187</td>
<td>71%</td>
</tr>
<tr>
<td>2005</td>
<td>Congo</td>
<td>Zaire ebolavirus</td>
<td>12</td>
<td>10</td>
<td>83%</td>
</tr>
<tr>
<td>2004</td>
<td>Russia</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>2004</td>
<td>Sudan (South Sudan)</td>
<td>Sudan ebolavirus</td>
<td>17</td>
<td>7</td>
<td>41%</td>
</tr>
<tr>
<td>2003</td>
<td>Congo</td>
<td>Zaire ebolavirus</td>
<td>35</td>
<td>29</td>
<td>83%</td>
</tr>
<tr>
<td>2002–2003</td>
<td>Congo</td>
<td>Zaire ebolavirus</td>
<td>143</td>
<td>128</td>
<td>90%</td>
</tr>
<tr>
<td>2001–2002</td>
<td>Congo</td>
<td>Zaire ebolavirus</td>
<td>59</td>
<td>44</td>
<td>75%</td>
</tr>
<tr>
<td>2001–2002</td>
<td>Gabon</td>
<td>Zaire ebolavirus</td>
<td>65</td>
<td>53</td>
<td>82%</td>
</tr>
<tr>
<td>2000–2001</td>
<td>Uganda</td>
<td>Sudan ebolavirus</td>
<td>425</td>
<td>224</td>
<td>53%</td>
</tr>
<tr>
<td>1996</td>
<td>Russia</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>1996</td>
<td>South Africa</td>
<td>Zaire ebolavirus</td>
<td>2</td>
<td>1</td>
<td>50%</td>
</tr>
<tr>
<td>1996–1997</td>
<td>Gabon</td>
<td>Zaire ebolavirus</td>
<td>60</td>
<td>45</td>
<td>75%</td>
</tr>
<tr>
<td>1996</td>
<td>Gabon</td>
<td>Zaire ebolavirus</td>
<td>31</td>
<td>21</td>
<td>68%</td>
</tr>
<tr>
<td>1995</td>
<td>DRC</td>
<td>Zaire ebolavirus</td>
<td>315</td>
<td>254</td>
<td>81%</td>
</tr>
<tr>
<td>1994</td>
<td>Côte d’Ivoire</td>
<td>Tai Forest ebolavirus</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1994</td>
<td>Gabon</td>
<td>Zaire ebolavirus</td>
<td>52</td>
<td>31</td>
<td>60%</td>
</tr>
<tr>
<td>1979</td>
<td>Sudan (South Sudan)</td>
<td>Sudan ebolavirus</td>
<td>34</td>
<td>22</td>
<td>65%</td>
</tr>
<tr>
<td>1977</td>
<td>Zaire (DRC)</td>
<td>Zaire ebolavirus</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>1976</td>
<td>England</td>
<td>Sudan ebolavirus</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1976</td>
<td>Sudan (South Sudan)</td>
<td>Sudan ebolavirus</td>
<td>284</td>
<td>151</td>
<td>53%</td>
</tr>
<tr>
<td>1976</td>
<td>Zaire (DRC)</td>
<td>Zaire ebolavirus</td>
<td>318</td>
<td>280</td>
<td>88%</td>
</tr>
</tbody>
</table>

Note: * Include suspect, probable and confirmed EVD cases.
then, mainly in Africa, with minimal spread to Spain, Italy, the UK and the USA. The largest epidemic was experienced in multiple countries in West Africa between 2014 and 2016 and affected 28,652 cases with 11,325 deaths. In total there have been 30 known epidemics, nine of which have happened in the Democratic Republic of Congo alone. Table 23.1 shows the chronology of all the reported outbreaks up to March 2018.

