

EFFECTS OF INFRASTRUCTURE ON EBOLA VIRAL DISEASE

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fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE
Strategic Studies

by

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ABSTRACT

EFFECTS OF INFRASTRUCTURE ON EBOLA VIRUS DISEASE, by Major John. J. Gartside, 68 pages.

This study examines the effects of infrastructure on combating Ebola Virus Disease (EVD) in Liberia and Sierra Leone since the EVD outbreaks of 2013 to 2015. The study is a Qualitative Case Study Comparison examining information from the World Health Organization, the United Nations, US Army Africa Operation United Assistance (OUA) Lessons Learned, and other literature reviewed sources. The study has a significant link to Army Warfighting Challenge #2: Shape the Security Environment. Infrastructure is subdivided into Ebola Treatment Centers (ETCs), Ebola Community Care Centers (CCCs), hospitals/medical clinics, roads, communications, and education/schools. Case study comparison concludes that infrastructure does have an effect on combating EVD. Similar trends are noted in both Liberia and Sierra Leone. Although outbreak containment strategies with ETCs and CCCs were effective in both countries, containment did not prevent recurrence. To prevent future outbreaks, adequate medical clinics/hospitals, roads, education, and CCCs are needed.

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ACRONYMS

AFL	Armed Forces Liberia
AFRICOM	Africa Command
ARCIC	Army Capabilities Integration Center
AWFC	Army Warfighting Challenges
CCC	Ebola Community Care Center
CDC	Centers for Disease Control and Prevention
DGDP	Directorate of Graduate Degree Programs
DoD	Department of Defense
DoS	Department of State
EVD	Ebola Virus Disease
ETC	Ebola Treatment Center
ETU	Ebola Treatment Unit
GDP	Graduate Degree Programs
MSF	Médecins Sans Frontières (Doctors Without Borders)
OUA	Operation United Assistance
UN	United Nations
US	United States
USAID	United States Agency for International Development
USARAF	United States Army Africa
WHO	World Health Organization

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CHAPTER 1

INTRODUCTION

This disease can be contained. It will be defeated. Progress is possible. But we're going to have to stay vigilant and we've got to make sure that we're working together. We have to keep leading the global response. America cannot look like it is shying away because other people are watching what we do, and if we don't have a robust international response in West Africa, then we are actually endangering ourselves here back home. In order to do that, we've got to make sure that those workers who are willing and able and dedicated to go over there in a really tough job, that they're applauded, thanked and supported. That should be our priority.

— President Barack Obama

The White House on America's Response to Ebola, October 28, 2014

Control of outbreaks of emerging disease has become more challenging with the advent of globalization and interdependence. Since the end of the Cold War in 1989, networks of economics across a global economy have grown as the cost of telecommunications and transportation have declined (Nye 2009, 202). With the relative ease of access to air travel, people can rapidly cross oceans and spread emerging diseases, potentially without even realizing it. The recent emergence of Ebola in West Africa caused a multinational concern for responding to global health threats. Interagency efforts were also used to include the United States Army, the State Department, and United States Agency for International Development (USAID). Multinational responses from Nongovernmental Organizations including the World Health Organization (WHO) and Médecins Sans Frontières (MSF)/Doctors Without Borders also responded to the emerging threat of Ebola Virus Disease (EVD) (Kieny and Evans 2014, 1). The global response to Ebola in West Africa was met with many challenges. Issues such as

containment and quarantine were complicated by poor economic conditions in countries with severely limited infrastructure (UNDP 2014, 46).

Ebola Viral Disease (EVD), previously known as Ebola hemorrhagic fever, is caused by infection with the Ebola virus. The virus causes disease in humans, and in primates. The virus is spread through direct contact with blood or body fluids of an infected person or primate. Spread from infected fruit bats has also been described (CDC 2016, 1). Symptoms of the disease include fever, rash, bleeding, diarrhea, vomiting, and damage to the central nervous system. The disease is fatal in 70-90% of those infected. The disease has an incubation period of up to 21 days, and there is currently no cure or vaccine (Chothia 2016, 10). Treatment involves supportive care such as rehydrating patients to help them recover (Chothia 2016, 10). Current research suggests that the virus is animal-borne with bats as the most likely natural reservoir (CDC 2016, 1). Ebola was discovered in 1976 in the vicinity of the Ebola River in the Democratic Republic of Congo (CDC 2016, 1). Since that time, sporadic outbreaks have occurred in West Africa.

The outbreak of Ebola Virus Disease in West Africa demonstrates how quickly an epidemic can spread and pose global problems in the absence of strong local health systems capable of rapid response (Kieny and Evans 2014, 1). The Ebola outbreak began in Guinea in December 2013, spread into the neighboring countries of Liberia and Sierra Leone, and was declared an international public health emergency by the World Health Organization in August 2014 (Kieny and Evans 2014, 1-3). Liberia and Sierra Leone experienced the largest outbreaks of Ebola Viral Disease (EVD) in history from 2014 to 2015. The Ebola outbreak in Guinea was declared over in December 2015 by the World Health Organization after the disease had killed over 2,500 people in Guinea, and another

9,000 in Liberia and Sierra Leone (Diane 2015, 1). The World Health Organization declared an end to the EVD outbreak in Liberia in May of 2015 (CDC 2015, 1). However, new cases emerged in June 2015 resulting in an additional 2 deaths. Liberia was again declared free of Ebola in September 2015, but three new cases emerged again in less than three months later in November 2015 (BBC Africa 2015, 1-2). The World Health Organization also declared the end of the Ebola outbreak in Sierra Leone in November 2014, only to have Ebola recur later that same month (BBC Africa 2016, 1-2). These smaller outbreaks (recurrences) still continue in parts of Liberia and Sierra Leone as of January 2016. Guinea has been more effective at containing the outbreak, and was noted to have a “more resilient” health care system than Liberia or Sierra Leone (Chothia 2014, 5).

The public health infrastructure in Liberia and Sierra Leone remains severely strained since the civil wars. Sierra Leone’s civil war lasted from 1991 to 2002, and left virtually no health care infrastructure in the nation, making disease management a difficult challenge (UNDP 2014, 5). The war left 50,000 people dead, 2 million people displaced, and those who remained in Sierra Leone had an average income of 38 cents per day. The first democratic elections post the civil wars took place in 2002. This encouraged new economic growth with a GDP rise of 9.5 percent per year from 2002 to 2013 (UNDP 2014, 5). However, severe challenges still remained. Most of the healthcare infrastructure has not been restored, and traditional healers are reported to provide the majority of healthcare, with 90 percent of deliveries in the local communities. Private sector health care remains largely undeveloped compared to other nations in the region such as Ghana and Nigeria (UNDP 2014, 7). The country also has a lack of adequate

roads and telecommunication systems, particularly in rural areas. Much of the nation remains poor, and up to three-quarters of children do not attend school at the correct age. Rural students are also less likely to complete a full cycle of education (UNDP 2014, 5).

The civil war in Liberia lasted for 14 years, and also resulted in the near destruction of the country's health care infrastructure. After the war, it was determined that 242 of the country's 293 public health facilities were non-functional (Mugo 2015, 1). In 2006, the new democratic elected government began to establish stability and access to humanitarian assistance (UNDP 2014, 4). Despite multiple programs undertaken over the years to address Liberia's post-civil war challenges, most families cannot afford to buy a full meal per day, or basic health services. Although the restoration of peace allowed for a period of rapid economic growth with a GDP rise of 7.6 percent per year from 2005-2012, most of Liberia remains poor (UNDP 2014, 4). Stability from the restored peace allowed for influx of foreign investments in iron ore production. However, outside business interests were threatened by the recent outbreak of Ebola in 2014. Most of the challenges that still face post-civil war Liberia concern a lack of infrastructure, human capital, and institutional capacity (UNDP 2014, 14). The lack of infrastructure also posed unique challenges to the international relief effort, as well as to combating the outbreak.

The Republic of Liberia created the *Agenda for Transformation: Steps Towards Liberia Rising 2030* to address these issues of human capital, institutional capacity and infrastructure. The agenda is a development strategy that fulfills the Liberian Government's commitment to "lift Liberians out of poverty to prosperity by transforming the Liberian economy" (Republic 2013, vi). *The Agenda for Transformation* emphasizes a plan for improvements in access to quality education, basic health care, and critical

infrastructure for Liberia to be achieved by 2030 (Republic 2013, vii). However, this plan was written prior to the events of the 2014 Ebola Outbreak in Liberia, and improvements had not yet been made to the nation's infrastructure.

The Ebola Virus Disease outbreak of 2014 in West Africa generated Operation United Assistance (OUA), which was the largest response to an international disease epidemic in the history of the United States (USARAF 2015, 2). Although initially confined to small areas in West Africa, the Ebola epidemic spread through Liberia, Sierra Leone and Guinea by September of 2014. Ebola was poised to spread throughout Africa, as well as internationally, posing a threat to United States national security (USARAF 2015, 2). As the World Health Organization (WHO) began efforts to address the Ebola threat in Sierra Leone, the United States designated the US Agency for International Development (USAID) as the lead agency for the US response in Liberia. The Department of Defense (DoD) supported USAID with engineering, communications, and logistics capabilities. United States Army Africa Command (AFRICOM) stood up Joint Force Command (JFC) Operation United Assistance (OUA) with US Army Africa (USARAF) as the core of the JFC. The JFC had a combined strength of 686 personnel, and was then transitioned to the 101st Airborne Division in October of 2014 (USARAF 2015, 2). The US led operation partnered with Armed Forces of Liberia (AFL) Engineers. The AFL required significant assistance with materials and equipment. JFC-OUA assisted the AFL with generators, lumber, hardware, and tools; as well as contracted heavy engineering equipment and construction that the AFL could not cover alone. The cost of this material assistance was \$900,000 dollars that the AFL was unable to provide. These US led construction efforts enabled the AFL Engineers to complete their first

major construction projects in Liberia to construct Ebola Treatment Units (ETUs) (USARAF 2015, 51). This was not only effective with respect to increased skills at building needed infrastructure, but gave the AFL increased standing with the Liberian People since the Liberian Civil War (USARAF 2015, 52).

