Journal of Health, Medicine and Nursing
ISSN 2422-8419 An International Peer-reviewed Journal
Vol.51, 2018

Factors Associated with the Ebola Viral Disease Outbreak in Montserrado County, Liberia

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Abstract
The 2014 Ebola Virus Disease (EVD) outbreak went on record as the most distressing epidemic in the 41 years history of Ebola following its discovery in DRC and South Sudan. Liberia, one of the three nations at the epicentre of the EVD outbreak, grapples with poverty and is still recovering from civil war that ended in 2003, suffers a weak health system. Montserrado County in Liberia was one of the three counties that were hit hardest by the outbreak, the others being Lofa and Margibi. The primary objective of this study was to assess the aspects linked to the identification and response patterns with regards to the EVD outbreak in Montserrado County, Liberia. This was necessitated by the dire need for effective infectious disease detection and control. A cross-sectional design was adopted. Primary data was collected from nurses in Montserrado and further secondary data was abstracted from County health records. Montserrado recorded a case fatality rate of 44.7%. Analysis showed that the odds of females dying from EVD were 21% lower than for men. Age and location decreased odds to 16% though not at a statistically significant level. Longer time to detection meant higher chances of fatality; mean days to detection for those who recovered was 5.49±4.02 and 5.82±4.18 for fatalities. Lack of diagnostic capacity, fear, limited knowledge of the disease, and sociocultural beliefs presented as some of the key barriers to detection and response. There is need to improve the health system in Liberia, conduct more rigorous health education, strengthen disease surveillance, and break barriers to detection and response for better preparedness.
Keywords: Ebola virus disease, outbreak, Montserrado, Liberia

1. Introduction

Infectious and communicable diseases comprise a major and obstinate public health problem all around the world (Fonkwo, 2008). Epidemiological transitions show improvements in the reduction of death rates overall, but a group of infectious diseases, emerging and re-emerging, still present a huge challenge and concern in public health (Dye, 2014). Ebola Virus Disease (EVD) is one such infectious disease that has proven lethal since its first outbreak in 1976. In December 2013, an EVD outbreak was officially reported, transcending the usual geographical location and hence crossing over continents as infections were reported as far as the United States, United Kingdom, and Italy. In West Africa, Liberia, Guinea, and Sierra Leone were among the worst hit countries (Lewis *et al*., 2015). However, key differences emerged regarding the handling of EVD in high-resource settings compared to identification and management in West Africa (Vetter *et al*., 2016). Identification and management of EVD in West Africa highlighted disease surveillance challenges and hindrances.

Liberia had never been a host of Ebola, at least not in the magnitude that it has been in the most recent Ebola outbreak. More than 10,000 people had been infected by the disease in Liberia in the 2013 to 2015 outbreak that took a new route affecting Guinea and Liberia as the first nations (Nsoedo, 2014). The diffusion in the recent outbreak was unprecedented, causing concern among health practitioners and researchers in the underlying factors that led to the fast transport, large geographic coverage, and difficulty to contain (Lewis *et al*., 2015). The inability to manage and contain the disease have been attributed to poor or delayed detection and a slow response from health teams among other factors. By the time the disease was coming to an end, one of the counties in Liberia, Montserrado, had reported one of the highest numbers of fatality cases (3,501 or 33%) resulting in 1,438 deaths (Lubogo *et al*., 2015). Understanding the specific factors underlying high numbers with almost a third of the fatality rate and those that prevented proper identification and reporting is critical. This research sets to bring this elucidation. Thus, the objectives of this study were to determine the case fatality rate, assess factors associated with the fatality rate, determine detection and response measures to EVD, and establish barriers to detection and response to EVD in Montserrado County, Liberia.

