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# The Effect of Social Vulnerability during the 2014 Ebola Outbreak in Monrovia, Liberia

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Abstract

Background: Ebola virus disease (EVD) is a dangerous, often fatal disease that spreads through infected bodily fluids. In 2014, an Ebola outbreak swept through West Africa, including Liberia.

Purpose: The purpose of this study is to examine how social vulnerability affected different aspects of life during the 2014 Ebola outbreak in Monrovia, Liberia. The association between vulnerability and hardship that people experience during the outbreak was examined. This was measured by indicator variables for hardship such as availability of food, cash, or medical care. Vulnerability was also compared with EVD knowledge and vigilance.

Method: An additive index for social vulnerability was constructed using demographic variables such as age and gender. A logistic regression was conducted between social vulnerability and hardship outcome variables. EVD knowledge and EVD vigilance were also compared with vulnerability through logistic regression.

Results: There was a significant relationship between social vulnerability and the availability of medical treatment, food, and employment. Odds ratios were observed between social vulnerability and some individual hardship variables. Vulnerable people were more likely to have no access to medical care or cash and less likely to know an Ebola survivor. Additionally, vulnerable people were more likely to have incorrect EVD knowledge and less EVD vigilance.

Conclusions: Social vulnerability is significantly associated with some aspects of hardship that people can experience, as well as EVD knowledge and vigilance. Further research is needed to observe the impact of vulnerability during crises, as well as comparing vulnerability during crises to normal life.

*Keywords*: Ebola Virus Disease, EVD, Pandemic, Vulnerable, Impact, Hardship, Africa

# The Effect of Social Vulnerability during the 2014 Ebola Outbreak in Monrovia, Liberia

An outbreak of Ebola virus disease (EVD) began in Guinea on December 13, 2013 (World Health Organization [WHO], 2016a). A single boy, playing under a tree where infected bats roost, contracted a mysterious illness. Soon, his mother, grandmother, and sister, contracted the same disease as well. All four died. The disease would continue to spread throughout the community, sowing death where it went. Despite the severity of the disease, it wasn't until March 2014 that the disease was identified as *Zaire ebolavirus* (Shultz, Espinel, Espinola, & Rechkemmer, 2016). This prompted the World Health Organization (WHO, 2014a) to issue a communique on March 23, 2014 announcing an Ebola disease outbreak in Guinea. This communique was the first of many, as the disease would continue to spread from 2014 to 2015, reaching neighboring countries such as Liberia and Sierra Leone (Dixon & Schafer, 2014; WHO, 2016a). By October 2014, Ebola virus had reached all 15 counties of Liberia (Centers for Disease Control and Prevention [CDC], 2014). Over the span of the outbreak period, there was an estimated 28,616 cases and 11,310 deaths in Liberia, Guinea, and Sierra Leone (WHO, 2016b).

The Ebola disease is a severe, often fatal disease caused by the Ebola virus. Ebola has an incubation period from two to 21 days, during which the individual is not infectious (WHO, 2018). Ebola spreads through contact with infected bodily fluids, such as blood, secretions, or infected surfaces (WHO, 2018). The first symptoms to develop include fever, muscle pain, sore throat, and headaches. After that, vomiting, diarrhea, rash, and impaired liver and kidney function begin to manifest. External and internal bleeding can also occur (WHO, 2018).

The case-fatality rate of EVD varies depending on certain outbreaks, ranging from 25% to 90% in some cases. The average case-fatality rate is 50% (WHO, 2018). There is currently no

official treatment or vaccine for Ebola disease. Treatment against EVD is limited to supportive care and reducing the symptoms to improve survival (WHO, 2018).

Previous research has attributed the rapid and prolonged outbreak of EVD to weak health systems, various sociocultural factors, and high cross-border movement between countries (Cranmer et al., 2015; Kieny, Evans, Schmets, & Sowmya, 2014). Shultz, Espinel, Espinola, and Rechkemmer (2016) reported that EVD moved from the forest and savannah to rural villages via human-animal contact. The disease would then spread from villages to urban cities to medical facilities, eventually finding its way to foreign shores due to international air travel.

When the outbreak struck many people suffered hardships that destabilized their lives, including loss of employment, lower income, and a lack of access to food or healthcare. Vulnerable populations in particular, such as elderly or those with large households, suffer the brunt of the destructive effects of the outbreak (Cutter, Boruff, & Shirely, 2003).

A study by Blair, Morse, and Tsai (2017) examined the association between public trust in government and compliance with EVD control measures. They found that people who had low trust in the government were more likely to ignore social-distancing mandates or not comply with EVD precaution measures. Another study examined the patterns of non-Ebola health services demand during the outbreak (Morse, Grépin, Blair, & Tsai, 2017). The authors concluded that negative EVD experiences and distrust in the government were negatively associated with health services demand.

Both of these studies utilized the same dataset as this study. The dataset is comprised of survey responses from a random sample of 1,572 people from Monrovia, Liberia. Respondents were asked questions about their demographic information, EVD knowledge and awareness, and economic impact during the 2014–2015 Ebola outbreak.

## Statement of Purpose

The purpose of this study was to examine how social vulnerability affected the population's experiences during the Ebola outbreak in Monrovia, Liberia. The effects of vulnerability can include the hardship a person suffers, their knowledge in EVD, and vigilance for it. Vulnerability is defined as an individual, family, or community's inability to anticipate, resist, cope with, or recover from the effects of a disaster (WHO, 2002b). Hardship is defined as the difficulty and challenges that an individual or family suffers over the course of the disaster, such as lack of employment, food, or medical care.

