

TRANSMISSION CONTROL CHALLENGES:

**Health Service Delivery and Community Engagement during the Ebola Virus Disease
Outbreak of 2014-2015 in Liberia**

Topian Zikeh

Liberia

56th Master of Public Health/International Course in Health Development

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TRANSMISSION CONTROL CHALLENGES: HEALTH SERVICE DELIVERY AND COMMUNITY ENGAGEMENT DURING THE EBOLA VIRUS DISEASE OUTBREAK OF 2014-2015 IN LIBERIA

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Public Health

By

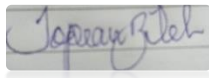
Topian Zikeh

Liberia

Declaration:

Where other people's work has been used (from either a printed source, internet, or any other source), this has been carefully acknowledged and referenced following departmental requirements.

The thesis *Transmission Control Challenges: Health Service Delivery and Community Engagement during the Ebola Virus Disease outbreak of 2014-2015* in Liberia is my own work.



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The road was not always smooth, I felt like giving it up, but you all were the strength that kept me at it.

Dedication

I dedicate this achievement to my dear mother, Mrs. Vonyee Luoka Zikeh (Deceased), whose trust in me served as my strength to pursue this program but did not live to share the joy of achievement. May her soul and the soul of my dear father, Mr. Charles S. Zikeh, rest in peace.

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Abbreviations

AJOL	African Journal Online
BPHS	Basic Package of Health Services
CDC	Centre for Disease Control and Prevention
CEBS	Community Event-based Surveillance
CHT	County Health Team
CSO	County Surveillance Officer
DHT	District Health Team
DPCU	Disease Prevention and Control Unit
DSO	District Surveillance Officer
EBS	Event-Based Surveillance
EOC	Emergency Operating Centre
EPHS	Essential Package of Health Services
ETU	Ebola Treatment Unit
EVD	Ebola Virus Disease
IDSR	Integrated Disease Surveillance and Response
IPC	Infection Prevention and Control
JEE	Joint External Evaluation
JISS	Joint Integrated supportive Supervision
KSKS	Keep Safe, Keep Serving
LASV	Lassa Virus
LIGIS	Liberia Institute of Geo-Information and Statistics
LIP	Liberia Investment Plan
MARS	Middle East Respiratory Syndrome
MeSH	Medical Subject Headings
MOH	Ministry of Health
MST	Minimum Standard Tool
NPHIL	National Public Health Institute of Liberia
NRL	National Reference Laboratory
PPE	Personal Protective Equipment
QMU	Quality Management Unit
RT-PCR	Real-Time Polymerase Chain Reaction
SARS	Severe Acute Respiratory Syndrome
SCMS	Liberia Supply Chain Management System
SCMU	Supply Chain Management Unit
SOP	Standard Operating Procedures
WFP	World Food Programme
WHO	World Health Organization

Glossary

Key terms	Definition
Infectious disease transmission	The spread of infectious disease from a host (humans and or animals) to an individual or group of individuals by direct or indirect contact (1) (2)
Ebola virus disease	The bleeding illness causes a severe, serious, usually deadly disease (3)(4).
Infection Prevention and Control	Evidence-based practical strategies used to prevent and control the spread of avoidable infections (5)
System measures	In this study: 'System Measures' are policies formulated at the level of authority (MOH) for controlling transmission in health service delivery and community
Field measures	In this study: 'Field Measures' are the application (operationalization of policies in health service delivery and community.
Success	Success as a term used in this work means progress in the right direction to a sustainable transmission control system than indicating a completion of a task
Challenge	The word 'challenge' in this work means that it is hard to accomplish what is ought or required for transmission control

Abstract

Background: Liberia has experienced the deadliest outbreak of Ebola in history, with a health system unprepared to control the EVD rapid transmission that reported 10,678 cases, 4,810 deaths including health workers, and disruption of routine health services. Rigorous joint efforts of the government and its partners eliminated the EVD transmission. Notwithstanding, Liberia continues to experience outbreaks of infectious diseases. An outbreak of Lassa Fever in December 2019 reported 50 confirmed cases, 18 deaths, and a fatality rate of 36%. This thesis reviewed the adaptations and interventions implemented to control the EVD transmission in health service delivery and at community levels; analyze the activities, successes, challenges, and sustainability measures during the EVD epidemic (2014-2015).