Efforts of Operation United Assistance supported the US *National Security Strategy 2015* by accelerating access to energy, health, and security in Africa. The United States defends our national interests, and upholds our commitments to allies and partners (NSS 2015, ii). Globalization brings increasing interdependence in the global economy, and is linking people across the world in unprecedented ways to enable rapid travel, and cooperation for shared economic and security interests (NSS 2015, 4). This interdependence also carries shared vulnerabilities to include pandemic diseases and transnational terrorism. (NSS 2015, 4). Increased global health security is a key component of the *National Security Strategy 2015*. The Ebola epidemic highlights that the spread of infectious diseases constitutes a growing risk (NSS 2015, 13). Despite technological and organizational accomplishments, many nations have not yet achieved international competencies for health security. Many countries lack the sufficient capacity to prevent or respond to disease outbreaks (NSS 2015, 14). The success of Operation United Assistance sets the stage for continued increased infrastructure in Liberia. With newfound engineering capabilities, the Armed Forces of Liberia may support Liberia's national efforts to transform their nation since the end of the civil war. By increasing our partnership capacity with Liberia, the United States is able to mitigate the threat of Ebola pandemic disease, and enhance the regional security of West Africa.

Purpose

The purpose of this comparative case study analysis is to explore the effects of healthcare infrastructure on Ebola outbreak management in Liberia and Sierra Leone for the Masters in Military Arts and Sciences (MMAS) Program at the United States Army Command and General Staff College. For the purposes of this qualitative study, healthcare infrastructure will generally be defined as Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs), Ebola Community Care Centers (CCCs), hospitals/clinics, adequate roads, and education/schools. This study has a significant link to the Army Capabilities Warfighting Challenges (ARCIC) Army Warfighting Challenge #2: Shape the Security Environment (ARCIC 2016, 2). The study is also of significance to DoS and USAID, as they prepare for future challenges in Liberia and Sierra Leone. The study supports AFRICOM's mission to advance U.S. national interests and promote regional security, stability, and prosperity (Rodriguez 2014, 5).

Research Question

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone? A secondary question is: What subtypes of healthcare infrastructure affect Ebola outbreak management, and what are the roles of these subtypes? Another secondary question is: Did improvements in infrastructure from the World Health Organization and Operation United Assistance prevent recurrence of Ebola Virus Disease? A third secondary question is: Has infrastructure been adequately restored to these two nations since their civil wars?

Significance of the Study

The Ebola outbreak in West Africa raised concerns for United States national security, had global implications of quarantines, travel alerts, and protective equipment costs in multiple cities across the United States in order to ensure that the outbreak did not spread to the United States. The challenges that healthcare infrastructure posed to managing the disease were significant, and in many cases preventable. Themes will be examined including infrastructure subtypes; outbreak recurrence; and post-civil war infrastructure restoration, in order to determine the effects of infrastructure on management of EVD outbreaks. This information may then enable future management by the World Health Organization, U.S. AFRICOM, the Department of State, and the United States Agency for International Development (USAID). Understanding the effects of healthcare infrastructure on the Ebola outbreak in West Africa may also lead to greater partnership between the United States and Liberia, and a greater understanding of outbreak management as the United States prepares for future operations in megacities, as well as in surrounding rural areas.

Assumptions

This thesis studies the effects of infrastructure on Ebola Virus Disease (EVD) management as shown in Liberia and Sierra Leone. It is built on the assumption that the impact of infrastructure on outbreak management in these West African countries applies to other countries. It is also assumed that generalities revealed regarding infrastructure in rural areas will have impact in urban areas as well. Another assumption of this study is that it is assumed that enough qualitative information will emerge since the Ebola outbreak of 2014 to allow for proper study.

Limitations

The relatively short amount of time since the outbreak of Ebola in West Africa in 2014 may limit the amount of published information available for qualitative study regarding infrastructure and its role in management of the outbreak. The comparative case study includes the countries of Liberia and Sierra Leone, and does not include a comparative case study of Guinea. The time allowed of less than 1 year for completion of the Master's in Military Arts and Sciences (MMAS) degree is also a limitation.

Delimitations

Review of the literature will begin with a broad focus to examine infrastructure effects on Ebola disease management in Liberia and Sierra Leone. Operational considerations from Operation United Assistance will also be assessed. Although personal or historical interviews will not be conducted first hand, personal accounts are available from published articles or prior historical interviews to mitigate potential relative lack of firsthand information in published works as of yet. Literature review is performed from my perspective as a Family Medicine Physician.

Chapter Summary

The background of Ebola Virus Disease, civil wars in Liberia and Sierra Leone, and scope of the infrastructure challenge have been discussed, as well as the potential for effects of infrastructure on Ebola Virus Disease (EVD) outbreak management. The significance of the thesis has been outlined, as well as the assumptions, limitations, and delimitations of the study. Chapter 2 will focus on the literature review. Qualitative methods and analysis to answer the primary and secondary research questions will be

discussed in chapter 3. The primary and secondary questions will be analyzed in chapter 4. Chapter 5 will state conclusions of the research study, provide recommendations for decision makers, and provide recommendations for future research studies.

CHAPTER 2

LITERATURE REVIEW

Chapter Introduction

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone? A secondary question is: What subtypes of healthcare infrastructure affect Ebola outbreak management, and what are the roles of these subtypes? Another secondary question is: Did improvements in infrastructure from the World Health Organization and Operation United Assistance prevent recurrence of Ebola Virus Disease? A third secondary question is: Has infrastructure been adequately restored to these two nations since their civil wars?

The literature review for this thesis covered a broad range of sources to determine the effects of infrastructure on the management of Ebola Virus Disease (EVD) outbreaks. Literature was reviewed broadly at first to encompass effects of infrastructure on outbreaks in general, narrowed to include operational lessons learned on infrastructure effects on disease management in West Africa, and then focused on infrastructure effects on the EVD outbreak in Liberia and Sierra Leone. Source materials were examined with the intent of performing qualitative case study comparison research of these two West African countries. Healthcare agency sources, operational sources, social sources, periodicals, and prior studies were reviewed. The World Health Organization, the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), the United Nations, Médecins Sans Frontières (MSF), also known as Doctors Without Borders, and U.S. Army Africa Operation United Assistance (OUA) Lessons Learned provided the majority of healthcare agency sources on review of the literature.

Infrastructure is subdivided into Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs), Ebola Community Care Centers (CCCs), hospitals/medical clinics, roads, communications, and education/schools.

Ebola Treatment Centers (ETCs) and Ebola Treatment Units (ETUs)

Ebola Treatment Centers (ETCs) are complex facilities that need substantial numbers of staff to run, and require substantial time to set up, in order to treat Ebola Viral Disease patients (Kucharski 2015, 393). ETCs have been used to isolate patients with Ebola and to provide clinical care. These treatment centers generally have a large capacity of 100 or more beds. They function under high levels of infection control (Kucharski 2015, 393). In Sierra Leone, Doctors Without Borders dedicated over 1,900 staff to respond to the Ebola threat. These staff included 157 international staff and 1,750 national staff to establish and run four ETCs, community outreach activities, and surveillance. These ETCs are located in Bo, Freetown, Kailahun, and Magburaka (MSF 2015, 2). MSF also uses the term Ebola Management Center (EMC) to describe an Ebola Treatment Center (ETC) (MSF 2015, 3). MSF reported admission rates of the Kailahun and Bo facilities to be relatively low, and had reached zero Ebola patients admitted as of November 2015 (MSF 2015, 2). However, at the height of the 2014 outbreak, The Freetown ETC had at one point used 30 individual Ebola patient rooms and 70 beds for suspected Ebola cases. The Freetown ETC also incorporated a new design in which the intensive care ward could be observed through Plexiglas to limit the number of staff who had to wear protective equipment (MSF 2015, 5). The ETC in Magburaka was largely used perform additional, complementary actions including outreach, health promotion,

surveillance, and training of the local national staff (MSF 2015, 5). It was found that in Sierra Leone, many of the ETCs reached capacity during the height of the 2014 outbreak, and that despite their 100 bed or more capacity, some people were turned away (Kucharski 2015, 393).