This study also examined social vulnerability and how such vulnerable populations were affected during the outbreak. By examining social vulnerability and its relationship with hardship during the outbreak, it is possible to create interventions that better support vulnerable populations in the future. The findings from this study would help better understand how vulnerability impacts people during a disaster and how to better prepare to prevent adverse outcomes in the future.

First, a social vulnerability index (SVI) will be compared with various indicator hardship variables. Second, the SVI will be compared to variables for EVD knowledge and EVD vigilance.

## Literature Review

Liberia is a low-income country; one of the poorest in Africa. The population size is approximately 4.5 million people, with over 60% under the poverty line. The population is predominantly Christian (United Nations Development Programme [UNDP], 2018). A 2014 census reports that male to female ratio is approximately 94.3 and the average household size is

4.3 persons per household (Liberia Institute of Statistics & Geo-Information Services [LISGIS], 2016).

Liberia was one of the countries that was hardest hit by the Ebola outbreak, along with Guinea and Sierra Leone. From 2013 to 2016, 10,678 cases of Ebola were recorded with 4,810 deaths, resulting in a case-fatality rate of 45.0% (Shultz et al., 2016). Once the Ebola outbreak peaked around October 2014, numerous public health entities such as the WHO, Centers for Disease Control and Prevention (CDC), and Doctors without Borders intervened. By November 2014, EVD cases were beginning to decrease in Liberia (Shultz et al., 2016).

The Ebola outbreak crippled the Liberian population and their economy. During the three years of the outbreak, there was zero growth in the country (UNDP, 2018). The prices of international commodities, such as iron ore and palm oil, plummeted. An already vulnerable and struggling economy was forced to rely even more on foreign aid and assistance to survive. There is little chance for improvement in the short-term (UNDP, 2018).

During the outbreak, the chances of contracting Ebola depended on a number of factors. Some activities were associated with an increased risk for Ebola transmission. A study on patient survival during the outbreak found people who interacted with a probable, suspected, or confirmed case of EVD were five times more likely to contract Ebola. Furthermore, a person who attended a funeral service for an Ebola patient had a four times increased chance of transmission (Weppelmann et al., 2016).

When tragedy strikes, it does not strike everyone equally. Disasters rarely cause a significant change in mortality, but they do harshly expose the underlying social, economic, and health inequities in the community. These inequalities are represented as not receiving timely aid, poor community resilience, or an increase in mortality.

An example of such inequality can be seen after Hurricane Katrina. In the wake of the hurricane many people were left stranded, simply because authorities had not considered them for emergency transit (National Council on Disability [NCD], 2006). In another study, Flanagan, Gregory, Hallisey, Heitgerd, and Lewis argue that populations whose needs are not properly considered and planned for beforehand are the most vulnerable. These people are more likely to suffer the effects of the disasters and less likely to be resilient afterward (Flanagan et al., 2011). Thus, the more vulnerable a population is, the more it has to lose when a tragedy strikes and the less likely it will receive the aid it needs to survive.

Vulnerability is a well-known concept in the field of public health and emergency preparedness. That said, there are a multitude of differing definitions and usages for the term, depending on the agency and discipline.

The World Health Organization (WHO, 2002b) refers to vulnerability as the ability, or lack thereof, of an individual, family, or community to handle the effects of disaster. This definition does not fully address how vulnerable populations are created prior to a disaster or the factors that go into their development. Nevertheless, it provides a simplified view into population vulnerability and how it affects disaster response and community resiliency.

In social science literature, the concept of ‘Social Vulnerability’ is also introduced. Flanagan et al. (2011) define social vulnerability as the socioeconomic and demographic factors that affect the resilience of a community.

In a study by Cutter, Boruff, and Shirley (2003), they determined that an SVI can be created using socio-economic and demographic data. This SVI can then be used to guide interventions and public health efforts. In the study, the authors construct an SVI then

demonstrate its use by comparing counties in the United States to one another (Cutter et al., 2003).

This study is crucial in that it introduces the concept of an SVI and demonstrates its feasibility in public health research. According to the Cutter et al. (2003) paper, an SVI can be constructed from a number of different factors. This can include individual factors such as gender, education, and occupation, as well as social factors such as population growth and healthcare availability. For the purposes of this study, social vulnerability as defined by Flanagan et al. (2011) was used.

This study followed the SVI method introduced in the paper by Cutter et al. (2003) to create the social vulnerability variable for Monrovia, Liberia. In the paper, the authors suggest various different variables that could be used to measure vulnerability; mostly socio-economic and geographical. They also provide a method for coding the variables to make the SVI; whether increasing vulnerability denoted as '+1' to SVI or lowering vulnerability denoted as '-1' to SVI. Variables that are believed to have no impact on vulnerability were denoted as '0' to SVI.

Previous research on vulnerable populations is valuable in identifying them and their determinants. It is important to recognize that most research on vulnerable populations is US-centric. This is to say that previous research assumes the country of origin is the United States (U.S.) and that a vulnerable population would include a minority U.S. population such as African Americans, or non-English speaking group, such as immigrants (Cutter et al., 2003; Flanagan et al., 2011).

This is not applicable to this study, where the country of origin is Liberia. The racial and linguistic dynamics that define a U.S. minority group, and in turn a potentially vulnerable

population, do not apply here. Vulnerable populations in Liberia are defined using more universal determinants, such as age, gender, and socioeconomic status.

The hardship that people suffer during or after a disaster is also frequently considered during disaster planning. Hardship is defined as the difficulty or suffering that a population undergoes as a result of a disaster. Depending on the location and the population, the type and magnitude of hardship can differ. In Liberia, this can include lack of access to food or healthcare, cash shortages, and loss of employment. In the case of an epidemic, as is the case with the Ebola outbreak, this can include contracting the disease.