2. Ebola Virus Disease and Integrated Disease Surveillance and Response

The Ebola Virus (EBOV) adopted its identity from the Ebola River situated in Zaire (Lewis *et al*., 2015). Previously referred as Ebola Hemorrhagic Fever (EHF), Ebola Virus Disease is an animal-based filovirus infection – or zoonotic disease – that leads to severe haemorrhage and is characterized by high fatality. Five different subspecies of Ebola are responsible for EVD outbreaks including Sudan ebolavirus (SEBOV), Zaire ebolavirus (ZEBOV), Tai Forest ebolavirus (TAFV), Bundibugyo ebolavirus (BDBV), and Reston ebolavirus (REBOV) (Beeching, Fenech, & Houlihan, 2014). Zaire ebolavirus has gone on record as the most fatal with a mortality rate of up to 90% (Gebre, Gebre, & Peters, 2014). The recent EVD outbreak involved the ZEBOV strain and stands as the biggest outbreak on record since 1976.

The Ebola Virus incubation time is an average of 11.4 days, with a range of 2 to 21 days. In most cases, though, cases are not infectious until the onset of symptoms. The most common symptoms associated with EBOV include fatigue, fever, vomiting or nausea, dehydration, skin rash, sore throat and bleeding (Wong *et al*., 2015). The fatal phase is characterized by increased vascular permeability, multiple organ failure, haemorrhage, and severe damage to tissues (Gebre *et al*., 2014). Transmission can occur between two human beings or from animals to humans; the virus spreads through secretions and transfer or body fluids. Transmission from animals occurs upon eating or dealing with animals that are contaminated with EBOV (Beeching *et al*., 2014). While there are no current known medications for EBOV, advancements that have been made in science concerning filoviruses have enabled the development of myriad experimental vaccines that scientists hope will curb infections (Beeching *et al*., 2014; Gebre *et al*., 2014; Wong *et al*., 2015). Most important, integrated disease surveillance and response, as a derivative of an efficient health system can support reduction of the fatality to below 20% (Vetter *et al*., 2016).

2.1. Disease Surveillance and Response

Timely outbreak control requires that an outbreak is detected and responded to early enough to reduce associated morbidity and mortality (Lindblade *et al*., 2016). Several factors have been associated with previous EVD epidemics in Africa. The affected West African countries had weak health systems, just like other African countries, which combined with the fact that EVD was not common in these countries, led to a low index of suspicion when the cases were first seen. Limited capacity to diagnose EVD and poor knowledge to diagnose Ebola led to detection after a long delay in previous outbreaks (Vetter *et al*., 2016).

According to the response team from WHO in the 2014 outbreak, most of the patients were aged between 15 and 44 years and the case fatality rate among these patients was 70.8% (WHO, 2014). The course of the infection was the same as that reported in other outbreaks of EVD. The most common symptoms in the worst case of EVD and in others were loss of appetite, fatigue, fever, diarrhoea, abdominal pain, headache and vomiting. The specific hemorrhagic manifestation was the very rate in addition to hepatic manifestation (Cenciarelli *et al*., 2015). However, despite that, the management of EVD in 2014 was met with myriad challenges that have to be tackled to prevent such a scenario in the future.

2.2. Containment Barriers

The most recent fatal EBV outbreak and other outbreaks have highlighted some of the barriers in containing EVD outbreaks. According to WHO, three main factors were responsible for the widespread nature of EVD and failure to contain the infectious disease in West Africa in 2014. These three factors included lack of sufficient capacity among affected communities, a factor that made early detection, proper isolation of cases, rigorous procedures, and adequate monitoring and contact tracing hard; fear; and managerial framework (WHO, 2014).

Studies show that health stigmas play a critical role in influencing health behaviour among infected as well as uninfected during the period of the epidemic, leading to barriers to the management of outbreak and possibly inducing the transmission and the fast spread of the disease-causing pathogen (Tenkorang 2017; Davtyan, Brown, and Folayan 2014). The HIV/AIDS pandemic should have provided important insight for public health systems and populations to learn with regards to Ebola Virus Disease. However, Ebola has left us with an even extreme example. Health practitioners, critical in managing the EVD outbreaks, have often times been stigmatized during outbreaks with their families and communities rejecting them (Davtyan, Brown, and Folayan 2014). There are also cases where they have been stoned by community members who believe that they have been infected. Indeed, such cases are barriers towards effective management of EVD (Alexander *et al*. 2015).