In Liberia, the use of Ebola Treatment Centers (ETCs) has also been well described. However, the term Ebola Treatment Unit (ETU) is often used interchangeably with ETC in literature presented by the Centers for Disease Control and Prevention (Washington and Meltzer 2015, 1). The term Ebola Treatment Unit (ETU) is also used in US Army Africa (USARAF) Operation United Assistance Lessons Learned with identical capabilities per the descriptions of ETUs as compared to descriptions of ETCs (USARAF 2015, 51). The Centers for Disease Control and Prevention (CDC) described successful use of ETUs in Liberia resulting in the prevention of 2,244 Ebola cases at the height of the outbreak from September to October of 2014 (Washington and Meltzer 2015, 67). ETUs were constructed by Joint Force Command for Operation United Assistance (OUA) with partnership with the Armed Forces of Liberia (AFL) Engineers. The OUA main construction projects consisted of 17 ETUs with a 100 bed capacity each, and a smaller Monrovia Medical Unit capable of treating up to 25 suspected Ebola patients/infected medical staff (USARAF 2015, 51). The main focus of OUA was the construction of new ETUs. This construction was challenging due to relative lack of Liberian construction standards and policies for contingency plans. Field engineering was critical for bridging the gaps between the lack of site assessments with respect to access to roads capable of moving construction assets through (USARAF 2015, 56). Despite these challenges, OUA was successful at construction of ETUs in Liberia with AFL

Engineers completing 25 percent of the project post US partnership training. AFL Engineers successfully established ETUs in Tubmansburg, Sinje, Kakata, and Cesto (USARAF 2015, 52). An example of ETU construction was summarized by the The104th Engineer Company deployed to West Africa (Liberia) in support of Operation United Assistance who encountered significant infrastructure challenges that had direct effects on management of the Ebola outbreak. This account stated that over the course of 22 days, the company deployed 30 Soldiers 125 miles, and worked with 40 AFL Soldiers. These Soldiers jointly completed the work for an ETU site that was taking contractors up to 45 days to finish (Moncata 2015, 3). ETU construction times were often long to ensure that the sites reduced the risks of transmission and were built for strict isolation (Washington and Meltzer 2015, 67).

Ebola Community Care Centers (CCCs)

The ETCs were complex facilities, requiring relatively long construction times of up to 45 days, and substantial staff. The World Health Organization (WHO) looked at additional options to care for Ebola patients to supplement the existing ETCs (Kucharski 2015, 393). Ebola Community Care Centers (CCCs) were an identified approach to solving this problem. These CCCs are small units with 3-5 beds each and staffed by a small number of health care workers. The purpose of a CCC is to isolate Ebola patients outside of their homes to reduce the risk of transmission to friends and family members, limiting spread in the community (Kucharski 2015, 393). These CCCs are designed to work in rural areas where access to an ETU may be limited due to lack of transportation, or roads. The CCCs are also designed to engage members of the community to provide basic health information and safe burial practices, and monitor close contacts of the

patients. Ebola CCCs are also easier to establish than ETUs, since they require less staff and can be made from local materials such as tents. Staff can also be trained members of the local community (Kucharski 2015, 393).

In Liberia, CCCs played a major role in community health settings where local clinics were not available, and ETUs were relatively distant. Liberian CCCs reduced the risk of Ebola transmission with isolation, and community based programs including safe burial practices to avoid contact with EVD (Washington and Meltzer 2015, 67). The estimates of Ebola cases in Liberia were impacted by both ETUs and CCCs in the figure below.

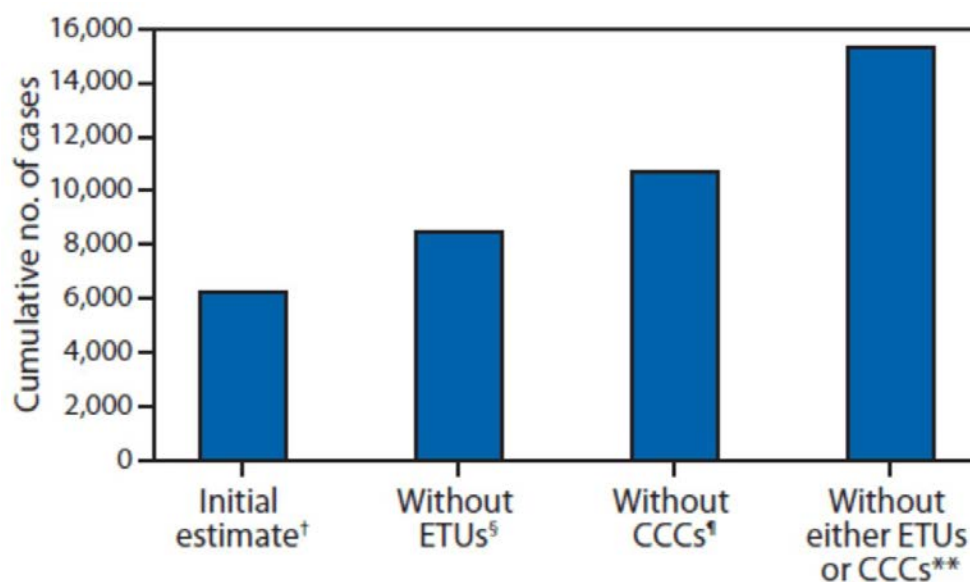


Figure 1. Estimates of Ebola Cases with and without ETUs and CCCs in Liberia, September 23-October 31, 2014

Source: Michael L. Washington and Martin L Meltzer, “Effectiveness of Ebola Treatment Units and Community Care Centers-Liberia,” *Morbidity and Mortality Weekly Report* 64 (January 2015): 69.

It was then determined that in Sierra Leone, CCCs provided rapid and increased coverage to complement ETCs (Kucharski 2015, 394). The figure below describes the number of CCC beds required to prevent further outbreak (turnover the outbreak by reduced reproduction number of less than 1). When Ebola transmission is reduced only by 50 percent, no amount of CCC beds alone will stop the outbreak as depicted in Figure 2A. However, when CCCs are used in combination with available ETU beds, less are needed and they have a complementary effect. This is shown as the number of CCC beds required to turn over the epidemic when an additional 500 ETU beds are available, and is depicted in figure 2B.

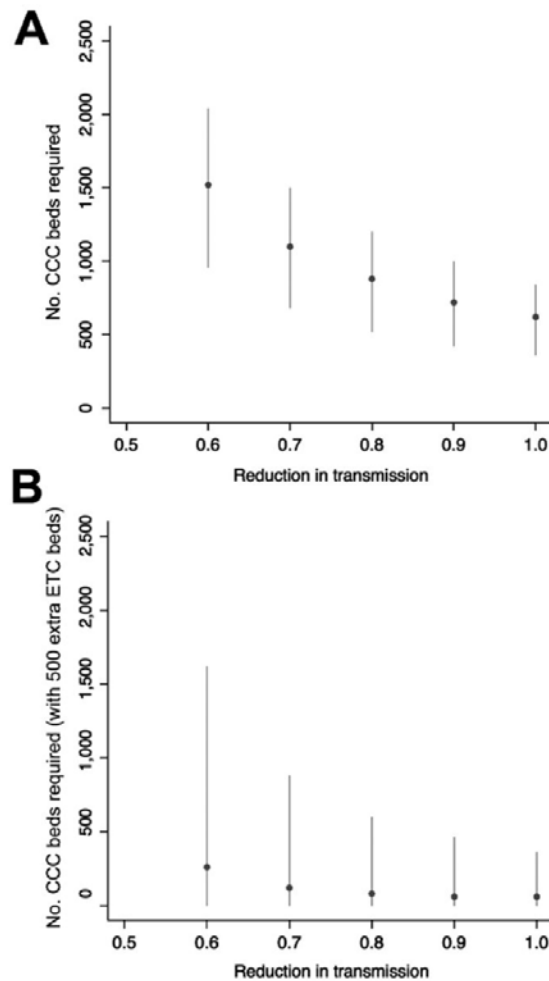


Figure 2. Estimated Number of CCC beds required to Control EVD Epidemic-Sierra Leone, December 2014

Source: Adam J. Kucharski and Anton Camacho, "Evaluation of the Benefits and Risks of Introducing Ebola Community Care Centers, Sierra Leone," *Emerging Infectious Diseases* 21 (March 2015): 398.

The above relationship with ETUs and CCCs in Sierra Leone demonstrates that CCCs can reduce the number of EVD cases in a community if the probability for an EVD negative patient being exposed to the virus is low, and if there is a reduction in EVD transmission as a result of patients being in CCCs (i.e. that CCCs are able to provide effective community education and isolation). The CCCs in this case have added benefit

since Ebola patients would not have to wait for ETU beds to become available (Kucharski 2015, 397). It was also noted that the number of Ebola cases averted was 4,487 with CCCs as compared to 2,244 with ETUs (Washington and Meltzer 2015, 69). When ETUs and CCCs were looked at combined, 9,097 Ebola cases were averted between September 2014 and October 2014 (Washington and Meltzer 2015, 69).

Hospitals and Clinics

Weak health systems cannot be resilient. A strong health system decreases a country's vulnerability to mitigate the impact of a crisis (Kieny and Evans 2014, 2). The aftermath of the civil wars in Liberia and Sierra Leone left West Africa virtually devoid of health care infrastructure. The economic hardships faced by the majority of citizens and the lack of resources and support to rebuild left these nations vulnerable to the EVD outbreak. Several accounts are available to support this, such as Amara Konneh's account in The Guardian "Ebola isn't just a health crisis- it's a social and economic one too." Due to the health and economic crisis, Liberia was not prepared for the threat of Ebola, and required considerable assistance from the rest of the world. The Liberian government signed a 52 million dollar grant from the World Bank, 10 million from the African Development Bank, and 5 million from USAID to respond to Ebola Viral Disease (Konneh 2014, 1).

Of the 293 operational public health facilities (clinics and hospitals) before the civil war in Liberia, 242 were rendered non-functional by the war's end. Most doctors and nurses fled during the war, leaving 30 doctors to serve the primary care needs of 3 million people (Mugo 2013, 3). Liberia's 14 year civil war ended in 2003, and today most people outside of the city of Monrovia have little to no access to health care (Kruk 2010, 7).