This study examined the association between social vulnerability and hardship, as represented by various questions. A previous study by Blair et al. (2017) used a hardship index; an additive index to represent the culmination of hardship that a person can experience during the outbreak period. It is difficult, however, to estimate or measure hardship as a variable since quantifying suffering is inherently unfeasible. As a result, there is no clear methodology on how to construct a hardship variable. In their paper, Blair et al. (2017) created a hardship index by gathering responses for questions such as seeing dead bodies, knowing EVD victims, or whether they forwent medical treatment in the past three months. This hardship index was found to be strongly negatively associated with trust in the government (Blair et al., 2017). Although this hardship index was novel in its construction, Blair et al. (2017) cite no previous literature to support their variable construction method. As a result, there is no evidence to suggest that their methodology is valid or if the variables they chose are sufficient indicators of hardship.

The dataset used for this study was utilized in two other papers. The study by Blair et al. (2017) examined the association between public trust in government and compliance with EVD control measures. The results of the study indicated that distrust in the government was

associated with lower compliance with EVD precautions and government-mandated social distancing. Furthermore, it was shown that people with low trust in the government were not more or less likely to know more about EVD or its transmission. This suggests that distrust towards the government is not due to ignorance of EVD but a lack of faith in the government's ability to control it or provide accurate advice (Blair, Morse, & Tsai, 2017).

Hardship experienced during the epidemic was defined using five questions, with some similarities to the study by Morse, Grépin, Blair, and Tsai (2017). If the respondent saw any dead bodies on the street, if they knew any Ebola victims, if they lost their job in the past six months, if they or their family had forgone medical treatment in the past three months (Blair et al., 2017).

As mentioned previously, this method of measuring hardship is imprecise; it does not include the different types of hardship that people can experience, such as food or cash shortages. Furthermore, the authors neglect to cite any literature that supports their hardship variable construction.

Morse et al. (2017) examined the patterns of non-Ebola health services demand during the outbreak. They also utilized the same dataset in this study. Their results showed a 77% and 104% increase in health services usage for children and adults respectively between the late-stage and post-crisis period. The prevalence of disease was relatively stable throughout all stages of the dataset. This indicates a resurgence in demand for health services as the outbreak period began to end. During the late-crisis stage period, exposure to EVD and distrust in government strongly predicted reduced health services utilization. On the other hand, participation in governmental community outreach predicted higher trust in the government and health services usage (Morse et al., 2017).

The sample population used for these latter two studies, a randomized sample from Monrovia, is the same as this study. The dataset that was utilized by Morse et al. (2017) and Blair et al. (2017) is the exact same as this study, as well. These studies are important because they utilize the same sample population as this study. Since the authors of those papers also created the dataset initially, their knowledge on the data collection method, response rate, and limitations of the sample dataset are valuable.

Their methods of constructing variables and analyzing the data are also directly applicable to this study. In the study by Blair and colleagues (2017), there were six categories of variables that were used, this included trust in government, compliance with EVD control measures, support for EVD control interventions, knowledge about EVD, and hardships experienced during the epidemic. To create the index variables, the responses of multiple questions were aggregated together.

## Method

### Data Collection

The data for Ebola Recovery dataset was retrieved from the United Nations Office for the Coordination of Humanitarian Affairs' data exchange (Humanitarian Data Exchange [HDX], 2015). IBM SPSS Statistics 24 was used for all data analyses. This research was considered 'Exempt' from Institutional Review Board review because the data were not individually identifiable and the study was therefore was not covered by 45 CFR part 46 (see Appendix A).

The data was collected from an in-person household survey in Monrovia, Liberia, conducted from December 6, 2014 to January 7, 2015. Data collection was a collaboration effort between a Liberian NGO called Parley and the authors of two previously published papers (Blair et al., 2017; Morse et al., 2017).

The data was collected in three stages. The first stage was from December 6, 2014 to January 7, 2015. This was referred to as the 'late-crisis' stage of the Ebola outbreak. This stage took place approximately two months after the peak of active transmission and the social and economic impacts of the epidemic. Two follow up surveys were also conducted by phone from March 16, 2015 to April 3, 2015 and June 10, 2015 to July 10, 2015. These follow up surveys were conducted in the 'post-crisis' stage of the outbreak (Blair et al., 2017; Morse et al., 2017).

The survey asked participants about their backgrounds, knowledge of Ebola, economic impact, and experiences during the outbreak. The response rate from this survey was 95%. The December sample included 1,572 participants. For the two follow-up surveys, the March sample included 774 and the June sample included 928 participants (Blair et al., 2017; Morse et al., 2017). For the purposes of this study, only information gathered in December will be used.

To compare vulnerability and hardship, an SVI was created. It was comprised of responses to demographic questions that were made into an additive index. The SVI was then compared to the hardship variables to examine associations. Additionally, EVD knowledge and EVD vigilance in populations were compared with the SVI for examination.

**Variable Construction**

Background variables were included in the sample, such as age, gender, household size, education, and religion. The exposure variable was the social vulnerability index. Outcomes were measured using variables representing 'Hardship', 'EVD Knowledge', and 'EVD vigilance'.

Each of the variables represents a question that was asked to the survey respondent. Depending on the question, they could answer them as 'yes' or 'no', or choose an answer based on a scale. For example, a question could ask if the respondent lost their job in the last six

months, which could be answered as yes or no. Alternatively, a question could ask how often the respondent had to forgo medical treatment in the past three months, to which they can respond ‘never’, ‘once or twice’, ‘several times’, and so on.

The SVI was constructed using questions that asked about a respondent’s age, gender, education, household size, and occupation. Responses to these questions were collected and used to create an additive index. The higher a person’s index level, the more vulnerable they were.