The potential negative responses from community members have hence prevented many community members from either seeking medical help or reporting cases that require attention. Survivors of Ebola have also been subjected to heavy stigmatization – many of them are not accepted back to their communities with their possessions being scorched, and are not permitted to share common facilities. According to reports from the management of EVD in 2001 in Uganda (Hewlett and Amola 2003), female survivors experience more stigmatization as opposed to male survivors. Stigmatization can extend beyond the families of survivors where the others in the community have been shown to stigmatize even the family members of those affected (Lukwago *et al*. 2013). Stigma and associated anxiety are not limited to the individual, community, or household, but it may also transcend to national levels where international response teams have failed to initiate interventions. Health-related stigmatization was prominently reported in the recent West Africa outbreak.

Lack of health education is a major factor preventing successful EVD interventions. Health education serves as the key to combating most of the issues that surround EVD outbreaks, including lack of trust amongst health officials and populations, lack of acceptance of EVD survivors, relatives of victims, and healthcare workers back to families and to the communities where they once coexisted (Tenkorang 2017). However, as critical as health education is, health education messages have to engage the traditions and cultures of the target groups, which are other significant barriers, or risk bearing no fruit, or worse still, generating a negative effect. Indeed, such a paradigm shift is critical in the management of EVD and ensuring that efforts to combat its epidemics are successful.

3. Methods

This study adopted cross-sectional design, which utilized quantitative data technique, to assess the factors associated with the EVD outbreak in Montserrado County, Liberia. Primary data were collected from nurses, through questionnaires, in five health facilities in Montserrado that were involved in the management of EVD patients during the outbreak in Montserrado County. Secondary data was abstracted from Montserrado County health office as well as health facilities in the areas where EVD outbreaks were reported during the study period. Montserrado County, which is located in the North-western part of the country, is the oldest of the 15 counties in Liberia and has four districts and with a population of 1,118,241 as per the Liberia 2008 population and housing census. The primary data was collected through interviews with nurses and completion of questionnaires. This sought to identify the barriers experienced in detection and response to the Ebola outbreak in Montserrado County. Data sources for the secondary data were outbreak reports, outbreak investigation forms, line lists, sample request forms and laboratory records.

The study targeted nurses from five hospitals that were involved in the management of EVD patients in Montserrado County in Liberia. These hospitals are John F. Kennedy (JFK) hospital, Eternal Love Winning Africa (ELWA) hospital, Redemption hospital, Catholic hospital and Bensonville hospital. The estimated total number of nurses in these hospitals is 1,681. From this, a sample size was computed. A random sampling of the nurses was done until the desired sample size was achieved. Further, the study was retrospective and perused health records of the EVD in health facilities across Montserrado County. For the secondary data, which was obtained from health offices, it was ensured that all records of the Ebola outbreak were captured.

Fischer's formula (1991) was used to get the desired sample for this study as shown below:

$$n = \frac{Z^2 pq}{\delta^2}$$

Where; n – desired study sample
Z - 1.96 as tabulated for 95% CI
p – Proportion of target population i.e. 19.9% (0.199)
δ – Desired precision level (0.05)

$$n = \frac{1.96^2 \times .199 \times .801}{.05^2}$$

$$n \approx 244.94$$

n = 245 Nurses

Questionnaires were identified as the main research tools. A data abstraction tool was used to collect data of EVD outbreaks reports from 1st March 2014 when EVD was first reported in Liberia, and 28th February 2015 when the last case of EVD was reported in Liberia. Research assistants collected the data from the health county health office after training by the researcher. Entry and analysis of data were performed using EPI info version 7. Demographics were described and univariate analyses were done. Prevalence and incidence were calculated per month to determine if there was a change. Bivariate and multivariate analyses were done to determine associations between factors and outcomes of the EVD patients. Furthermore, calculation of the time elapsed between outbreak start, diagnosis, the response was done for each outbreak event, and median times were established both for each year of study and the entire study period, including 95% confidence intervals. In order to ascertain the ratio of study hazards, Cox proportional hazards regression analyses were performed. Univariate analysis was done to determine the time taken to detection and response for each EVD patient and median time calculated for all.