Methodology: A literature review of challenges in controlling EVD transmission in Liberia's health service delivery and community. The health system building blocks as a conceptual framework for public health Disaster Risk Management (DRM), specifically the service delivery and community resilience components, assisted the organization of results.

Results: The results showed a lack of health policies, adequate health funding, effective community engagement, skilled mixed health workforce, essential IPC, and medical supplies for controlling transmission in health service delivery and community; and that some policy and operational measures proved successful to contain the EVD transmission.

Conclusion and recommendations: System and Field measures controlled the EVD transmission. Nonetheless, transmission control, including its sustainability measures, remains a challenge and threat to public health. Recovery plans should focus on control measures sustainability, and MOH / NPHIL transmission control strategies include community engagement at the start.

Keywords: Liberia, health system, community engagement, Ebola Virus disease, Transmission control challenges.

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Introduction

My name is Topian Zikeh, a Liberian registered nurse. I have worked in various Liberian health service delivery and community settings as a bedside nurse, public health promotions' Officer, surveillance / supplementary immunization activities officer in water sanitation and hygiene promotions, restoration of health services programs, and surveillance systems in underprivileged healthcare settings.

My motivation for this thesis stems from my experience in disease transmission, the challenges to control the transmission, and the practices of infection prevention and control (IPC) at health facilities and in communities. This motivation is driven by the rapid and uncontrollable transmission of the Ebola virus disease (EVD) and the extent to which the transmission claimed lives and impacted the Liberian society in 2014-2015.

This thesis reviews the adaptations and interventions implemented to control EVD transmission in service delivery and at the community level and analyzes the measures, successes, challenges, and sustainability measures during the EVD epidemic (2014-2015).

Chapter One

1.0. Background

1.1. Demographics information

The Republic of Liberia is a low-income country in West Africa with an area of 111,369 square kilometers. It shares borders with Sierra Leone, Ivory Coast, Guinea, and the Atlantic Ocean (figure 1). The estimated population of Liberia is 5,214, with about over half of the population living in urban areas. The median population age is 18 years, with a total life expectancy of 65 years (7)(8).



Figure:1 Map of Liberia (9).

1.2. Socio-economic information

Liberia is a poor country in West Africa (10)(11) though, the country is rich in natural resources such as iron ores, gold, diamond, and falls in the list of rubber-producing and exporting countries globally (12). The years of civil war and mismanagement destroyed the country's economy and infrastructure. Foreign business returned to the country after the election of a democratic government in 2006. Between 2010 to 2013, the country's economy improved, achieving high growth (13). Although the government contribution (\$50-60 million) to the health sector surpassed the Abuja target of 15% (fiscal 2013/2014), the health sector needed about \$200 million investment at that time, underfunding the sector in absolute terms(14).

1.3. Overview of the Health System

A 14-year civil conflict (December 1989-June 2003) overwhelmed and destroyed the health system, leaving health infrastructure in poor condition, neglecting health services, and

creating an uncultured shortage of skilled health workers with a dysfunctional epidemic preparedness system (15). Nonetheless, at the onset of the EVD epidemic, Liberia's health indicators, though slow, were showing gains after the civil war (16). A health sector reform process aimed at improving coverage and access to the basic package of health services (BPHS) made health services available at the marginal levels of the health system and decentralized health services management to county levels implementation (17). Though the policy exists, the BPHS implementation still had challenges with equitable distribution of qualified health workers and adequate supply of essential medical and infrastructure (18). Only 71% of the population [71% lived 5km] had access to a public health facility before the EVD. The BPHS extended by the essential package of health services (EPHS) under a ten-year national health policy [2011-2021] (19)(20). The EPHS requires a minimum of two skilled personnel (physician assistant, registered nurse/nurse-midwife, or a midwife) at a level two primary clinic and at least one physician at a health Center, the reality of the situation at primary and secondary health facilities were different (21)(22).