Using previous literature, each response was coded with a numerical value. If a response increased a person’s vulnerability, it was coded as ‘1’. If a response lowered a person’s vulnerability, it was coded ‘-1’. If a response had potentially no impact on vulnerability it was coded as ‘0’. These values were then added together to create the SVI. The index ranged from -2 to 5.

For the purposes of this study, a different definition of social vulnerability emphasizes more universal determinants of a vulnerable population such as age, gender, education, and income. Each of these determinants used Liberian population averages as a baseline to create the vulnerable population. When determining the age range of elderly persons, a 2001 WHO (2002a) report defined the elderly population in Africa as anyone above the age of 50. According to a 2014 Liberian census, the average household size of a Liberian household was 4.26 individuals per household (LISGIS, 2016).

**Hardship** refers to the difficulties that a respondent suffered during the outbreak period. Questions about the availability of medical care, food, cash, and employment were used for analysis. Additionally, respondents were asked if they knew any Ebola survivors in their community.

Other variables were used as indicators to test for EVD knowledge and vigilance. **EVD Knowledge** refers to the respondent's knowledge about Ebola virus disease, its symptoms, and transmission. To measure their knowledge, questions about Ebola transmission and treatment were used. **EVD Vigilance** refers to the respondent's awareness about Ebola disease and the precautionary measures they take to prevent infection. For example, questions about using hand sanitizer daily or knowing the Ebola hotline number were used to measure EVD vigilance.

The individual questions were used as outcome variables which were divided into three categories by compiling questions with a common theme together. These categories were 'excessive hardship'. 'EVD knowledge', and 'EVD vigilance'. Responses for each question were collected and recoded into '0' and '1' for logistic regression. If the question had more than two responses, they were collapsed into two, then recoded.

**Statistical Analysis**

Three tables were created to display the variables used in the study. The first table was created for descriptive statistics for the demographic information of the sample population. A second table was created to show the SVI as well as the questions used to create it and how they were coded. Each question shows the responses used, the number of responses and percentage, and the coding assigned to it. A third table was created to show the frequency for outcome variables used the binary logistic regression analyses.

It is important to note that some variables had missing cases. These are situations where the respondents chose to not answer the question. In some cases, the response was coded incorrectly, which invalidated the entry and was removed.

Binary logistic regression was used to test the association between social vulnerability and individual hardship variables, EVD knowledge, and EVD vigilance. The SVI was held as the

dependent variable while each variable was inputted as the outcome variable. All tests were two-sided and conducted at the $\alpha = .05$ level of significance. The odds ratio, p-value, and 95% confidence interval for the odds ratio were reported for each outcome variable.

## Results

Table 1 shows the demographics of the sample, along with SVI after it was created.

Table 1

*Demographic Information of the Sample*

| **Characteristic** | **Overall** *N*=1,572 |
|---|---|
| Age (years), *mean* ± *sd* | 36.85 (12.7) |
| Sex, *n (%)*[1] | |
| Male | 697 (44.6) |
| Female | 865 (55.4) |
| Education, *n (%)*[1] | |
| Less Than High School | 848 (54.3) |
| High School or Some University | 645 (41.3) |
| Completed University | 50 (3.2) |
| Other | 19 (1.2) |
| Occupation, *n (%)* | |
| Unemployed | 211 (13.4) |
| Sales and Services & Professional | 610 (38.8) |
| Clerical and Domestic Services | 123 (7.8) |
| Manual and Agriculture | 441 (28.1) |
| Other | 187 (11.9) |
| Household Size, *n (%)* | 7.6 (4.4) |
| Religion, *n (%)*[1] | |
| Christian | 1,400 (89.6) |
| Muslim | 153 (9.8) |
| Other | 9 (0.6) |

[1]Ten (10) cases missing, removed.

The analysis shows that there was a relatively even split in gender, with a slight majority being female (55%) (Table 1). The vast majority of respondents were Christian (89.6%). When asked about occupation approximately 12% replied ‘Other’, not choosing any of the options

above (Table 1). The survey did not ask respondents to specify which occupation or religion if they chose 'Other'.

Table 2 contains the descriptive statistics for each variable used to create the SVI as well as the mean of the SVI. The frequencies for each variable was reported as well as how each response was coded.

Table 2

*Descriptive Statistics of SVI and the Variables Used to Create It*

| **Variables** | ***N* (%)** | **Response Coding** |
|---|---|---|
| **Social Vulnerability Variables** | | |
| Age | | |
| Less than 50 | 1,312 (83.5) | 1 |
| 50+ years or more | 260 (16.5) | 0 |
| Gender[1] | | |
| Male | 697 (44.6) | 0 |
| Female | 865 (55.4) | 1 |
| Education[1] | | |
| Less Than HS | 848 (54.3) | 1 |
| Completed HS, Some College, Other | 664 (42.5) | 0 |
| Completed University | 50 (3.2) | -1 |
| Household Size | | |
| 8 persons or Less | 937 (59.6) | 0 |
| Above 8 persons | 635 (40.4) | 1 |
| Occupation | | |
| Professional | 199 (12.7) | -1 |
| Other | 187 (11.9) | 0 |
| Clerical, Domestic, Manual, None, Agriculture, Sales & services | 1,186 (75.4) | 1 |
| **Social Vulnerability Index, *mean* ± *sd*[1]** | 2.3 (1.4) | |

[1]Ten (10) cases missing, removed.

In order to create the SVI, each variable was recoded into two separate entries collapsing some variables together. The number of responses for each category and their percentages is depicted, as well as the coding that was given to them.

The table results indicate that the majority of the sample population was younger than 50 and did not work as professionals (Table 2). Approximately 40% of the population lived in a

household of eight persons or more, including the respondent. After the SVI was calculated, the mean SVI was 2.3 with a standard deviation of 1.4 (Table 2). The mean SVI was considered middling for the range of SVI values.