Transmission and Risk Factors

The Reservoir for Ebola Virus

Although the natural reservoir of Ebola infection remains unknown, the virus clearly has a zoonotic origin. The great apes were previously suspected to be reservoirs of the virus. However, new studies have shown that they are susceptible hosts rather than reservoirs. A sudden decline in the great ape populations in the tropical environment of Gabon and the Democratic Republic of Congo has been known to precede Ebola outbreaks in humans (Pourrut et al. 2005). A number of ecological studies conducted in plants, monkeys, bats, rodents, insects and birds have not been successful in demonstrating the virus in these species for a couple of reasons. First, they are usually implemented retrospectively, several weeks or months after the index Ebola case has been infected by a suspected reservoir. It is possible that, by the time such studies are conducted, the suspected reservoirs may have moved to another site. Second, there is no or poor EVD surveillance; thus early detection and real time human–animal studies in the remote areas of Africa where outbreaks are common are impossible. Studies on several plant varieties and animal species have given a clue that both insectivorous and frugivorous bats can support the replication and circulation of Ebola virus (Swanepoel et al. 1996). In addition, studies have found Ebola specific antibodies in six bat species (Leroy et al. 2005; Pourrut et al. 2005), and some human index cases have reported recent contact with bats, hence suggesting they could be likely hosts. Despite this, Ebola virus has never been isolated from bats.

Transmission of Ebola Virus

The transmission of Ebola virus commonly takes place after the onset of signs and symptoms. The latent period (time from when the virus enters the body to onset of symptoms) ranges from 2 to 21 days (average 10 days), and during this period no transmission happens. In most outbreaks, humans get infected by coming into contact with tissues, blood, secretions or body fluids of an infected wild animal found dead or hunted for food (Leroy et al. 2004). This is usually followed by human-to-human transmission from the index case to close family members. A single case of Ebola virus infection and disease has previously been reported in an ethologist conducting a post-mortem on a chimpanzee from the Tai Forest National Park in Côte d’Ivoire (Le Guenno et al. 1995). Usually, massive deaths of chimpanzees and gorillas preceded Ebola outbreaks among humans in the Democratic Republic of Congo and Gabon (Rouquet et al. 2005). The second highest risk group are health care staff who handle the first human cases as people seek care for their non-specific symptomatic illness.

Animal-to-Human Transmission

The increase in human activities within the African tropical forests, including deforestation, farming, hunting and mining, has caused drastic changes in forest ecosystems and promoted direct or indirect contact between humans and the natural reservoirs of the virus. Hunting wild animals such as bats, non-human primates (NHPs) and duikers has been linked to many index cases among humans. Humans and NHPs are thought to be definitive hosts of Ebolavirus, whereas bats have been identified as important reservoirs of the virus (Leroy et al. 2009).
**Human-to-Human Transmission**

Ebola virus infections spread by individuals coming into direct contact with infected body fluids such as secretions, blood, semen, excretions, body tissues of a patient or direct contact with contaminated materials both in the home or community and in hospital settings. During large Ebola outbreaks, deaths tend to cluster in families, which is also related to family members nursing or visiting the sick, meaning the family of an infected person is a great risk factor. Conducting funeral rites such as shaving, washing and clothing dead bodies or carrying dead bodies during burial is associated with acquisition of infection. Studies have shown that community-based outbreaks tend to abate quite early, while hospital settings tend to amplify outbreaks (Gostin et al. 2014). This is especially true in hospital settings where the standards of sanitation are low, with absence of barrier nursing or universal hygiene precautions. Therefore, nosocomial spread is characterized by a relatively high proportion of deaths amongst health care workers and can act as an epicenter of the outbreak, spreading it back to the community. Some studies have reported a high prevalence of Ebola antibodies in communities in the absence of reports of Ebola outbreaks (Busico et al. 1999; Gonzalez et al. 2000; Becquart et al. 2010), and this could be related to the exposure to yet unknown, less pathogenic or non-pathogenic variants of Ebola virus. Therefore outbreaks could spontaneously erupt in Ebola endemic geographical locations. Cases of sexual transmission have been reported in humans (Diallo et al. 2016), and the virus has been isolated in semen for up to three months following recovery (Bausch et al. 2007). Aerosol infection is questioned, since people sharing the same space with infected persons do not contract the infection even though aerosol infection of NHPs has been demonstrated in the laboratory (Leffel and Reed 2004). Insect vectors such as mosquitoes, house flies and ticks are not known to transmit Ebola, and neither have domestics animals been infected.