Considering 36 clinics and 4 hospitals, a survey was conducted of citizens in 2008 with 67 percent responding with the closest health facility being a clinic, and 10 percent being a hospital, but only 27 percent reported that they could access basic services (Kruk 2010, 7). With the exception of Monrovia, the vast majority of Liberia's clinics and hospitals have not been rebuilt since the end of the civil war prior to the Ebola outbreak. As of 2014, Liberia had 51 doctors, 978 nurses and midwives, and 269 pharmacists to care for a population of 4.2 million people (Chothia 2014, 4). The Liberian government outlined a basic package for health services in 2008, but efforts to implement it were hindered by low budgetary constraints which would have required 67 percent of the country's per capita spending to fund. As a result, 80 percent Liberia's health is dependent on foreign assistance (Kruk 2010, 3). Liberia's economy was finally starting to grow at 5.9 percent annually when the Ebola outbreak struck in 2014. With the advent of Ebola, mining operations halted and harvesting stopped. The World Bank estimated the economic impact of Ebola on West Africa to be 36 billion dollars (Konneh 2014, 1). The Republic of Liberia *Agenda for Transformation: Steps Towards Liberia Rising 2030* states that 85 percent of urban households are within a one hour walk from a health clinic, while 67 percent of rural households are more than one hour away from a clinic or hospital (Liberia 2013, 86). The Liberian government has prioritized the establishment of a decentralized network for health services composed of health service points for populations of less than 3,500; health clinics for a population of 3,500 to 12,000; health centers for populations of up to 40,000; and hospitals for populations up to 200,000 (Liberia 2013, 87). Health service points are described as community sites staffed by volunteers to provide basic health screening, education, and vaccines. Health centers are

described as larger clinics with the possibility of more than one specialty; providing primary care, emergency, and obstetrics services (Liberia 2013, 87). The plan outlines a goal for improvement by 2030, but does not state an indicator for 2017 as it does for other national plans.

Accounts are also available from Physicians providing aid in Sierra Leone, as in Lisa O'Carroll's article "Ebola doctor calls for fatal flaws in Sierra Leone health system to be addressed" (O'Carroll 2015, 1). She stated that before EVD reached Sierra Leone in 2014, the country's health system had little infrastructure, few resources and a lack of doctors. The average life expectancy is only 45 years of age. As of 2014, the country had only 136 doctors to care for a population of 6 million people (O'Carroll 2015, 2). The World Health Organization only lists 74 public health centers in Sierra Leone with a density of 1.215 per 100,000 population (WHO 2014, 2). Sierra Leone was also reported to have only 136 doctors, 1,017 nurses and midwives, and 114 pharmacists for a population of 6 million people (Chothia 2014, 4).

Despite the increased funding provided to Liberia and the international efforts to defeat EVD, resurgence of the disease occurred both in Liberia and in Sierra Leone post the initial declaration of the end of the outbreak. The World Health Organization declared the EVD outbreak in Liberia over in May of 2015 (CDC 2015, 1). However, new cases emerged in June 2015 resulting in an additional two deaths. Liberia was again declared free of Ebola in September 2015, but three new cases emerged less than three months later in November 2015 (BBC Africa 2015, 1-2). The World Health Organization also declared the end of the Ebola outbreak in Sierra Leone in November 2014, only to have Ebola recur later that same month (BBC Africa 2016, 1-2). These smaller recurrences

still continue in parts of Liberia and Sierra Leone as of January 2016. Guinea and Nigeria have been more effective at containing the outbreak, and were noted to have a “more resilient” health care systems with more resources and wealth than Liberia or Sierra Leone (Chothia 2014, 5).

Roads

There is a myriad of emerging data in recent periodicals over the past year relating to the challenges of roadway infrastructure to the Ebola outbreak in West Africa. Many have begun to notice the impact of infrastructure in the involved outbreak nations, most notably in Liberia and Sierra Leone. Roads in both countries are largely inadequate for the rural populations and have not been reestablished or updated since the civil wars.

After 14 years of civil war in Liberia, infrastructure was largely underdeveloped. The lack of paved roads isolates most of the country from the capital city of Monrovia, which is the only largely paved area. This is especially apparent during the heavy raining season between May and October each year according to the United Nations Development Programme (UNDP 2014, 5). Roughly 55 percent of the population has no access to an all-season road within 5 km, and 27 percent of the population has no access within 30 km. The heavy raining season also causes high maintenance costs of existing roads. The lack and degradation of existing roads in rural areas also leads to underutilized farming with less than 10 percent of the land being effectively cultivated (UNDP 2014, 5). Liberia’s road network remains the most striking symptom of the civil war, limiting access to markets, which causes malnutrition in rural areas (Nicholson, Buckley, and Schubert 2014, 2). Many roads have potholes in them the size of small vehicles, and less than seven percent of the country’s 66, 000 miles of road are paved. The most heavily

populated rural area of Bong County is the most in need of roads, with citizens having to walk all day to schools, markets, and clinics (Nicholson, Buckley, and Schubert 2014, 2). USAID conducted a cost-benefit analysis of which improvements would have the most long term benefit for Liberia, and concluded that the answer was building improved roads. At the beginning of 2014, it was less expensive to ship rice 7,500 miles from Thailand to Monrovia than it was from the Gbarnga agricultural community just 100 miles away from Monrovia (Nicholson, Buckley, and Schubert 2014, 4). USAID began road rehabilitation projects in February of 2014, improving access to food for 140,000 people who live within one mile and a half of rural roads (Nicholson, Buckley, and Schubert 2014, 5). Improvements are being made, and projects are ongoing. When roads are improved, transportation costs decrease and local foods are able to reach the markets cheaper (Nicholson, Buckley, and Schubert 2014, 3). The Republic of Liberia *Agenda for Transformation: Steps Towards Liberia Rising 2030* states that Liberia will need 30 percent greater feeder roads to allow for emerging economic progress including mining, logging, and agriculture (Liberia 2013, 64). Since the end of Liberia's civil war, 95 percent of road project improvements have been made with only laterite (dirt), and not paved roads. This is mostly due to cost, as asphalt paved roads cost 16 times more than laterite roads (Liberia 2013, 66). Operation United Assistance (OUA) engineers also noted challenges associated with Liberia's roads. As of the beginning of OUA planning in September 2014, there was no reliable information available on Ground Lines of Communication (GLOCS). Information gained relied heavily on US Military Observers Group (USMOG) representatives, and this information became critical to mission planning for potential ETU sites. Planned sites and roadways were also coordinated with

USAID and the UN (USARAF 2015, 79). On arrival to Monrovia, the US Army Corps of Engineers reported problems not only with the conditions of the roads, but of the airfields, with damaged pavement over 40 years old. Construction efforts were largely concentrated on repairing roads near the airfields, and roads to the ETU sites. Repairs to roads were often time consuming, and repair teams were often only available one week after the initial requests were placed for maintenance and repairs (Holland 2015, 1). Little was able to be done for roads in most rural areas, where dirt roads were often unable to be traveled in the raining season. The Republic of Liberia is working on improvements according to the *Agenda for Transformation: Steps Towards Liberia Rising 2030*, and has described year 2017 outcome indicators as having more roads in good condition the entire year, decreased travel times, decreased cost of travel between urban and rural areas, and more cost effective road construction and maintenance (Liberia 2013, 67).

In Sierra Leone, Bernadette O'Hare described crippled health care infrastructure not only from civil war, but from the lack of reinvestment (O'Hare 2015, 1). Roads were also mostly unpaved, especially in rural areas, and were left without maintenance since the civil war. The roads were considered especially weak in rural areas, which hindered transport of patients, communication of alerts by ground, and public education campaigns (WHO 2015, 3). The Government of Sierra Leone has looked to corporate tax exemptions for the country's five major mining companies in order to encourage them to remain in Sierra Leone, and assist with economic development including road infrastructure around mines for shipping (O'Hare 2015, 2). However, many companies' profits decreased in 2014 due to the Ebola outbreak's negative impact on employment, travel, and daily life in Sierra Leone (O'Hare 2015, 2).

Communications

Most of Liberia's telecommunications infrastructure was destroyed or deteriorated during the years of civil war, and was not reestablished in the period leading from the end of the civil war in 2003 to the Ebola outbreak in 2014 (Liberia 2013, 64). An additional 80 percent of power resources are needed to supply needed electricity for internet services to rural areas outside of the capital of Monrovia, and there is still a lack of clear national vision for the expansion of internet services and telecommunications licenses (Liberia 2013, 68). Access to cellular telephone services is relatively high despite this, with 50 percent of overall Liberian households owning at least one cell phone since 2010 and 80 percent of households owning at least one cell phone in Monrovia (Liberia 2013, 68). Difficulties with communications were noted during the Ebola outbreak due to lack of internet and phone services to rural areas. Ebola emergency preparedness plans at the county level were deficient. Although Ebola task forces were established in each county, reports from the field stated that communications infrastructure and lack of paved roads made communicating with local communities difficult (Forrester et al. 2014, 891). The Liberian Ministry of Health and Social Welfare (MOHSW) developed a national task force to oversee management of Ebola emergency response. This task force enabled an Ebola incident management system with the help of external partners including CDC, WHO, MSF, and USAID (Pillai et al. 2014, 932). The role of the task force was to provide 24-48 hour response to operations including ambulance services to ETUs; safe burial education and practices; and surveillance support for case investigation, including the following of EVD patient contacts and their families (Pillai et al. 2014, 932).

Telecommunications were also noted to be weak in Sierra Leone post the civil war. This delayed transportation of patients to ETUs, call for assistance, and public education campaigns in rural areas (WHO 2015, 3). Lack of operational communication systems was also noted when information on cross-border transmission of EVD from Guinea to Sierra Leone failed to reach proper authorities in Sierra Leone. Sierra Leone also had no national preparedness plan for Ebola, and no initial surveillance system (Okunogbe 2015, 12-13). Improvements were made by developing Ebola response plans with the assistance of CDC, WHO and other partners. Surveillance systems were established similar to those in Liberia with training and support from CDC, WHO, and USAID (Okunogbe 2015, 13). A national call center was established in Sierra Leone for Ebola response. The call center conducted a three day house-to-house campaign where teams visited homes to provide EVD basic education including use of contact precautions and safe burial practices. More than 28,000 volunteers were involved in the project. (Miller et al. 2015, 28). The call center was able to provide a next day response in 81 percent of cases where a call was received for an Ebola death, but only able to respond 45 percent of the time to possible new Ebola cases (Miller et al. 2015, 29). The need to provide more services to rural areas for potential cases, and improve telecommunications to rural areas contributed to the lack of response (Miller et al. 2015, 28).