Ethical endorsement was sought from the Ethical Review Board at the University of Liberia. Confidentiality was upheld by storing the hard copy data under lock and key and soft copy data using a password-protected computer. Soft copy data was backed up to an external hard disk which was stored under lock and key. No personal identifiers were retained.

4. Results and Discussion

4.1. Results

A total of 2,032 records from the EVD database met the inclusion criteria and were included in the analysis of patient data. Of these, 1,123 (55.3%) recovered and 909 (44.7%) died from EVD. The case fatality rate among EVD patients was 44.7%. The summary of patient demographic characteristics is shown in Table 4.1

Table 1: Socio-demographic Characteristics of Patients

Characteristics	Category	Recovered from EVD	Died from EVD
Total		**N=1123(55.3%)**	**N=909(44.7%)**
Sex	Male	532(52.4%)	484(47.6%)
	Female	591(58.2%)	425(41.8%)
Geographic location	Greater Monrovia	366(42.3%)	500(57.7%)
	Others	12(36.4%)	21(63.6%)
Age	N(Mean)SD	1073 (28.84)15.65	864 (32.26)31.20

The age of the patients ranged from 5 months to 95 years.

Onset of symptoms for recorded patients was between 11th June 2014 and 14th March 2015. The secular curve (Figure 4.2) showed two peaks of the outbreak; one in mid-August 2014 and another in mid-September 2014.

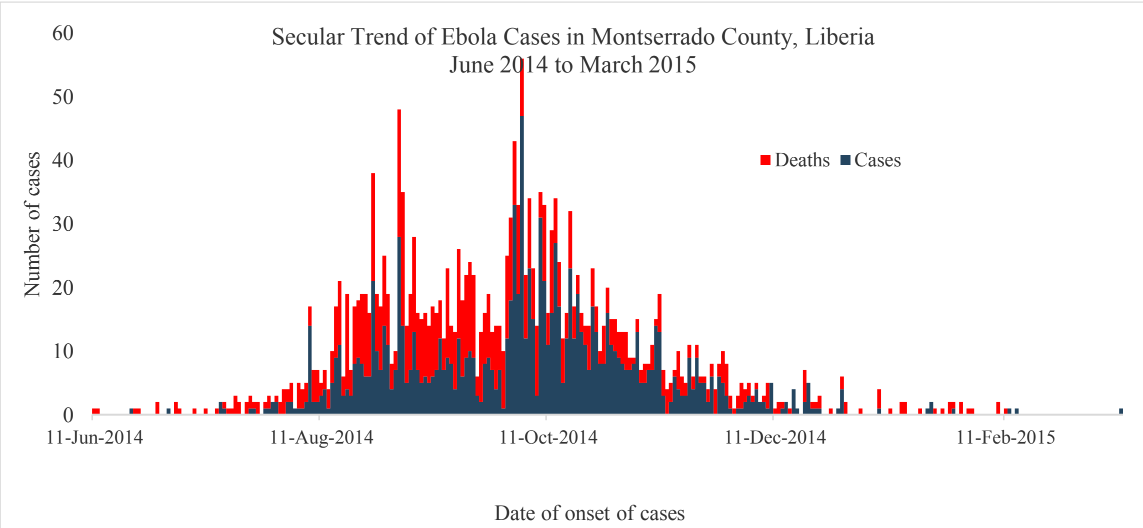

Figure 4.1: Secular Trend of EVD cases in Montserrado County, June 2014 to March 2015

Binary logistic regression was used to assess the factors associated with fatality among EVD cases. The odds of dying from EVD among the females are 21% lower than that of the males. When adjusted for age, days of detection and geographic location the odds decrease to 16% though it is not considered to be statistically significant, as seen in Table 4.3.