**Signs and Symptoms**

The occurrence of clinical symptoms of Ebola is divided into four main phases:

**Phase 1: Influenza-like syndrome**

The onset is abrupt, with non-specific symptoms or signs such as high fever, headache, arthralgia, muscle aches, sore throat, and malaise with nausea.

**Phase 2: Acute (days 1–6)**

Persistent fever not responding to antimalarial drugs or to antibiotics, headache, intense fatigue, followed by diarrhea and abdominal pain, anorexia and vomiting.

**Phase 3: Pseudo-remission (days 7–8)**

During this phase the patient feels better and seeks food. The health situation presents with some improvement. Some patients may recover during this phase and survive the disease.

**Phase 4: Aggravation (day 9)**

The health status gets worse. Patients develop multi-organ failure, where the following may be observed:
• respiratory disorders: dyspnea, throat and chest pain, cough and hiccups;
• hemorrhagic diathesis: bloody diarrhea, hematemesis, conjunctival injection, gingival bleeding, nosebleeds and bleeding at the site of injection consistent with disseminated intravascular coagulation;
• skin manifestations: petechiae (not so obvious on black skin) and purpura (morbilliform skin rash);
• neuro-psychiatric manifestations: prostration, delirium, confusion and coma;
• Cardio-vascular distress and hypovolemic shock (death).

Given non-specific clinical manifestations of Ebola, especially in the earlier phases, mimicking many other tropical diseases such as malaria, typhoid fever or yellow fever, the diagnosis of Ebola is often missed. Outside the epidemic context, it is practically impossible to recognize the index Ebola case, and this is the very reason it kills many health workers in the early days of the epidemic.

**Diagnosis of Ebola**

The diagnosis of acute EVD is usually made in the laboratory by several tests, including:

• antibody–capture enzyme-linked immunosorbert assay (ELISA);
• antigen–capture detection tests;
• serum neutralization test;
• real time polymerase chain reaction (RT-PCR) assay;
• electron microscopy;
• virus isolation by cell culture.

WHO recommends that consideration should be given to the selection of diagnostic tests, with a strong emphasis on the use of diagnostic tests that have undergone an independent international evaluation. Viral genome detection via RT-PCR generally detects the virus within 48 hours after infection in both lethal and non-lethal cases. This means that a negative test result within the first 48 hours after exposure does not exclude Ebola infection.

**The Deadly Ebola Outbreak in West Africa and Its Spread to Cities**

The 2014–2016 Ebola outbreak in West Africa started as a small localized outbreak from one village in Guinea, where an 18-month-old boy is believed to have been infected by bats in December 2013 (CDC 2018). The occurrence of this index case was followed in January 2014 by five reports of death from diarrhea in the same locality. In March 2014 the Guinea Ministry of Health issued a public alert for morbidity and mortality following an undiagnosed disease. Tests at the Pasteur Institute in France confirmed it to be EVD caused by the *Zaire ebolavirus* species. By the end of March 2014 over 49 cases and 29 deaths had been confirmed to be due to EVD. An unknown large number of people had come in contact with the cases or asymptomatic contacts. In July 2014, the outbreak had progressed to a full-blown epidemic affecting both the rural populations and the metropolitan cities of Conakry, Freetown and Monrovia.

The EVD epidemic in West Africa had some quite special characteristics. It was the first time in over 40 years that such an unprecedented EVD epidemic had affected both rural and urban settings as well as involving several countries. Prior to the West African epidemic, Ebola had never entered a capital city with more than just a handful of cases. In this outbreak, three capital cities in three countries simultaneously experienced large and explosive outbreaks. This led to a declaration of a state of
emergency, institution of quarantine, deployment of the army and for the first time the deployment of a United Nations mission created to handle the epidemic (Campbell 2017). On August 8, 2014, the World Health Organization declared the EVD outbreak in West Africa to be a public health emergency of international concern. Such a declaration is reserved by WHO for disease outbreaks that have a significant potential for international spread and require a concerted international effort to control. Cases of EVD occurred in other countries, such as Nigeria, Senegal and Mali in West Africa, as well as countries such as Italy, Spain, the UK and the USA.