Education and Schools

Educational resources in Liberia and Sierra Leone are severely limited, and have been since the aftermath of 10 years of civil war. The UN Security Council reported that the UN initiated an awareness raising campaign in Liberia at the onset of the 2014 EVD outbreak. This campaign was met with difficulties due to traditions, denial, and

community resistance in a population that is largely uneducated (UN 2014, 5). It was quickly realized that the Ebola outbreak would not be controlled without local population understanding and cooperation (Guerrier and D’Ortenzio 2014, 315). The United Nations International Children’s Emergency Fund (UNICEF) describes the literacy rate in Liberia as roughly 63 percent for males and 37 percent for females (UNICEF 2013, 1).

Educational campaigns were limited to those Liberians who could read the posted signs, and those who were willing to speak with and listen to volunteers from the Ebola task force. Speaking with the task force was needed in order to ensure proper surveillance, close contact precautions of infected persons, and safe burial practices to avoid transmission of EVD (Blackley et al. 2015, 175). Leaders in rural communities often had to be convinced that EVD was real. Earning trust was critical to education. In Mawah, Liberia, some community members were only willing to accept the truth about Ebola and the need for quarantines and safe burial practices after witnessing the deaths of friends and family members who had not followed safe practices (Nyenswah et al. 2015, 181). Liberia’s *Agenda for Transformation: Steps Towards Liberia Rising 2030* has described year 2017 outcome indicators for education as ensuring equal, free, and compulsory access to basic education with increased enrollment and completion rates; increased numbers of certified teachers; and increased numbers of schools that meet minimum standards for safety, sanitation, and educational materials (Liberia 2013, 93).

In Sierra Leone, the literacy rate is 70 percent for males and 52 percent for females (UNICEF 2013, 1). Aid workers and volunteers in Sierra Leone encountered similar challenges to those in Liberia with respect to rural community members having to have rapport with the Ebola task force to allow for understanding of isolation precautions,

reduction in transmission, and safe burial practices. Sierra Leone also received educational grants from organizations such as the GE Foundation, who provided a two million dollar grant used to train 500 clinical healthcare workers and 800 community health workers who were able to educate rural communities about proper sanitation and safe burial practices to prevent the spread of Ebola Virus Disease (Ness 2015, 5). These newly trained individuals were also able to staff 47 Community Care Centers to assist with education and surveillance, and staff one Ebola Treatment Unit with 50 treatment beds (Ness 2015, 5). The Sierra Leone Ministry of Health and Sanitation (MOH) established a program with CDC assistance to assess safe burial practices, perform cemetery management, and stress adherence to safe practices to prevent the spread of Ebola (Nielsen et al. 2015, 20). This program focused on education to prevent the spread of Ebola Virus Disease through traditional burial practices in which contact with the bodies and fluids of infected individuals may be spread when family members handle and wash the bodies of the deceased in the traditional ways (Nielson 2015, 20). The national burial teams from the Ebola task force received reports of dead bodies from multiple sources, and often requested improvements in coordination of staff communication and telecommunications when receiving reports. Whether a death was properly recorded largely depended on how the death was reported. Ebola deaths were not recorded properly if they were not reported by family or community members through the official alert system (Nielsen et al. 2015, 21). This led to difficulties with ensuring proper education and safe burial practices for those community members involved with Ebola cases that were not reported through the official system, and some rural communities had greater exposure risks if infected bodies were not buried safely.

The public health infrastructure in Liberia and Sierra Leone remains largely un-restored since the civil wars. Liberia and Sierra Leone experienced the largest outbreaks of Ebola Viral Disease (EVD) in history from 2014 to 2015 with the infrastructure limitations and improvements made in the discussion of the above infrastructure subtypes. The Ebola outbreak killed over 9,000 people in Liberia and Sierra Leone (Diane 2015, 1). The World Health Organization declared an end to the EVD outbreak in Liberia in May of 2015 (CDC 2015, 1). Despite the best efforts of the WHO, CDC, MSF, USAID and OUA, new cases emerged in June 2015 resulting in an additional two deaths. Liberia was again declared free of Ebola in September 2015, but three new cases emerged in November 2015 (BBC Africa 2015, 1). The World Health Organization also declared the end of the Ebola outbreak in Sierra Leone in November 2014, only to have Ebola recur less than one month later (BBC Africa 2016, 2).

Chapter Summary

Evaluation of the literature review in this chapter has demonstrated ample source material to serve as the foundation for this thesis. Source material was examined and generally reveals an infrastructure theme with six subtypes of infrastructure. These infrastructure subtypes have been defined as Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs), Ebola Community Care Centers (CCCs), hospitals/clinics, roads, communications, and education/schools. The literature review also yielded notable themes in EVD recurrence in Liberia and Sierra Leone after the initial outbreak, and a lack of post-civil war infrastructure restoration in both countries. Chapter 3 will discuss methods for conducting research, and identify the qualitative methods used for this thesis. Chapter 4 will then provide data presentation and analysis to answer the primary and

secondary research questions. Chapter 5 will discuss conclusions, provide recommendations for decision makers, and provide recommendations for further research studies.

CHAPTER 3

RESEARCH METHODOLOGY

Chapter Introduction

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone? A secondary question is: What subtypes of healthcare infrastructure affect Ebola outbreak management, and what are the roles of these subtypes? Another secondary question is: Did improvements in infrastructure from the World Health Organization and Operation United Assistance prevent recurrence of Ebola Virus Disease? A third secondary question is: Has infrastructure been adequately restored to these two nations since their civil wars?

Qualitative case study comparison methodology will be used to explore the effects of infrastructure on Ebola Virus Disease management in Liberia and Sierra Leone for the Masters in Military Arts and Sciences (MMAS) Program at the United States Army Command and General Staff College. John W. Creswell's Research Design will be used as a guide for qualitative research method development (Creswell 2014, 13). For the purposes of the study, infrastructure will generally be defined as Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs), Ebola Community Care Centers (CCCs), local clinics/hospitals, roads, communications systems, and available education/schools. Outbreak comparison will also be described between Liberia and Sierra Leone comparing resolution and recurrence of Ebola Viral Disease in the two nations as declared by the World Health Organization (WHO). Restoration of infrastructure post the civil wars in these two countries will also be described.

Methods

The three primary approaches to research methodology are qualitative, quantitative, and mixed methods procedures (Creswell 2014, 4). Qualitative research is “an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (Creswell 2014, 4). The process of qualitative research involves emerging questions. Data collected is typically in the form of words and analyzed as general themes, with the researcher making interpretations of the data’s meaning. This form of research tends to render the complexity of a situation and hones research of an inductive style (Creswell 2014, 4). In contrast, the quantitative research approach tests theories by examining relationships between variables. The variables are then measured so that they can be presented as numerical data, and analyzed using statistical methods. Similarities between qualitative and quantitative methods include having assumptions about testing theories in a deductive manner, protections against bias, controlling for alternate explanations, and being able to generalize and replicate findings (Creswell 2014, 4). The mixed methods research approach involves the collection of both qualitative and quantitative data, and the integration of both forms. This method uses distinct designs that may include philosophical assumptions and theoretical frameworks. The main assumption of the mixed methods approach is that a more complete understanding of a research problem is gained by using a combination of qualitative and quantitative approaches (Creswell 2014, 4-5).

In choosing which of these three methods is best to conduct research, it is important to take the worldview of the researcher and the material being studied into consideration. Worldview describes a general philosophical orientation about the world,

and the nature of the research that is brought to the study by the researcher (Creswell 2014, 6). Constructivism is the worldview that involves seeking understanding about the world through specific contexts and settings in order to gain a more complete understanding of the research problem. Constructivists seek understanding in the world in which they live and work, and seek to find meaning in a complex world (Creswell 2014, 8). The constructivist worldview was consistent with the body of evidence in the literature review, particularly in those sources from organizations such as the World Health Organization, the United Nations, the Republic of Liberia, and US Army Africa.

Constructivism lends itself well to qualitative research methods. Qualitative researchers tend to use open ended questions so that participants and others can understand and share their views (Creswell 214, 9). Secondary questions in this thesis were left open ended to better support qualitative design methodology. The primary research question was kept in Yes/No format. People engage the world based on historical perspectives and take meaning from it based on culture.

Data Collection

Qualitative researchers look to understand the context of events and interpret what they find. The generation of meaning arises out of interactions with human communities (Creswell 2014, 9). These communities can be countries such as Sierra Leone and Liberia, which are the focus of this comparative case study; or can be organizations such as the UN or WHO, whose interactions and experiences were studied in the review of literature. Data for this study was collected from the review of literature. Success of the study depended on reading the assorted documents published on Ebola Virus Disease, infrastructure in Liberia and Sierra Leone, civil wars in these two countries, and

published data on the Ebola outbreaks and their resolution. Source materials from the World Health Organization, the United Nations, the Centers for Disease Control, US Army Africa, and the Republic of Liberia were all carefully studied so that relevant themes could be identified for case study comparison. Additional sources used included credible news agencies such as the British Broadcasting Corporation (BBC). Additional information from published online sources were used to provide recent news correspondence for updates. Historical interviews and surveys were not conducted due to time constraints. The author used the assistance of the Combined Arms Center Research Library at Fort Leavenworth, KS. There were ample sources available to collect data from the literature review.