1.4. Health Sector Information

Liberia is estimated to have 458 public and 373 private health facilities across the country; the health system operates at the primary, secondary, and tertiary levels. The primary level runs the community health system and operates levels one and two clinics. It provides health promotions and integrated outreach services. The secondary level offers county and district referrals with a focus on maternal and child emergency services. The tertiary level consist of regional hospitals that serve three to five counties referrals (Figure 2) see Appendix I for detail (23)(24). The health system's efforts to provide quality health services to its people stem from inadequacy associated with funding limitations. It lacked previous experience controlling transmission of high magnitude, and there existed unavailability of qualified human and material resources (20). Health workers were discouraged by health authorities, unfavorable responses to demands for increased salaries, civil servant status, and decent work environment, demotivated the already inadequate health workforce just before the onset of the EVD epidemic (25). In February 2014, the health workers were on strike for timely and higher salaries, civil servants' status, and other needs. Unfavorable responses from health authorities further created a fragile relationship, causing many health workers to stay away from clinics and hospitals. A range of diseases constitute the burden of Liberia disease, and preventable diseases rank in the top five (26).

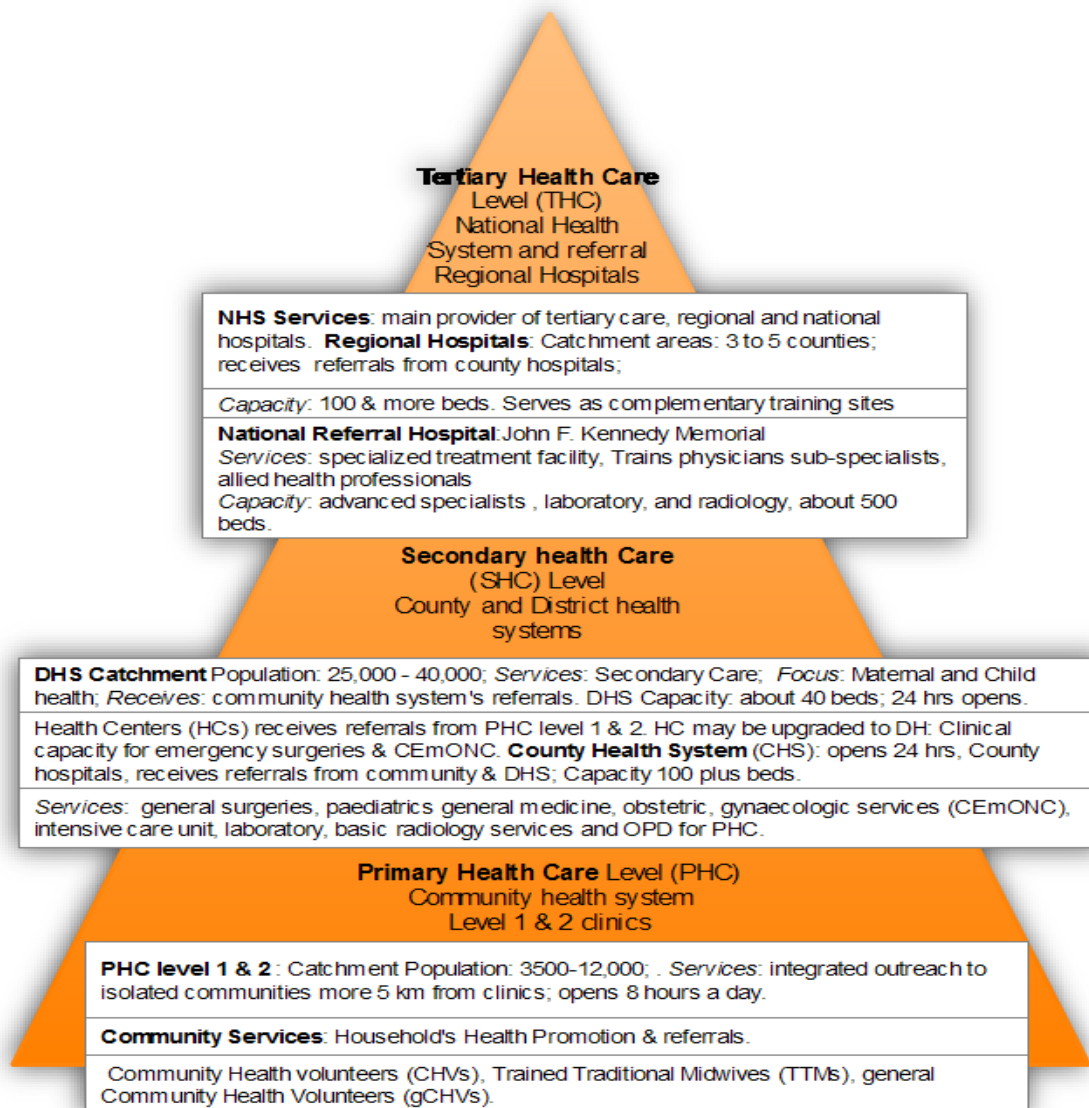


Figure 2: Health System Levels of Operation in Liberia (24)(22).

1.5. **History of Ebola virus disease transmission in Liberia**

Liberia was one of the West African countries that experienced the deadliest and most challenging outbreak of Ebola in history. The size of the infection, rapidity, and geography of transmission, and fatality made it unparalleled. The first case of the EVD was recorded in Foya District (Lofa County) in March. The virus reached Monrovia in mid-April, with 209 confirmed cases and 131 deaths recorded in the country. The EVD outbreak had started in late March of 2014, and by February of 2015, Liberia had 8881 cases reported (27)(20). Poor IPC infrastructure, Health workers' infection, and cultural practices challenged and complicated the control of the epidemic. The Liberian government declared a national emergency due to the rapid and uncontrollable transmission of EVD in the country (27).

2.0. Problem statement