Several factors were responsible for the widespread occurrence of the epidemic in West Africa: 1) generally the health system infrastructure is poor and countries have a low disease surveillance system; 2) there are extensive uncontrolled cross-border migrations; 3) there are strong cultural practices involved in handling the sick and dead; and 4) there is poor health seeking behavior, with the population preferring traditional herbalists to professional health care from established health units. Other reasons are related to: 5) the role of health workers in the transmission chain; 6) the indiscriminate practice by developed countries of evacuating their citizens affected by disasters; and 7) the complex human interactions in the densely populated cities, which is our focus in the next subsection.

Urban Context of Ebola in Africa

Past outbreaks of Ebola occurred mainly in Central Africa and were confined to relatively rural areas with minimal spread to urban centers. In rural areas the population density is low, and communities tend to be of the same ethnic identity with similar cultural practices. Because of this, the measures to prevent transmission are easier to implement. The first aspect of urban Ebola outbreak was experienced in the 2000–2001 Uganda outbreak, one of the largest outbreaks, which involved 425 presumptive cases, with a 53% case fatality rate (Okware et al. 2002). It was reported that 60% of the cases were from urban areas of Gulu town in northern Uganda. Gulu is a relatively small town with an estimated population of 146,858 people, 80% of whom are from the same ethnic group (Acholi). It is 340 kilometers (211 miles) away from Kampala, the capital city of Uganda, and is approximately four hours away by road transport. The city is served by an international airport, which is the second largest after Entebbe international airport. Gulu airport is mainly used by staff of international organizations supporting the rehabilitation of communities recovering from the insurgency led by the Lord’s Resistance Army rebel group for close to 20 years. Although the urban population of Gulu was mainly concentrated in crowded informal settlements, the Ebola outbreak was confined within Gulu town and the neighboring villages.

The Gulu Ebola outbreak was relatively unusual in comparison to other recent outbreaks because it affected primarily one ethnic group (the Acholi) and most medical staff and decision makers were from the same ethnic group (Hewlett and Amola 2003). It was therefore easier to communicate health messages and mobilize communities to take precautionary measures to avoid further spread. Although Gulu is not far from Kampala, most travel to Kampala city was by members of the business community, who mainly traveled by road and could easily be controlled. During this time EVD cases were also diagnosed in Mbarara and Masindi towns, and their index cases had traveled from Gulu. The most common route from Gulu to Mbarara is by road through Kampala, and hence there was a high potential for a seeded urban outbreak. Since more than 80% of Uganda’s population is predominantly rural and the population of Gulu town was ethnically homogeneous, measures that were successfully used in controlling the more than 20 rural Ebola outbreaks were effective in stopping the epidemic in Gulu.

The Ebola epidemic in West Africa marked the most intense urban transmission. The urban population in West Africa is growing at a faster rate owing to a high rural-to-urban migration and
higher fertility rates than in Central and East Africa, where previous Ebola epidemics occurred. Between 1960 and 2013, the proportion of urban population increased by 248% in Guinea, by 130% in Sierra Leone, and by 163% in Liberia (World Bank 2014). Large-scale population movements in the region, both within and between countries, have been driven by decades of conflict and the search for improved socioeconomic conditions and opportunities. Therefore, the present-day population mobility in West Africa has been an important contributing factor to the explosive nature of the West African Ebola outbreak.

The transmission of Ebola in West African occurred in large cities (Conakry, Freetown, Monrovia and Lagos) which have major international airports. This raised concerns about a quick internationalization of the outbreak. Indeed this was the first time the virus had spread by air travel, when a Liberian-American flew from Liberia to Nigeria’s most populous city of Lagos on July 20, 2014. This suggests that, with the growing urban population in Africa and frequent air travel, Ebola could quickly spread to any country, including the wealthy countries outside Africa.