Table 2: Factors Associated with Fatality among EVD Cases

Characteristics	Category	Univariable analysis OR(95% CI)	Multivariable analysis OR(95% CI)
Sex	Male	Ref	Ref
	Female	0.79(0.66-0.94)*	0.84(0.62-1.13)
Age		1.01(1.01-1.02)*	1.02(1.01-1.03)*
Days to detection		1.02(0.99-1.05)	1.02(0.98-1.06)
Geographic location	Others	Ref	Ref
	Greater Monrovia	0.78(0.38-1.61)	0.71(0.34-1.50)

Age and days to detection have odds ratios of around 1 in both the univariable and multivariable models and it is statistically significant for age in both models, meaning age has no effect on the outcome. There seems to be no significant difference in the odds of dying from EVD or surviving from EVD based on the geographic location.

a. Detection and Response to EVD in Montserrado County

The average days to detection for EVD survivors was 5.49 (SD=4.02) and 5.82 (SD=4.18) for fatalities. Days of response were 14.28 (SD=15.80) and 4.20 (SD=13.00) respectively.

Table 3: Days to Detection and Days of Responses among Fatalities and Survivors

Characteristics	Category	Recovered from EV	Died from EV
Total		**N=1123(55.3%)**	**N=909(44.7%)**
Days to detection	N(Mean)SD	599 (5.49)4.02	719 (5.82)4.18
Days of response	N(Mean)SD	641 (14.28)15.80	851(4.20)13.00

Majority (82.6%) of healthcare workers in the study reported that detection of EVD in Montserrado County was not carried out in a timely fashion. Time to response, as reported by the healthcare workers also followed a similar pattern with 89.2% of them indicating that the response to EVD was not timely.

The combined frequency distribution for days to detection and days of response are shown in Figure 4.3 and Figure 4.4 respectively.

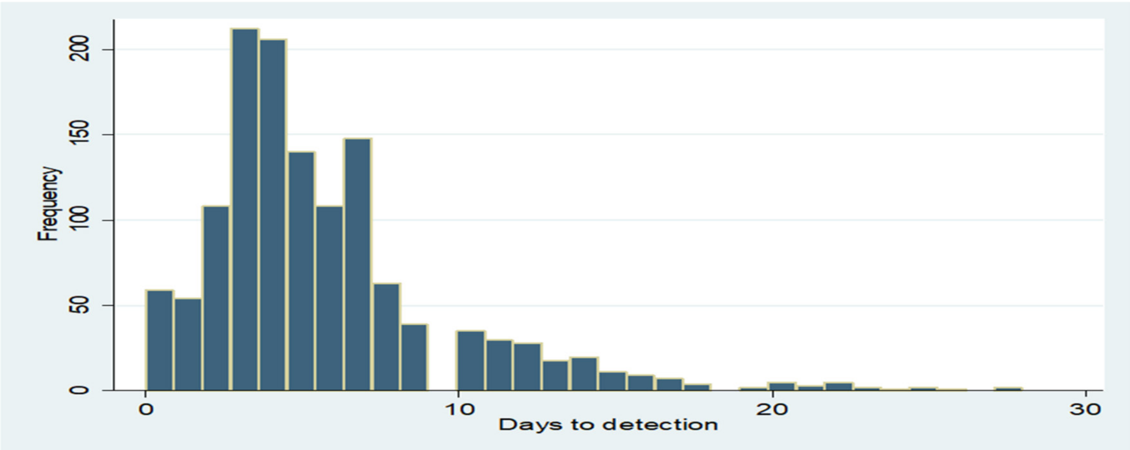

Figure 4.2: Days to detection which is the time difference between date of onset of symptoms and date of admission