The transmission of infectious diseases is now even more than ever one of the major global causes of morbidity and mortality. In 2002, the World Health Organization (WHO) report attributed 22% of death and 27% of disability-adjusted life years to infectious diseases (28). The contagious disease trend has shifted from the usually known infectious diseases (diarrheal diseases, HIV/Aids, etc.) to more rapidly communicable emerging and reemerging diseases. The EVD outbreak in West Africa (2014-2015) and the current novel coronavirus pandemic affecting every healthcare service are examples of such a shift (29). Africa shares a disproportionate burden of infectious diseases. Their weak healthcare service delivery coupled with poor WASH (infrastructure in countries) and behavior in many African countries serves as a fertile ground for the rapid transmission of infections and a risk to public health globally (30). The world was in shock and feared the rapid high transmission rate of the EVD during the outbreak in three West African countries. The high number of cases and deaths marked the virus's first appearance (31). By August of 2014, Liberia, Guinea, and Sierra Leone reported 2,599 cases and 1,422 deaths (32).

When Liberia awakened to the phenomenon of the EVD in 2014, it had already built a record on speed transmission. The health services were overwhelmed, and the public health impact was devastating for households and families; shockwaves, forceful separations, and deaths raged from every corner (33)(34).

At the onset of the EVD epidemic, the health system had a key challenge of sourcing adequate resources for health services (35). Hence, the EVD epidemic of 2014-2015 challenged and showed the fragilities in the Liberian health service delivery to control and prevent transmission. The shattering effects of the EVD outbreak were felt not only in the health services but also in the population and on the already struggling economy in the country (27). By August of 2014, Liberia was already at its peak of the outbreak, reporting 1082 cases and 624 deaths at an alarming rate in the country (32).

To control and eliminate the fast transmission of the disease at health facilities, in communities, and in the country, rigorous joint efforts of the government and her partners were required. Various methods were used such as mobilization of community leaders, training of health workers, standard-based measures such as hand hygiene, no contact with body fluid, availability and use of PPEs, sharp and injection safety in the health service delivery (36).