The spread of EVD to cities increases the challenges of managing an outbreak owing to increased population interactions. Similarly, increased travel—especially air travel—enables people to travel to distant places within the incubation period of the most dangerous pathogens associated with hemorrhagic fevers. Most airports in the world link cities and/or large highly populated metropolitan areas. Air travel has been previously known to facilitate propagation of infectious disease outbreaks into full-blown epidemics. For example, during the 2003 outbreak of severe acute respiratory syndrome (SARS), the index case was identified in Hong Kong (Hollingsworth et al. 2007). This index case resulted into 16 secondary cases who had shared a hotel with the index case. Out of these secondary cases, six took international flights to Australia, Canada, Indonesia, Malaysia, Singapore, the Philippines and Vietnam. Their travel to these countries led to subsequent outbreaks of SARS in the cities of Hanoi, Singapore and Toronto, and this took a few days following an index case in Hong Kong. Similarly, the annual global dispersal of meningococcal meningitis has been reported following pilgrims returning from the Hajj and Umrah Muslim religious festival in Mecca, and this spread is facilitated by the quick air travel used by most pilgrims (Heymann 2004; Abubakar et al. 2012). Therefore tight screening and infection control strategies need to be instituted at airports during Ebola outbreaks to curb the spread of the disease to other cities.

Peter Salama, the WHO Deputy Director-General of Emergency Preparedness and Response, echoed a major concern on urban Ebola outbreaks in a BBC interview on May 17, 2018 that: “We have urban Ebola, which is a very different animal from rural Ebola. The potential for an explosive increase in cases is now there.” This remark was made during the ninth outbreak in the Democratic Republic of Congo, and the city affected by the outbreak was Mbandaka, which is a major transport hub along the Congo River. The major worry was the spread to major cities such as Kinshasa, which has 10 million residents, and the surrounding African countries, including Congo-Brazzaville and the Central African Republic.

The biggest concern about urban Ebola in Africa is related to the urban informal settlements. Informal settlements have: inadequate access to safe water, sanitation and other infrastructure; poor structural housing quality; overcrowding; and insecure residential status. These conditions are rife for Ebola outbreaks. The Ebola outbreak in West Africa was augmented by the informal settlement conditions within the cities of Kenema and Freetown in Sierra Leone (Snyder et al. 2014). In addition, West Point in Monrovia, Liberia, the largest and most famous of West Africa’s informal settlements, which has a population of more than 70,000, was the flashpoint for that country’s epidemic. The number of Ebola deaths in that informal settlement will likely never be known, as bodies were simply thrown into the ocean and two rivers nearby.

People living in informal settlements are highly mobile, with limited economic opportunities, forcing them to frequently migrate clandestinely and often illegally to new cities and countries.
This type of migration subverts anti-Ebola surveillance, screening and control measures, thus presenting an imminent threat to other informal communities and the rest of the world. The primary factor contributing to the informal settlement dwellers’ disproportionate disease burden is their invisibility and neglect. This makes them an ideal vehicle for the epidemic. Ebola is essentially a disease of interaction between people, and generally this is an inherent characteristic of populations in urban settings. Therefore, it can be quite challenging to halt a virulent disease outbreak. Populations in urban settings continuously and anonymously move for different reasons. The movements are usually driven by factors such as conflicts and disasters, agricultural patterns, and day-to-day movements for trade and work, social and cultural reasons (Campbell 2017). When an outbreak occurs, new movement patterns may arise as affected people seek health care, attend burials or visit to comfort relatives or flee from stigma. The movements are usually complex and involve movements within and between urban centers as well as between urban and rural communities. In addition, the public transport vehicles in cities tend to overload passengers. Places such as shopping malls, restaurants, churches and recreational facilities are often crowded and ripe for outbreaks. These dense human environments can become incubators of the disease and pose a great risk to all travelers. The high population density in West Point, for example, created difficulties in contact tracing. The habits of the residents were also difficult to predict, as many moved in and out of the area for work and socio-economic reasons. During an outbreak, authorities need to be cautious if the affected urban community has fishing as one of the main occupations (Njock and Westlund 2010). Fishing communities are known to be highly mobile, meaning they can quickly spread the disease, with serious challenges in tracking contacts.