Table 3 shows the outcome variables that were used for the binary logistic regression. They were split into three categories: excessive hardship, EVD knowledge, and EVD vigilance.

Table 3

*Descriptive Statistics of the Outcome Variables Representing Hardship, EVD Knowledge, and EVD Vigilance*

| **Variables** | ***N* (%)** |
|---|---|
| **Excessive Hardship Variables** | |
| No Medical Treatment in Past Three Months | |
| None/Once or Twice | 1,219 (78.4) |
| Several Times or More | 335 (21.6) |
| No Cash Since July 2014 | |
| None/Once or Twice | 546 (35.2) |
| Several Times or More | 1,003 (64.8) |
| No Food Since July 2014 | |
| None/Once or Twice | 679 (43.8) |
| Several Times or More | 870 (56.2) |
| Losing Job in Past Six Months | |
| No | 828 (53.3) |
| Yes | 725 (46.7) |
| Working Less Compared to Normal Times | |
| No | 548 (35.3) |
| Yes | 1,004 (64.7) |
| Family Member Losing Job Past Six Months | |
| No | 868 (55.9) |
| Yes | 685 (44.1) |
| Family Members working Less Compared to Normal Times | |
| No | 634 (40.9) |
| Yes | 915 (59.1) |
| Know Any Survivors of Ebola in Community | |
| No | 1,114 (83.1) |
| Yes | 227 (16.9) |

Table 3 (Cont'd)

| **Variables** | ***N* (%)** |
|---|---|
| **EVD Knowledge** | |
| Ebola Can Be Spread by Air | |
| No *(Correct Answer)* | 1,230 (78.9) |
| Yes/Don't Know | 329 (21.1) |
| Ebola Can Be Spread by Body Fluids | |
| False | 60 (3.8) |
| True *(Correct Answer)* | 1,499 (96.2) |
| Ebola Can Spread Before Symptoms Develop | |
| False *(Correct Answer)* | 614 (39.6) |
| True/Don't Know | 937 (60.4%) |
| Drinking Salt Water Can Cure Ebola | |
| False *(Correct Answer)* | 1,407 (90.9) |
| True | 141 (9.1) |
| **EVD Vigilance** | |
| There is a Community Awareness Group to Spreads News About Ebola | |
| No | 303 (19.4) |
| Yes | 1,258 (80.6) |
| Use Hand Sanitizer Daily | |
| No | 874 (56.0) |
| Yes | 687 (44.0) |
| Keep Bucket of Chlorine Water at Home for Handwashing | |
| No | 362 (23.2) |
| Yes | 1,199 (76.8) |
| Know the Ebola Hotline Number | |
| No | 801 (51.4) |
| Yes | 758 (48.6) |

With regards to hardship, the majority of respondents did not get medical treatment or received it sparingly in the last three months since taking the survey (78.4%). The vast majority of respondents also reported that they did not know of any Ebola survivors in their community (83.1%).

When testing EVD knowledge, the majority of respondents were able to correctly answer questions about Ebola virus transmission. Approximately 91% of all respondents also disagreed

with the statement that drinking salt water cures Ebola (Table 3). When testing EVD vigilance, the results varied. A majority of respondents reported that they had a community awareness group for Ebola news (80.6%) as well as having a bucket of chlorine water for handwashing at home (76.8%) (Table 3). However, nearly half of the respondents reported that they did not use hand sanitizers daily (44%) and did not know the Ebola hotline number (48.6%) (Table 3).

Table 4 shows the results of the logistic regression tests that were conducted between the SVI and the hardship outcome variables.

Table 4

*Logistic Regression of Excessive Hardship Variables*

| **Excessive Hardship Variables** | **OR** | **95% CI** | ***p*** |
|---|---|---|---|
| No Medical Treatment in Past Three Months | 1.23 | 1.12 – 1.35 | <.001 |
| No Cash Since July 2014 | 1.00 | 0.92 – 1.07 | 0.908 |
| No Food Since July 2014 | 1.11 | 1.04 – 1.20 | .004 |
| Losing Job in Past Six Months | 0.94 | 0.87 – 1.01 | .089 |
| Working Less Compared to Normal Times | 0.91 | 0.84 - 0.98 | .013 |
| Family Members Lost Job in Past Six Months | 1.08 | 1.00 – 1.16 | .040 |
| Family Members Working Less Compared to Normal Times | 1.01 | 0.94 – 1.09 | 0.768 |
| Knowing Any Survivors of Ebola in Community | 0.87 | 0.79– 0.97 | .009 |

Note: OR = Odds Ratio, CI = Confidence Interval, *p* = *p*-value

All of the variables shown were hardship variables. Each variable was chosen as an indicator for the hardship that a person potentially experiences during the outbreak period. Of the eight hardship variables, five were significantly associated with the SVI. The three outcome variables with the highest odds ratios were availability of medical treatment, food, and knowing

Ebola survivors. Availability of cash, personal loss of employment, and family members working less compared to normal times were not significantly associated with the SVI (Table 4).

Five of the hardship variables were significantly associated with social vulnerability. Three of these variables had odds ratios higher than one; the availability of medical treatment, food, and family members losing their jobs. A 1-degree increase in SVI was associated with a 23% increase in likelihood to forgo medical treatment several times or more in the past six months, and 23% less likely to know Ebola survivors in their community. Two of the variables had odds ratios less than one; working less during normal times and knowing Ebola survivors.

Table 5 shows the logistic regression of the SVI with outcome variables for Ebola disease knowledge, and vigilance. The variables reported below are the outcome variables only.