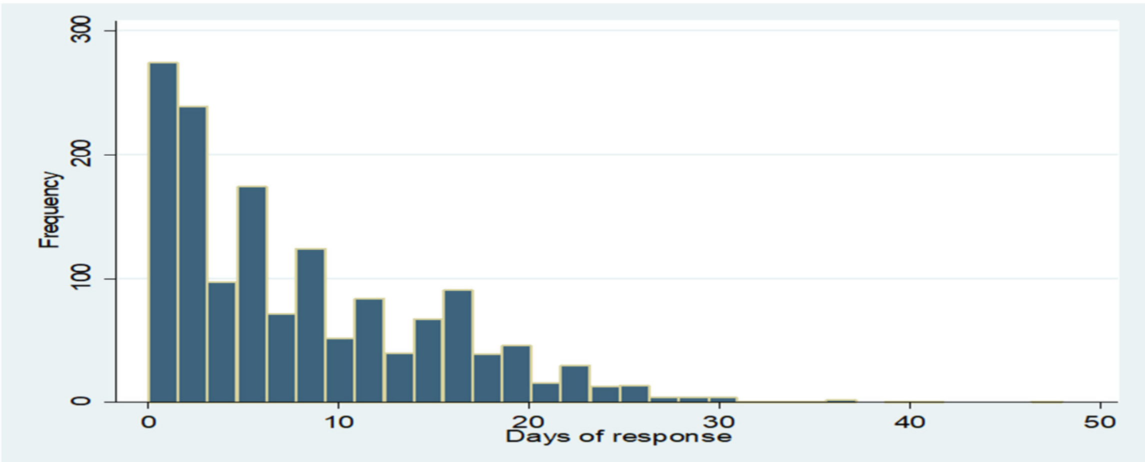

Figure 4.3: Days of care, which is the average time that each patient spent in the Ebola Treatment Unit

4.2. Discussion

4.2.1. Case fatality and associated factors

According to the WHO, the average case fatality rate for EVD is 50%, but over the past in different EVD epidemics, the fatality rate of the disease has varied from around 25% to around 90% (WHO, 2017a). The Ebola Zaire virus is classified as the most lethal with a case fatality rate that ranges between 60 and 88% (Khan *et al*., 1999). The case fatality rate identified in Montsserado County in Liberia by this study was 44.7%. The outbreak was reported to have been caused by Ebola Zaire virus. Studies also report the Ebola Sudan virus as being lethal with a case fatality rate ranging from 53 to 69% (Kerkhove *et al*. 2015). In the recent significant and protracted epidemic in West Africa, where 20200 cases had been reported as of December 31, 2014, the case fatality rates for Guinea, Liberia, and Sierra Leone were 63%, 42%, and 29% respectively. The case fatality rate for Nigeria, Mali, and Senegal were 40%, 75%, and 0% respectively (Cenciarelli *et al*., 2015).

The odds of dying from EVD among the females are 21% lower than that of the males. When adjusted for age, days of detection and geographic location the odds decrease to 16% although it was statistically significant. Age has no effect on the outcome. There seems to be no significant difference in the odds of dying from EVD or surviving from EVD based on the geographic location. In other studies, men have been shown to be exposed to the virus due to their responsibilities in caring for livestock, hunting activities, and an initial exposure to bush meat as opposed to women (Nkangu, Olatunde, and Yaya 2017). While age was not statistically significant in this study, patients of older age have been shown to be more vulnerable (Li *et al*. 2016). At the county level, geographical location was not found to be a factor of vulnerability, but across national borders, Liberia was among two other countries that were hit hardest. Studies have shown the case fatality of EVD to be higher in West African countries compared to European and other developed countries (Alexander *et al*. 2015; Vetter *et al*. 2016).