**Lessons Learned from the Urban Ebola Outbreak in West Africa**

Although the response to approximately 30 Ebola outbreaks since 1976 had provided the international community with experience in responding to the disease, the urban Ebola outbreak in West Africa presented new challenges. It also provided an opportunity to rethink the response, especially in the context that rapid urbanization will continue in Africa. Some of the experiences in approaching such an epidemic are clearly voiced by Campbell (2017).

**Attention to Pre-Existing Vulnerabilities in the Health System**

The Ebola outbreak in West Africa exposed chronically fragile and under-resourced health systems (Barbiero 2014). Control efforts were hindered by weaknesses in the formal health system, lack of trust in the health system by the communities, inadequate reporting of health events and the public’s lack of access to health services among other factors (Heymann et al. 2015). In most African countries, health care facilities and workers are concentrated within urban settlements. Individuals suffering from Ebola from rural communities are more likely to first seek treatment from the urban health facilities and, in the process, Ebola can spread quite quickly from rural communities to urban centers through health facilities. Since most of the health facilities are under-resourced, they quickly run out of supplies. In West Africa, the influx of cases from outside the cities stifled access to health care by the city dwellers, and the health facilities ran out of supplies, which worsened the spread. In light of the Ebola virus crisis, three key developments are needed for resilient health care systems: 1) improved disease surveillance; 2) greater trust and engagement with communities; and 3) a stronger health workforce (Kieny and Dovlo 2015). Another challenge observed was health care workers working in multiple clinics in more than one place, and this was an amplifying factor in the spread of the outbreak. It is also important to monitor the working pattern of health workers, as those working in several clinics could lead to an explosion of an urban EVD outbreak. Such health workers should therefore be a target of preventive interventions.
Intersectoral Connections within Cities

Big sections of the urban settings are often overcrowded, with poor water, sanitation and hygiene standards, especially where settlements are largely informal. Cities also host mixed tribes, culture, religions, languages and people of varied education standards. In informal urban spaces, there are a high number of anonymous, untraceable interactions every day, and it is easy for people to disappear. This problematizes response strategies such as contact tracing and surveillance efforts. Hence there is a need to learn the local dynamics of populations, which are usually tightly interwoven with the health seeking behavior of the people. Ignoring these linkages can leave many vulnerable to infections.

Communication Challenges

In African cities, people live quite close to one another, and rumors spread quickly by word of mouth. People easily come together in smaller groups, get information and spread it to other groups, and this goes on. Misconceptions can thus spread easily to all areas of the city. It is important that the right messages are designed and communicated as fast as possible through the channel used to spread false rumors. For example, in West Point the delayed and poor approach to communication between the government and the community led to mistrust, anger and riots (Campbell 2017). The community hid their sick relatives from the health authorities, threw the dead in the sea and were always suspicious that the government intended to infect them with Ebola. As a result, the community attacked the school-based isolation center that had been gazetted for patients. They looted all the available supplies, including the bedding and clothes of the patients. Patients who had been admitted also escaped from the isolation center, mixing with others in the community. Therefore, poor messaging and inadequate communication can have disastrous consequences to the community. Conventional EVD messages such as avoiding contact with bush meat, although important, may not be relevant in urban settings. There is a need to tailor messages according to the cultural settings and the needs of the population in urban settings.