Table 5

*Logistic Regression of EVD Knowledge and Vigilance Variables*

| **Variables** | **OR** | **95% CI** | ***p*** |
|---|---|---|---|
| **EVD Knowledge** | | | |
| Ebola spreads by air | 1.38 | 1.25 – 1.53 | <.001 |
| Ebola spreads by body fluids | 0.73 | 0.59 – 0.91 | .004 |
| Ebola spreads before becoming symptomatic | 1.20 | 1.11 – 1.29 | <.001 |
| Drinking salt water cures Ebola | 1.16 | 1.02 – 1.33 | .029 |
| **EVD Vigilance** | | | |
| Do you have a community awareness group for News? | 0.91 | 0.83 – 1.00 | .0540 |
| Do you use hand sanitizer daily? | 0.80 | 0.74 – 0.86 | <.001 |
| Do you have a bucket for handwashing at home? | 0.84 | 0.77 – 0.92 | <.001 |
| What is the Ebola hotline number? | 0.65 | 0.60 – 0.70 | <.001 |

Note: OR = Odds Ratio, CI = Confidence Interval, *p* = *p*-value

Each variable was chosen to act as an indicator for the specific characteristic that was tested for. All the variables that test for Ebola disease knowledge were significantly associated with the vulnerability index. Three of the variables that tested for EVD vigilance were statistically significant, with all the variables having an odds ratio lower than one (Table 5).

## Discussion

It was hypothesized there would be a significant association between social vulnerability and the hardship variables. It was found that the SVI was significantly associated with some hardship variables while others are not. Out of the eight hardship outcome variables, five were significantly associated with the SVI.

A 1-point increase in SVI was associated with a 23% increase in likelihood to forgo medical treatment several times or more in the last three months (Table 4). This suggests that people who are vulnerable; whether socially or economically could not access care easily. This can be attributed to multiple factors. The cost of health care can be prohibitive, though it is possible that transportation or the time needed to access medical care was not available.

A 1-degree increase in the SVI was associated with a 11% increase in likelihood to not have food available several times or more since July 2014, and an 8% increase to have a family member lose their job in the last six months. Interestingly, the odds of working less compared to normal times decreased for more vulnerable people (OR = 0.907) (Table 4). Though these results are statistically significant, they are not large in magnitude.

People with a higher vulnerability index were less likely to know an Ebola survivor in their community (OR = 0.873) (Table 4). The reason for this association is unclear. It is possible that only a small minority of people were actually infected with Ebola in Monrovia. Out of an urban population of 2.3 million, there was approximately 7,800 cases in January 2015. The case-

fatality rate for EVD in 2014 Monrovia was 39.5% (LISGIS, 2016; Schultz et al., 2016). This means the chances of knowing an Ebola patient is very low, let alone an Ebola survivor.

It is also possible that people living in vulnerable communities who were infected with Ebola were less likely to survive. Previous literature has suggested that basic medical care can drastically improve the odds of surviving EVD (Weppelmann et al., 2016). It is possible that people in vulnerable communities could not access medical care and decreased their odds of survival. There is not enough data to draw this conclusion, however, since more data would be necessary to compare health outcomes between vulnerable and non-vulnerable populations.

The difference in association between hardship variables can be explained by the different circumstances people go through. It is likely that people experience hardship in different ways; one person may report lack of medical care and not a lack of food, for example. Another respondent may work less compared to normal times but not lack cash.

The results showed a significant relationship between EVD knowledge and social vulnerability. All EVD knowledge outcome variables were significantly associated with the SVI. A 1-degree increase in the SVI was associated with a 38% increase in likelihood to believe that Ebola is transmitted by air droplets and 27% less likely to believe that Ebola spreads by body fluids (Table 5). According to the WHO, the Ebola virus transmits through bodily fluids such as saliva and vomit and not air droplets (WHO, 2018). An increase in SVI was also associated with a 16% more likelihood to believe that drinking salt water cures EVD and 20% more likelihood to believe that the Ebola virus can spread during the incubation period (Table 5). A report by the WHO notes that drinking salt water to cure Ebola is a common rumor with no basis in fact and two people have died attempting this. Furthermore, the report states that the Ebola virus does not transmit until the person develops symptoms (WHO, 2014g).

The results of the regression indicate that individuals who have a higher SVI, and are thus more vulnerable, are more likely to have inaccurate or false information regarding the Ebola virus disease. Vulnerable people are less likely to attain higher education and high-paying occupations, making them more susceptible to misinformation.

EVD vigilance also decreased as vulnerability increased. Of the four variables used to represent EVD vigilance, three were significantly associated with the SVI. A 1-point increase in SVI was associated 35% decrease in likelihood to know the Ebola hotline. There was also 20% decrease in likelihood to use hand sanitizer daily and 16% decrease in likelihood to keep a bucket of chlorine water at home to prevent Ebola transmission (Table 5).

The results indicate that vulnerable people were less vigilant of Ebola disease than their less vulnerable counterparts. This manifested in not taking the proper precautions to prevent Ebola transmission such using hand sanitizer or keeping a bucket of chlorine water available. They were also less likely to take preemptive action for Ebola cases, such as memorizing the Ebola hotline number. It is possible that these individuals did not receive proper briefings on Ebola outbreak procedure. However, the presence of a community awareness group was not significantly associated with vulnerability. Thus, it also likely that vulnerable people received Ebola outbreak information but simply do not act upon it.

Morse et al. (2017) showed that public trust was significantly associated with governmental outreach. If these people had less trust in the government and their ability to control the disease, it is possible they disregard information. When considering that vulnerable people knew less about Ebola, it is also possible that they underestimated the effect of Ebola and or its transmission, and thus were less vigilant than others.