The process of qualitative research is inductive, and generates meaning from the data collected from the literature (Creswell 2014, 9). Emerging themes may be generated from patterns in these relevant sources, and then interpreted. The qualitative research may then be used to draw conclusions and make recommendations for change or reform (Creswell 2014, 18).

Data Analysis

Case studies are a type of qualitative research design that allow researchers to develop an in-depth analysis of a cases, events, and processes of one or more individuals. Case studies are useful in collection of a variety of data over a period of time (Creswell 2014, 14). The United Nations Children's Fund (UNICEF) Office of Research describes comparative case studies as the analysis of the similarities, differences, or patterns across two or more cases that share a common focus (Goodrick 2014, 1). These case study comparisons may use qualitative, quantitative, or mixed methods. Case study comparison

methodology is also useful when it is not feasible to conduct an experiment with a control group, as is the case with this study (Goodrick 2014, 1).

An overview of the qualitative case study comparison methodology is described in the figure below in accordance with Creswell's qualitative research model.

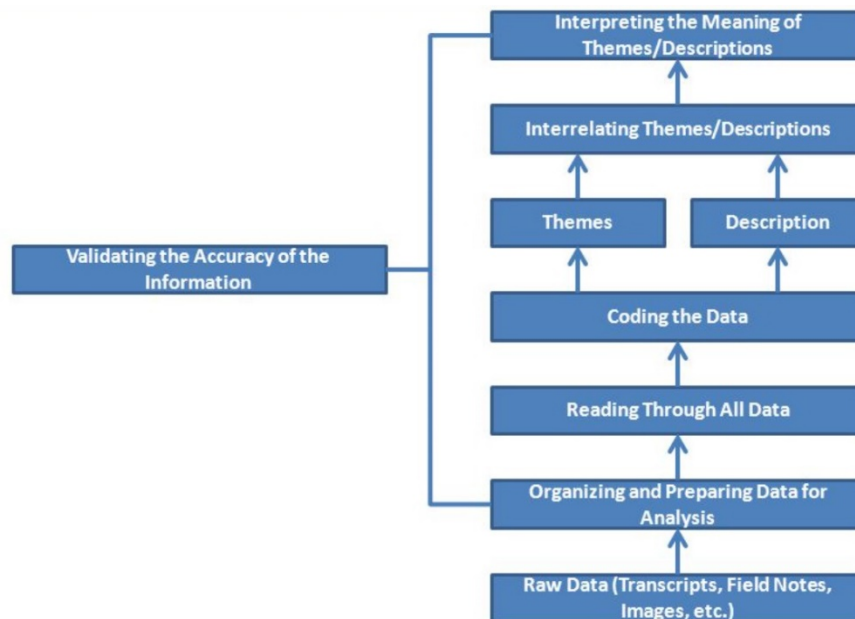


Figure 3. Data Analysis in Qualitative Research

Source: John W. Creswell, *Research Design*, 4th ed. (Los Angeles, CA: Sage Publications, 2014), 197.

The raw data from the review of literature was organized according to the case study involved by country (i.e. either Liberia or Sierra Leone). The literature was read through and discussed in the review of literature. The raw data was then coded according to infrastructure subtypes. These subtypes were then described in the coding as Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs), Ebola Community Care

Centers (CCCs), local hospital and clinics, roads, communications systems, and available education and schools. These subtypes will be analyzed in chapter 4 to complete the below table in a (+) or (-) format, where (+) = presence of improvement in the infrastructure subtype during the period of the 2014 Ebola outbreak; (+/-) = relatively minor improvement; and (-) = absence of improvement. These infrastructure subtypes appear in the table below of the case study comparison.

Table 1. Infrastructure Subtypes

	ETCs/ ETUs	CCCs	Hospitals and Clinics	Roads	Communications	Education and Schools
Liberia						
Sierra Leone						

Source: Created by author.

The coding of infrastructure subtypes also described infrastructure as a theme. Themes are major findings or patterns in qualitative studies (Creswell 2014, 200).

Another theme found in this study is an outbreak comparison between Liberia and Sierra Leone, in which new cases of EVD were confirmed after the WHO declared resolution of the outbreak post Ebola Treatment Center (ETC)/Ebola Treatment Unit (ETU) and Ebola Community Care Center (CCC) use. This theme will be analyzed in chapter 4 to complete the below table in a (+) or (-) format, where (+) = declaration by the WHO of the 2014 Ebola outbreak; and (-) = absence of declaration of outbreak

resolution in the first column. In the second column, (+) = confirmed new cases of EVD after the initial 2014 outbreak; and (-) = lack of recurrence of the outbreak.

Table 2. Outbreak Resolution

	Outbreak Declared Over Post ETC/ETU and CCC Use	Confirmed New EVD Cases Post Outbreak
Liberia		
Sierra Leone		

Source: Created by author.

A third theme noted in the study was the lack of post-civil war infrastructure restoration in the two countries. This theme will be analyzed in chapter 4 to complete the below table in a (+) or (-) format, where (+) = history of a civil war prior to the Ebola outbreak; and (-) = absence of a civil war prior to the Ebola outbreak in the first column. In the second column, (+) = confirmed infrastructure restoration after the civil war; and (-) = lack of infrastructure restoration after the civil war.

Table 3. Post-Civil War Infrastructure Restoration

	History of Civil War	Infrastructure Restoration Post-Civil War
Liberia		
Sierra Leone		

Source: Created by author.

These noted themes will be described in a case study comparison between Liberia and Sierra Leone. Interpretation and meaning of these themes will then be described.

In order to validate the accuracy of the information, qualitative validity was ensured by incorporation of multiple validity strategies as recommended by Creswell's methods. Qualitative validity means that the researcher checks the accuracy of the findings by using validity strategies (Creswell 2014, 1). The triangulation strategy was used to ensure themes included data from multiple sources. Source materials were checked against other sources to ensure that more than one source was coded in regards to data for infrastructure subtypes, and that sources were used from more than one country (i.e. Liberia and Sierra Leone) to ensure validity. Validity was also ensured by using clarity of any bias the researcher brought to the study (Creswell 2014, 201). Self-reflection allowed for an appropriate qualitative study in keeping with constructivism, and awareness of the researcher's experience as a Family Medicine Physician. Qualitative reliability was also assured by utilizing the qualitative research data analysis protocol as described by Creswell. Qualitative reliability means that the researcher's approach is consistent across different researchers on different projects (Creswell 2014, 201). Use of Creswell's widely accepted method for qualitative analysis and comparison to the qualitative case studies as described by Goodwick's methods with UNICEF ensured the reliability of this qualitative case study comparison (Goodwick 2014, 1).

Chapter Summary

This chapter described the qualitative case study comparison and analysis methods of the research design. The chapter discussed why this qualitative case study comparison was chosen, and briefly compared it to other research methods. Qualitative

case study comparison was described in depth according to Creswell's method. This method is widely accepted and compares well to Goodwick's research method used by UNICEF for qualitative case study comparisons to ensure qualitative reliability. Validity of the study was assured by use of the triangulation strategy to ensure that themes included data from multiple sources in both of the involved countries. Themes were identified and data tables created as described above. The primary and secondary research questions will be answered with the analysis in chapter 4. Chapter 5 will state conclusions, provide recommendations for decision makers, and provide recommendations for future research studies.

CHAPTER 4

DATA PRESENTATION AND ANALYSIS

Chapter Introduction

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone? A secondary question is: What subtypes of healthcare infrastructure affect Ebola outbreak management, and what are the roles of these subtypes? Another secondary question is: Did improvements in infrastructure from the World Health Organization and Operation United Assistance prevent recurrence of Ebola Virus Disease? A third secondary question is: Has infrastructure been adequately restored to these two nations since their civil wars?

Data presentation and analysis will be conducted using the tables prepared in the previous chapter. Each table corresponds to a theme that will answer each of the three secondary research questions. Themes presented include infrastructure subtypes comparison, outbreak resolution comparison, and post-civil war infrastructure restoration comparison. The primary research question will then be then be answered at the end of this chapter.

Infrastructure Subtypes Comparison

Infrastructure subtypes comparison was identified as a theme in the qualitative case study comparison. This theme is designed to answer the secondary research question: What subtypes of healthcare infrastructure affect Ebola outbreak management, and what are the roles of these subtypes?

The theme includes evidence from literature reviewed raw data that was coded according infrastructure subtypes. These subtypes were described as Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs); Ebola Community Care Centers (CCCs); hospitals and clinics; roads; communications; and education and schools.

These subtypes were then analyzed in this chapter to complete the below table in a (+) or (-) format, where (+) = presence of improvement in the infrastructure subtype during the period of the 2014 Ebola outbreak; (+/-) = relatively minor improvement; and (-) = absence of improvement. These infrastructure subtypes appear in the table below of the case study comparison.

Table 4. Infrastructure Subtypes Comparison

	ETCs/ ETUs	CCCs	Hospitals and Clinics	Roads	Communications	Education and Schools
Liberia	(+)	(+)	(-)	(-)	(+/-)	(+/-)
Sierra Leone	(+)	(+)	(-)	(-)	(+/-)	(+/-)

Source: Created by author.