To Quarantine or Not to Quarantine

Quarantine of populations during epidemics has been used for centuries as an effective control strategy achieved through controlling movements to reduce the frequency of potentially effective contact and risk of infection. However, quarantine may present additional challenges, as reported from the experiences in West Point, where the quarantine measure instituted by the government led to an increase in food prices. Many were forced to join queues to receive raw food supplies distributed by humanitarian organizations. The distribution of raw food did not solve the problem either, as people still lacked fuel and water for cooking. In addition, quarantine has psychological effects on the human population, as people feel imprisoned and denied their rights by the government. It is therefore recommended that the use of quarantine as a public health epidemic control measure by governments follow the Siracusa Principles on the Limitation and Derogation Provisions outlined in the International Covenant on Civil and Political Rights (American Association for the International Commission of Jurists 1985). This covenant requires that quarantine should be: 1) instituted in line with the law; 2) following a genuine cause; 3) considered after all other possible strategies have been tried and failed; and 4) based on scientific evidence from research and implemented in a non-discriminatory manner. In Monrovia, the army and the police arbitrarily implemented the quarantine strategy in West Point, as residents observed them facilitating the evacuation of the commissioner and her close family members (Campbell 2017). This fueled the riots and triggered the population to flee.
**Community Mobilization**

The engagement of community structures should be harnessed as early as possible during an urban Ebola outbreak. Community-based volunteers can play a big role in door-to-door awareness campaigns, as well as identifying the sick and removing them from the community. They can help monitor households that have been quarantined and help in tracking their recent contacts within the 21-day incubation window. In densely populated settings, such undertakings cannot be solely executed by health workers and other humanitarian aid workers as in rural outbreak situations. However, community health workers should be trained and closely monitored by trained professional health workers to undertake such tasks. In the West African case, the community health workers were trained and went house to house to provide important information about Ebola and search for active cases and contacts. They also worked with local religious leaders to expand their education and outreach strategies such as conducting safe burials (Cole 2015).

**General Strategies for Controlling Ebola Epidemics**

During the first reported Ebola outbreak in 1976, an international response team developed certain measures to stop the outbreak. These included identification, isolation and care of persons with Ebola symptoms, with meticulous tracing of contacts, working closely with community leaders, sensitizing communities on culturally sensitive and safe burial and enforcing effective infection control measures.

The first step in the management of the Ebola epidemic is to identify patients with symptoms consistent with the case definition as outlined by the World Health Organization (WHO 2018) or the Centers for Disease Control and Prevention (CDC 2018). The patients should rapidly be isolated, their contacts identified, and appropriate containment and preventive measures instituted. Blood samples need to be immediately obtained and sent to the nearest biosafety level 4 clinical laboratory certified to conduct diagnostic evaluation for Ebolavirus.

The current proven standard of care is supportive care, which includes providing intravenous fluids and balancing the electrolytes, maintaining oxygenation and blood pressure and treating other infections as they occur. This supportive care is reported to significantly improve survival if started early during the illness, and it is probably responsible for the varying case fatality rates during the different epidemics.

Effective EVD control strategies should focus on ensuring effective case management, surveillance and contact tracing, a good laboratory service, safe burials and social mobilization. Other measures should ensure early community engagement, education of affected populations, and counselling of family members of the sick EVD patients. WHO recommends several risk reduction steps, which should focus on:

1. **Reducing the risk of wildlife-to-human transmission** from contact with infected fruit bats, monkeys or apes and the consumption of their raw meat. Animals should be handled with gloves and other appropriate protective clothing. Animal products (blood and meat) should be thoroughly cooked before consumption.
2. **Reducing the risk of human-to-human transmission** from direct or close contact with people with Ebola symptoms, particularly with their bodily fluids. Gloves and appropriate personal protective equipment should be worn when taking care of ill patients at home. Regular hand washing is required after visiting patients in hospital, as well as after taking care of patients at home.
3. **Reducing the risk of possible sexual transmission** based on further analysis of ongoing research and consideration by the WHO Advisory Group on the Ebola Virus Disease Response. WHO recommends that male survivors of Ebola virus disease practice safe sex and hygiene for 12 months.
from the onset of symptoms or until their semen tests negative twice for Ebola virus. Contact with body fluids should be avoided, and washing with soap and water is recommended. WHO does not recommend isolation of male or female convalescent patients whose blood has tested negative for Ebola virus.

4 Outbreak containment measures including prompt and safe burial of the dead, identifying people who may have been in contact with someone infected with Ebola and monitoring their health for 21 days, separating the healthy from the sick to prevent further spread, and the importance of good hygiene and maintaining a clean environment (Figure 23.1).