## Limitations

There are several limitations to this study that must be addressed. The dataset used for this study was gathered from a survey. This survey was administered in December 2014, two months after the peak of the outbreak (Blair et al., 2017; Morse et al., 2017). There is no similar data on Monrovia prior to the outbreak period. Thus, it is impossible to make a comparison between the results of this study and the results from a period prior to the outbreak. As a result, most conclusions drawn from this study are only applicable to the outbreak period.

Another limitation is the way questions were asked. Some questions had 'other' as a possible answer but did not ask the participant to specify what they meant afterwards. This was observed in the occupation, education, and religion variables. For example, approximately 12% chose 'other' for their occupation (Table 1). This resulted in a significant amount of cryptic or vague entries, with no way to understand their meaning. It is believed that this oversight has skewed the results to some degree.

Lastly, this study can only prove that an association between vulnerability and these outcomes exist. Based on the results of this study, causation between vulnerability and these outcomes cannot be established. Much of the causation guidelines required to establish a causal link are not present. Hardship experienced cannot be specifically tied to vulnerability, and there is no way to measure if hardship during the outbreak was significantly different from normal times.

## Recommendations and Conclusion

Further research on Liberia is need. A study that examines the social, economic, and health status in Liberia prior to the outbreak period would provide valuable context to compare the hardships that people suffered during the outbreak to those they suffer on a 'normal' basis.

Without literature on the normal conditions of a society, it is impossible to understood how those conditions meaningfully change during an emergency and how vulnerability affects people.

Furthermore, research is needed to understand how vulnerability is associated with hardship. It is possible to compare how vulnerability in different populations and cultures is represented. It is also possible to examine how the hardship that people go through can also differ. For example, the hardship that a Liberian experienced during the Ebola outbreak might be significantly different from that a Guinean might have experienced, despite both being Ebola disease crises. It is recommended that a study examine the association between vulnerability and health outcomes with the goal of establishing causation.

The results of this study suggest that social vulnerability significantly affected an individual's experiences during the 2014–2015 outbreak period in Monrovia, Liberia. Socially vulnerable people were more likely to experience certain forms of hardship that others might not have. Furthermore, vulnerable people had lower levels of EVD knowledge and vigilance. This put them at greater risk for Ebola infection and less able to respond appropriately in such an event.