Liberia and Sierra Leone demonstrated similar results across all six infrastructure subtypes. ETCs and ETUs were effectively established and utilized in both countries in order to stop the spread of Ebola Virus Disease (EVD). ETCs and ETUs are large facilities composed of 50 to 100 beds, and require significant staff and resources to establish and effectively operate. The role of ETCs and ETUs is to provide isolation to

stop the spread of EVD and to provide supportive medical care capabilities to enhance patient recovery. Supportive care includes rehydration therapy and treatment of symptoms to support recovery. There is currently no vaccine or cure for Ebola. ETCs were also improved upon with a new design at the MSF site in Freetown, Sierra Leone. This design enabled the ETC to have the same level of isolation to prevent the spread of Ebola, while exposing less staff to critical care patients and using less sets of personal protective equipment. This was done by constructing a Plexiglas viewing window that staff could use for patient observation. ETUs constructed in Liberia during OUA were equally effective at stopping the EVD outbreak, but required more sets of protective equipment than the improved site in Sierra Leone. Liberia requested assistance from the United States with respect to Operation United Assistance (OUA). This created a permissive environment that enabled building partner capacity between the US Army Corps of Engineers and the AFL Engineers, which allowed the AFL to improve their capabilities by constructing ETUs. OUA demonstrated that there is greater potential for building partnerships while preventing further disease in a permissive environment, than what may have occurred with resistance to assistance from the United States, had Liberia refused aid.

Ebola Community Care Centers (CCCs) were also effectively used in combating Ebola in both Liberia and Sierra Leone. Use of CCCs tended to increase when ETCs reached capacity. The role of the CCC is to provide effective isolation and community education in order to stop the spread of EVD. An advantage of CCCs was noted in their ability to be established quicker than ETUs. CCCs were also able to be established in small, rural communities without paved roads. They may be staffed with trained local

nationals within the community, and may be constructed with local materials including tents. CCCs were also noted to have added benefit when used in combination with ETUs. The number of CCC beds required to turn over or halt an Ebola epidemic was proportional to the availability of an additional 500 ETU beds available by the Kucharski study of “Evaluation of the Risks and Benefits of Introducing Ebola Community Care Centers, Sierra Leone.” The study demonstrated that CCCs can reduce the number of Ebola cases in a community where an ETU is not available, or when ETU capacity is full. However, CCC’s were noted to be ineffective at stopping an Ebola outbreak by themselves. This was noted in the Kucharski study, and was depicted in Figure 2. CCCs may be used to augment Ebola isolation and treatment capabilities in combination with ETUs. It was noted that the number of Ebola cases averted was over 4,000 with CCCs as compared to just over 2,000 with ETUs. When CCCs were used in combination with ETUs, over 9,000 Ebola cases were averted between September and October of 2014 (Washington and Meltzer 2015, 69). Although OUA was effective in halting the spread of Ebola in Liberia, the operation focused on providing ETUs and repairs of roads at airfields and ETU sites. There is potential to incorporate the establishment of CCCs in future operations to take advantage of the complementary relationship between ETUs and CCCs. Ebola Community Care Centers (CCCs) also have the potential to be used as vaccine distribution points in rural communities if an Ebola vaccine is later developed.

There was no significantly noted improvement in hospitals and clinics in both Liberia and Sierra Leone during the Ebola outbreak of 2014. The role of hospitals and clinics is to provide primary health care, obstetrical care, and emergency surgical care. Although some ETU sites may have collocated in the vicinity of hospitals or clinics, no

significant improvements in building new clinics or hospitals that were not ETU or ETC sites was found in the data obtained on review of the available literature. Significant improvements are still needed to restore clinics and hospitals to pre-civil war conditions in both countries. Approximately 80 percent of Liberia's healthcare relies on foreign assistance (Kruk 2013, 3). A similar trend was noted in Sierra Leone, with most healthcare provided by foreign assistance per Doctors Without Borders (MSF). The Republic of Liberia *Agenda for Transformation: Steps Towards Liberia Rising 2030* has outlined goals for improvement by 2030 as described in the literature review, but does not have a 2017 indicator planned as it does for some other areas of improvement. It is also of note that the Republic of Liberia *Agenda for Transformation: Steps Towards Liberia Rising 2030* was written in 2013. This was prior to the 2014 Ebola outbreak, and the *Agenda* has not yet been updated. There is potential for improvement in prioritizing healthcare infrastructure in Liberia. It is also of note that the West African countries of Ghana and Nigeria were largely unaffected by Ebola Virus Disease, and have more robust infrastructure to include hospitals, clinics, and roads. Ghana's infrastructure also allowed for the movement of thousands of Ebola responders and medical supplies to assist with MSF and WHO efforts in Liberia and Sierra Leone (Soy 2015, 2).

Roads in both Liberia and Sierra Leone demonstrated no significant improvement during the course of the 2014 Ebola outbreak. Although some improvements of roadways were mentioned in the literature, these improvement were limited to roads of airfields and in the immediate vicinity of large ETUs located in cities, as was the case in OUA. The majority of roads in both Liberia and Sierra Leone remain unpaved, and with little to no access to the majority of rural areas in both countries. Roads in both countries are still

largely inadequate for the rural populations, and have not been reestablished or improved since the civil wars. The Republic of Liberia has planned improvements according to the *Agenda for Transformation: Steps Towards Liberia Rising 2030*, and has described year 2017 outcome indicators as having more roads in good condition the entire year, decreased travel times, decreased cost of travel between urban and rural areas, and more cost effective road construction and maintenance (Liberia 2013, 67). In Sierra Leone, roads were considered especially weak in rural areas, which hindered transport of patients, and building additional facilities. The Government of Sierra Leone has looked to corporate tax exemptions for the country's mining companies to encourage them to remain in Sierra Leone, and assist with economic development including road infrastructure around mines for shipping. This has thus far been met with minimal success, as many companies' profits decreased in 2014 due to the Ebola outbreak's negative impact on employment and travel in Sierra Leone (O'Hare 2015, 2). The role of roads in Ebola outbreak management is critical to mission success, as roads are needed to ensure access to airfields, Ground Lines of Communication (GLOCs), and other infrastructure subtypes including hospitals, clinics, CCCs, ETUs, and schools. Paved roads need to be established prior to effectively building additional healthcare infrastructure, such as clinics and hospitals, to meet the long term needs of Liberia and Sierra Leone. Roads are also key to establishing improvements to communications systems in rural areas.

Communications infrastructure was found to have some relatively minor improvements in both Liberia and Sierra Leone over the course of the 2014 Ebola outbreak. Although telecommunications systems including telephone and internet access

had little improvement and posed communications challenges, other improvements were made including Ebola emergency response systems in Liberia, and establishment of the national call center in Sierra Leone. The role of communications is to ensure EVD patients and their families are provided rapid response to ambulance services to ETUs, safe burial education, and surveillance support for case investigation to follow close contacts of EVD patients and family members. However, surveillance of rural communities was often difficult, and reports from the field stated that communications infrastructure, and the lack of paved roads, made communicating with local communities difficult (Forrester et al. 2014, 891). The Liberian Ministry of Health and Social Welfare (MOHSW) developed a national task force to oversee management of Ebola emergency response. The role of the task force was to provide 24-48 hour response to operations including ambulance services to ETUs, safe burial education and practices, surveillance support for case investigation, and following of contacts of EVD patients and their families (Pillai et al. 2014, 932). This practice was largely effective, but some of these services with respect to education and contact follow-up could have been conducted by establishment of CCCs in rural communities. Surveillance systems in Sierra Leone were also established similar to those in Liberia with training and support from CDC, WHO, and USAID (Okunogbe 2015, 13). A national call center was established in Sierra Leone for Ebola response. The call center conducted a three day house-to-house campaign where teams visited homes to provide EVD basic education including use of contact precautions. However, the call center was able to provide a next day response in only 45 percent of the time to possible new Ebola cases (Miller et al. 2015, 29). The need to provide more services to rural areas for potential cases, and improve telecommunications

to rural areas contributed to lack of response (Miller et al. 2015, 28). This practice was somewhat effective, but these services could also have been provided by a local CCC with better access to the community in these rural areas.

Education and schools were considered to have had relatively minor improvements in both Liberia and Sierra Leone during the course of the EVD outbreak. No improvements were noted in the data obtained from the literature review with respect to improvements in literacy rates or construction of new schools. Educational campaigns specific to Ebola were largely unsuccessful due to the relatively low literacy rates in both countries when conducted with posting signs. However, improvements were noted in education with respect to CCC use in both Liberia and in Sierra Leone. CCCs were effectively utilized in rural areas to provide basic Ebola healthcare education, and safe burial practices. It was estimated that without CCCs in Liberia, there would have been an additional 2,000 EVD cases from September to October of 2014 (Washington and Meltzer 2015, 69).

The role of education and schools with respect to EVD management is to provide basic healthcare education for isolation and surveillance protocols, and to teach contact precautions and safe burial practices. In essence, the role of education is to decrease transmission and encourage prevention of disease. With respect to schools specifically, the role of education in this case is to improve the literacy rate. CCC's played a major role in education in Liberia and Sierra Leone, but were largely implemented later in the course of the 2014 outbreak as a way of performing outreach to rural areas, and adding capacity to overpopulated ETUs. There is great potential in incorporating CCCs early on

in future humanitarian missions due to their effectiveness in education, as well as in augmentation of ETUs.

Outbreak Resolution Comparison

Another theme found in this study is an outbreak resolution comparison between Liberia and Sierra Leone, in which new cases of EVD were confirmed after the WHO declared resolution of the outbreak post Ebola Treatment Center (ETC)/Ebola Treatment Unit (ETU) and Ebola Community Care Center (CCC) use. This theme is designed to answer the secondary research question: Did improvements in infrastructure from the World Health Organization and Operation United Assistance prevent recurrence of Ebola Virus Disease?