**Vaccination against Ebola**

For nearly four decades, there has been no known effective vaccine against Ebolavirus. Little attention was given to treatment and vaccination interventions during the pockets of epidemics in Central and East Africa. The Ebola epidemic in West Africa generated a global interest in developing vaccines.

The Merck pharmaceutical vesicular stomatitis virus vectored Zaire ebolavirus vaccine (rVSV-ZEBOV) was found to be effective against EVD in Guinea during the West African epidemic (Henao-Restrepo et al. 2015). This was evaluated in a phase III open label cluster randomized trial using a novel ring vaccination approach employed in the eradication of smallpox in the 1970s.

![WHO–UNICEF training community relay networks in Beni, Democratic Republic of Congo on Ebola knowledge and effective measures to avoid disease.](image)

Photo by Eugene Kabambi.
Ring vaccination is defined as the vaccination of a cluster of individuals at high risk of infection, owing to their social or geographical connection to a confirmed case of disease. The ring vaccination strategy was used to vaccinate populations at risk of Ebola during an outbreak that occurred recently in the DRC four years after the West African epidemic (Figure 23.2).

Other vaccines are currently under investigation, with promising safety and immunogenicity results, and these include: the monovalent Ad26 ZEBOV expressing the glycoprotein of Zaire ebolavirus strain; the multivalent MVA-BN-Filo expressing the glycoproteins of Zaire ebolavirus, Sudan ebolavirus and Marburg virus, as well as the nucleoprotein of the Tai Forest ebolavirus (Anywaine et al. 2017). Phase I trials conducted in Kenya, Tanzania, Uganda, the UK and the USA have shown the vaccines to be quite safe and highly immunogenic among healthy adults. Phase II studies are also underway in several countries involving several populations including healthy adults, the elderly, HIV-positive individuals and children in the 4–11 years and 12–17 years age strata. The results of these trials and further development plans may add more vaccines to the EVD vaccine prevention tool kit.

**Treatment of Ebola**

Small molecule drugs have shown potential in treating EVD in pre-clinical studies, including Favipiravir, a pyrazin-carboxamide derivative currently used in the treatment of influenza virus.
Other drugs worthy of consideration include lamivudine, TKM-Ebola, Ribavirin and Brincidofovir. Monoclonal antibodies (MAbs) known as ZMapp have also been developed. ZMapp is an improved IgG MAb cocktail comprising MAbs from two precursors, ZMAb (providing MAbs c2G4 and c4G7) and MB-003 (providing MAb c13C6). This was found to be efficacious in NHPs and used in the two American patients during the 2014–2016 Ebola epidemic with promising results.

Lastly, there is some evidence that passive immunization with blood from survivors of Ebola disease can reduce the case fatality rates. However, this promising therapy has many problems, which can be ameliorated through further scientific modifications. WHO declared that, considering the magnitude and severity of the 2014–2016 outbreak in West Africa, it is ethical to use experimental drugs for treatment and prevention of EVD.

**Conclusion**

Concentrated human settlements increase the chances of contracting diseases owing to the human population “herding effect” that they exhibit. In the 21st century, this becomes a particular concern given that most of the world’s population lives within an urban context. Highly pathogenic infectious disease outbreaks such as Ebola can occur following natural mechanisms or arise as intentional harm from human conflicts, including the potential of bioterrorism. These threats seem to increase over time as environmental degradation persists and humans continue to come more in contact with the natural habitats of several pathogens. Cities continue to expand and merge, and connections between them are currently much easier through travel. It is this combination of dense human environments and mobility, including high-speed travel, which makes the management of Ebola and other highly contagious disease outbreaks within an urban setting extremely difficult to coordinate. In addition to the increased density and mobility, urban dynamics are usually more complicated and diverse. With mixed ethnicities and overcrowded informal settlements perpetually encumbered with inadequate access to safe water and sanitation, the complexity and dynamics of these environments further accentuate the ability of dense urban spaces to act as disease incubators.

**References**