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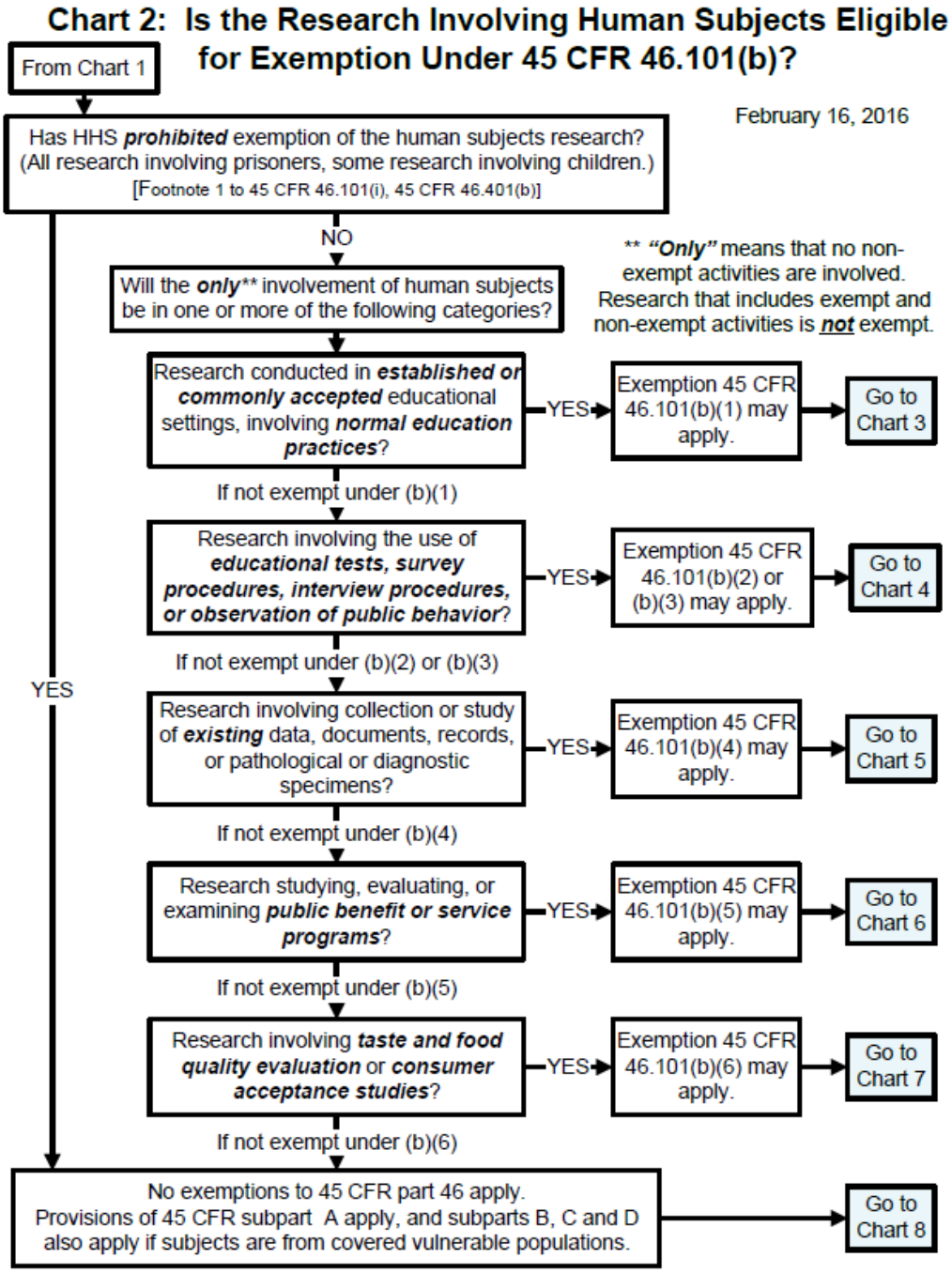
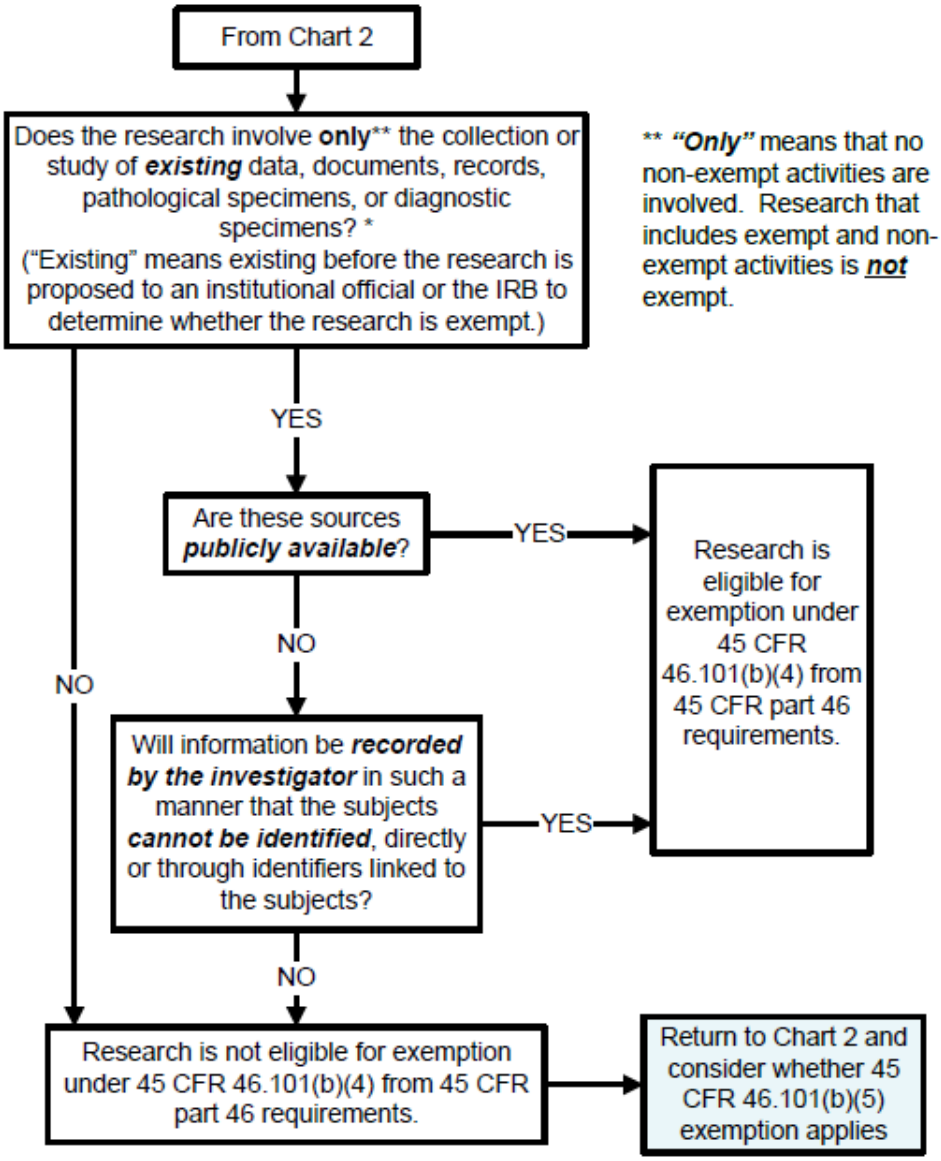
Appendix A – Human Subjects Regulations Decision Charts



## Chart 5: Does Exemption 45 CFR 46.101(b)(4) (for Existing Data Documents and Specimens) Apply?




* Note: See OHRP guidance on research use of stored data or tissues and on stem cells at http://www.hhs.gov/ohrp/regulations-and-policy/guidance/guidance-on-research-involving-stem-cells/index.html, and on coded data or specimens at http://www.hhs.gov/ohrp/regulations-and-policy/guidance/research-involving-coded-private-information/index.html for further information on those topics.

February 16, 2016

# Appendix B – List of Competencies Met in Integrative Learning Experience

**Wright State Program Public Health Competencies Checklist**

| |
|---|
| Assess and utilize quantitative and qualitative data. |
| Describe how policies, systems, and environment affect the health of populations. |
| Communicate public health information to lay and/or professional audiences with linguistic and cultural sensitivity. |
| Address population diversity when developing policies, programs, and services. |
| Make evidence-informed decisions in public health practice. |
| Evaluate and interpret evidence, including strengths, limitations, and practical implications. |
| Demonstrate ethical standards in research, data collection and management, data analysis, and communication. |
| Explain public health as part of a larger inter-related system of organizations that influence the health of populations at local, national, and global levels. |

**Concentration Specific Competencies Checklist**

| Population Health Concentration |
|---|
| Explain a population health approach to improving health status |
| Use evidence-based problem solving in the context of a particular population health challenge. |
| Demonstrate application of an advanced qualitative or quantitative research methodology. |
| Demonstrate the ability to contextualize and integrate knowledge of a specific population health issue. |
| Evaluate population health programs or policies that are designed to improve the health of the population, reduce disparities, or increase equity. |