The theme will be analyzed to complete the below table in a (+) or (-) format, where (+) = declaration by the WHO of the 2014 Ebola outbreak; and (-) = absence of declaration of outbreak resolution in the first column. In the second column, (+) = confirmed new cases of EVD after the initial 2014 outbreak; and (-) = lack of recurrence of the outbreak.

Table 5. Outbreak Resolution Comparison

Table 2	Outbreak Declared Over Post ETC/ETU and CCC Use	Confirmed New EVD Cases Post Outbreak
Liberia	(+)	(+)
Sierra Leone	(+)	(+)

Source: Created by author.

Outbreak recurrence was noted in both Liberia and Sierra Leone despite the effective use of ETCs/ETUs and CCCs to stop the initial outbreak with international efforts. These smaller outbreaks (recurrences) still continue in parts of Liberia and Sierra Leone as of January 2016. WHO declared an end to the EVD outbreak in Liberia in May of 2015, but new cases emerged in June 2015 resulting in an additional 2 deaths (CDC 2015, 1). Fortunately, this was small compared to the death toll in the initial outbreak of 9,000 deaths in Liberia and Sierra Leone. Liberia was declared free of Ebola in September 2015, but three new cases emerged again in less than three months later in November 2015 (BBC Africa 2015, 1-2). WHO also declared the end of the Ebola outbreak in Sierra Leone in November 2014, only to have Ebola recur in later that same month (BBC Africa 2016, 1-2). It was noteworthy that Guinea has been more effective at containing the outbreak, despite having 2500 deaths, and was stated to have a “more resilient” health care system than Liberia or Sierra Leone (Chothia 2014, 5). West African countries with well-established infrastructure such as Nigeria and Ghana were largely unaffected by the outbreak; with Nigeria having had only eight deaths, and Ghana having no reported Ebola deaths (Soy 2015, 3). Improvements in infrastructure thus far in Liberia and Sierra Leone have not been enough to prevent recurrence of EVD. There is still potential for great improvements in roads, clinics and hospitals, education, communications, and the incorporation of more CCCs in rural areas.

Post-Civil War Infrastructure Restoration

A third theme noted in the study was the lack of post-civil war infrastructure restoration in the two countries. This theme is designed to answer the secondary research

question: Has infrastructure been adequately restored to these two nations since their civil wars?

This theme will be analyzed to complete the below table in a (+) or (-) format, where (+) = history of a civil war prior to the Ebola outbreak; and (-) = absence of a civil war prior to the Ebola outbreak in the first column. In the second column, (+) = confirmed infrastructure restoration after the civil war; and (-) = lack of infrastructure restoration after the civil war.

Table 6. Post-Civil War Infrastructure Restoration Comparison

Table 3	History of Civil War	Infrastructure Restoration Post-Civil War
Liberia	(+)	(-)
Sierra Leone	(+)	(-)

Source: Created by author.

Infrastructure has not been adequately restored to Liberia or to Sierra Leone since these two nations' civil wars. The public health infrastructure in Liberia and Sierra Leone remains severely strained.

Sierra Leone's civil war from 1991 to 2002 left the country almost devoid of healthcare infrastructure (UNDP 2014, 5). The majority of healthcare infrastructure has not been restored, and traditional healers are reported to provide the majority of healthcare, with 90 percent of deliveries in the local communities. Private sector health care remains undeveloped compared to other countries in West Africa, such as Ghana and

Nigeria (UNDP 2014, 7). Sierra Leone also has a lack of adequate roads and telecommunication systems, particularly to rural areas. Much of the nation remains poor, and up to three-quarters of children do not attend school at the correct age. Rural students are also less likely to complete a full cycle of education (UNDP 2014, 5).

Liberia's civil war lasted for 14 years, and also devastated the country's health care infrastructure. It was determined that 242 of the nation's 293 public health facilities were non-functional (Mugo 2015, 1). The new democratic elected government began to establish stability and access to humanitarian assistance in 2006 (UNDP 2014, 4). Despite multiple programs undertaken over the years to address Liberia's post-civil war challenges, most families do not have basic health services. This lack of infrastructure posed difficult challenges to the international relief efforts mounted by OUA, USAID, WHO, and MSF to combat the outbreak.

Chapter Summary

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone?

The answer is: Yes, healthcare infrastructure affects the successful management of Ebola Virus Disease in Liberia and Sierra Leone. The effects are described according to the themes used to answer the secondary research questions.

Chapter 5 will state the conclusions of this qualitative case study comparison, provide recommendations for decision makers, and provide recommendations for future research studies.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Chapter Introduction

The primary question of this thesis is: Does healthcare infrastructure affect the successful management of Ebola Virus Disease (EVD) in Liberia and Sierra Leone?

The answer is: Yes, healthcare infrastructure affects the successful management of Ebola Virus Disease in Liberia and Sierra Leone. The effects are described according to the themes of infrastructure subtypes comparison, outbreak resolution comparison, and post-civil war infrastructure restoration used to answer the secondary research questions in the previous chapter. These answers lead to a number of conclusions and recommendations.

Conclusions

Infrastructure affects the successful management of Ebola Virus Disease as demonstrated by healthcare infrastructure subtypes studied in Liberia and Sierra Leone. These subtypes include Ebola Treatment Centers (ETCs)/Ebola Treatment Units (ETUs); Ebola Community Care Centers (CCCs); hospitals and clinics; roads; communications; and education and schools. Each of these subtypes has a distinct role in Ebola outbreak management. The effects of these subtypes followed similar patterns in Liberia and Sierra Leone during the 2014 Ebola Virus Disease outbreak.

Outbreak recurrence was noted in both Liberia and Sierra Leone despite international efforts and effective use of ETCs/ETUs and CCCs to stop the initial outbreak. These smaller outbreaks (recurrences) still continue in parts of Liberia and

Sierra Leone as of January 2016. Improvements are needed to ensure adequate roads, primary care capabilities (clinics and hospitals), education, and proper incorporation of Ebola Community Care Centers (CCCs) with simultaneous use of Ebola Treatment Units (ETUs) in the event of future outbreaks of Ebola Virus Disease (EVD).

Infrastructure has not been adequately restored to Liberia or to Sierra Leone since these two nations' civil wars. The public health infrastructure in Liberia and Sierra Leone remains severely strained. The global health community must be vigilant in the future to rapidly reestablish healthcare infrastructure to countries devastated by civil wars which could not be prevented.

Recommendations

Recommendations can be made based on the findings of this qualitative case study comparison between Liberia and Sierra Leone taking into account United States strategic interests in Liberia in accordance with the *National Security Strategy 2015*. These recommendations support ARCIC's Army Warfighting Challenge #2: Shape the Security Environment, and may be used to improve building partner capacity.

These recommendations are divided into recommendations for decision makers and recommendations for future research. Recommendations for decision makers includes those recommendations for DoD, DoS, USAID, the Republic of Liberia, WHO, and MSF to support the planning of future humanitarian operations. Recommendations for future research include those recommendations for students and researchers to explore in order to improve the body of evidence in publications, thesis writing, and other scholarly activities.

Recommendations for Decision Makers

1. It is recommended that DoS and USAID coordinate with the Republic of Liberia to update the *Agenda for Transformation: Steps Towards Liberia Rising 2030* published in 2013. Improvements should be made to incorporate knowledge gained from the 2014 Ebola outbreak. These improvements should prioritize specific 2017 progress indicators to ensure adequate paved roads to rural communities. Roads were found to be key to allowing other capabilities such as transportation, ambulance services, and construction of healthcare capabilities including Ebola Treatment Units (ETUs) and Ebola Community Care Centers (CCCs). These capabilities could then be expanded to build additional clinics and hospitals. Education should also be prioritized to include education capabilities at CCCs, which could perform a role of EVD healthcare education including safe burial practices. CCCs could also serve as future vaccination points if an Ebola vaccine is developed, ensuring distribution to rural communities.

2. It is recommended that AFRICOM and USARAF consider the integration of Ebola Community Care Centers (CCCs) with simultaneous use of Ebola Treatment Units (ETUs) in the event of future outbreaks of Ebola Virus Disease (EVD). This would enable reduction in the spread of EVD as compared to the use of ETUs alone. It is also not recommended to use CCCs without ETU capabilities, as CCCs were shown to augment ETU capabilities, but not shown to halt an outbreak by themselves.

3. It is recommended that communications systems not only be established in rural areas according to the *Agenda for Transformation: Steps Towards Liberia Rising 2030*, but that specific indicators of maintenance of communications systems including those involved in national emergency response be addressed in case of future outbreaks.

These systems also need to be coordinated with those of neighboring countries such as Sierra Leone and Guinea.

Recommendations for Future Research

1. It is recommended that a comparative study be done with infrastructure in Liberia and Sierra Leone with infrastructure in Guinea, once substantive literature for Guinea becomes available.

2. It is recommended that another comparative study be done for infrastructure in the affected countries of Liberia and Sierra Leone as compared to Ghana and Nigeria, as the latter two countries were largely not affected by the 2014 Ebola outbreak.

3. It is recommended that a comparative study of infrastructure subtypes be done with Liberia and Sierra Leone to follow infrastructure progress with respect to potential achievement of 2017 progress indicators as defined by the *Agenda for Transformation: Steps Towards Liberia Rising 2030*. Subtypes may also be expanded to include separate power infrastructure as opposed to including power with communications capabilities, as was the case in this study. A comparison with water infrastructure subtype may also be done in the future.

Closing Thoughts

Despite the world knowing of the existence of Ebola Virus Disease since its discovery in 1976, the world paid little attention until the advent of globalization, and the international relief efforts that followed.

When you turn a blind eye to atrocities, you are complicit in them.

— David Crossman
A Terrible Mercy, November 17, 2014

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