4.2.2. Detection and response

The days of detection among those who recovered from EVD were shorter 5.49±4.02 compared to fatalities 5.82±4.18. In relation to detection and response, 82% of the nurses included in the study reported that the identification of EVD in Montserrado was not in a timely manner. Similarly, 89% reported that response was not timely. Research proves that reducing the time to detection bears a momentous impact on various aspects of a response intervention. First, timely detection ensures better clinical management as the non-specific presentation of EVD may expose patients but early confirmation allows for better control of the infection and proper allocation of limited health resources. Second, early detection promotes community reintegration as negative results are imperative for patients to be received back into their communities. Third, timely testing allows families to continue with their burial plans as prescribed and assists in surveillance as well as contact tracing. Lastly, early identification and confirmation of true cases increase contact tracing efforts (Broadhurst, Brooks, and Pollock 2016).

4.2.3. Barriers to identification and response

This study adds to the WHO (2014) list of barriers to identification and response of EVD. Among the most significant barriers identified were lack of diagnostic capacity, limited knowledge on the disease, fear of contracting the disease, lack of support from the government, the attitude of the healthcare workers, sociocultural beliefs, poor infection control measures, shortage of health workers, and health workers strike.

As the world is working towards a vaccine and an effective drug for Ebola, community awareness and vigilance along with enhancing the global health security is crucial to the success in the fight against EVD. Researchers also show that since the natural history of the Ebola is known, if stakeholders take simple detection and control measures, there is absolutely no reason to fear (Broadhurst, Brooks, and Pollock 2016; Fletcher, Brooks, and Beeching 2014).

5. Conclusion

This study sought to determine the case fatality rate of EVD, factors associated with the case fatality, detection and response patterns, and barriers to detection and response to EVD in Montserrado County. The case fatality rate among EVD patients in the study area was 44.7%, which was slightly higher than the case fatality of Liberia, 42%, and lower than that of Guinea, 63%, reported in the literature. Gender was significantly associated with EVD case fatality rate. In addition, age and days to detection were assessed but the association was not found to be significant. The study also showed that detection of EVD was not done in a timely fashion. Among case fatalities, the days of detection were slightly more as compared to survival cases. Average days to detection was 4.49±4.02 for survivors and 5.82±4.18 among fatalities. The study identified various barriers to detection including limited knowledge of the disease, lack of capacity, fear, socio-cultural beliefs, and poor infection and control measures. Additionally, lack of support from government and government agencies, and attitude of health workers, in combination with the barriers to detection, made the response a challenge.

This study recommends improvements in the healthcare system in Liberia to enable faster detection of cases since delaying of detection means that the case fatality rate increases. Proper health education regarding the use of protective equipment to women who care for sick Ebola patients at home and men who are involved with handling meat in rural settings will help reduce case fatality rate that was shown to be associated with gender. This study also recommends that integrated disease surveillance and response teams should be keen on their disease identification and report to ensure that the rate of survival increases. There is also need for both health practitioners as well as other key people in the affected communities to help break barriers to detection and response, particularly as relates to fear, socio-cultural beliefs, and infection control measures.

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Table 1: Factors Associated with Fatality among EVD Cases

Characteristics	Category	Univariate analysis OR(95% CI)	Multivariable analysis OR(95% CI)
Sex	Male	Ref	Ref
	Female	0.79(0.66-0.94)*	0.84(0.62-1.13)
Age		1.01(1.01-1.02)*	1.02(1.01-1.03)*
Days to detection		1.02(0.99-1.05)	1.02(0.98-1.06)
Geographic location	Others	Ref	Ref
	Greater Monrovia	0.78(0.38-1.61)	0.71(0.34-1.50)

Table 2: Days to Detection and Days of Responses among Fatalities and Survivors

Characteristics	Category	Recovered from EVD	Died from EVD
Total		N=1123(55.3%)	N=909(44.7%)
Days to detection	N(Mean)SD	599 (5.49)4.02	719 (5.82)4.18
Days of response	N(Mean)SD	641 (14.28)15.80	851(4.20)13.00