The measures of handwashing at home, in schools and communities, triaging and use of infection prevention and control (IPC) protocols at health facilities, safe burial rites were adapted in Liberia. Despite the lessons learned in eliminating the EVD, Liberia continues to have a constant outbreak of infectious diseases in the country. The country reported an outbreak of Lassa fever in December 2019 with 50 confirmed cases, 18 deaths, and a fatality rate of 36% compared with 66% in 2018. Health authorities considered this an improvement though these outbreaks were in communities without a history of Lassa fever experience or within the belt of Lassa fever in the country (37)(38). It is an alarming concern because disease outbreak (as the EVD demonstrated) brings with it not only a lot of human suffering but as well as a high direct and indirect economic impact on a nation and its people. The immense economic impact becomes a burden on the population with an already low social-economic status (39). Inability to control hemorrhagic fevers transmission puts a considerable burden on the health sector. It increases the number of sick persons, overwhelms health workers, and causes neglect of other health services. It unsatisfactorily affects households' resources and drives the population of helpless members into further poverty producing an unending circle of poverty (39)(37).

This also leaves one to wonder, what are the lessons learned from the Ebola outbreak; what might have happened to all the knowledge and skills acquired and the measures employed during the EVD epidemic? These inquiries point to the challenges to prevent transmission, especially at the health service delivery and in the community. This thesis analyzes the challenges to transmission control by health service delivery and by community engagement in Liberia.

2.1. **Justification**

The uncontrolled transmission of the EVD epidemic affected all aspects of Liberian society. It had multiple impacts ranging from direct Ebola illness and death to deteriorating social and economic conditions for health (40).

The EVD infection has a lifelong complication that is crippling for survivors and families. Survivors report pain (53-77%), 14-60% of ocular complications, and weakness (70%). Survivors of EVD and their families experience psychological effects, stigma, and discrimination that follow fear, stress, and grief (41)(42).

The EVD epidemic brought routine health services to a complete stop. Health services became overwhelmed with the number of cases. Essential health supplies became scarce, with health workers deserting health facilities. Many health workers were infected (378) and died (192) of the EVD. Health workers were not knowledgeable and skilled about the EVD (13) (14). At the early stages of the EVD epidemic, health workers were considered not to have adequate knowledge of transmission control measures (43)(44). Health workers refused to assist women in labor for fear of contamination with the body fluid in the absence of PPEs. Infectious disease outbreak diverts attention from other health services to the control of the transmission. A third of healthcare services stopped operating, with 62% of health facilities been closed by August of 2014 (45).

The EVD had an enormous negative social impact. Common in the population was the belief that Ebola was an experiment of a biological weapon by the West and that national governments had received money for such an experiment. The use of overall PPE (made response health workers look like men from the moon) and chlorine for disinfection of homes in which an infected person lived further enforced this belief. The forceful admission of suspected cases to Ebola Treatment Units (ETU) and uncustomary burials were perceived as inhumane and undignified by the community. These, among others, created fear of the health services and distrust of health authorities (46).

Furthermore, household earnings in Liberia dropped to 35% six months after the EVD epidemic. Food was scarce, and prices increased due to the epidemic. The banning of wild animals used as meat resulted in many families lacking their primary source of protein. The World Food Programme (WFP) estimated a rise in the number of persons with food insecurity with pregnant women, breastfeeding mothers, and young children disproportionately affected by 2015 (47).

What does this study contribute to - This study is conducted to contribute to the growing knowledge on disease transmission control and prevention, focusing on the challenges of transmission control of the EVD on health services and community engagement in Liberia (48)(49). While other studies were conducted with a focus on general consequences and impact of the epidemic on a specific aspect of the health service or the health system in general, this study reviews the control measures to prevent transmission and the measures to sustaining the implementation of these control measures in health service delivery and community engagement during the EVD epidemic. Considering the thesis findings, the

recommendations can be used by the ministry of health (MOH) and the National Public Health Institute (NPHIL) to collaborating closely with communities to promote disease control and transmission prevention in the healthcare service delivery of Liberia.

2.2. Study Objectives

2.2.1. General objective

Overall objective: To review the adaptations and interventions implemented to control EVD transmission in service delivery and at the community level, and to analyze the measures, successes, challenges, and sustainability measures during the EVD epidemic (2014-2015).

2.2.2. Specific objectives

1. To describe measures taken to control and prevent Ebola virus transmission in Liberia during the EVD epidemic
2. To analyze the main successes and challenges (as well as the lessons learned) in controlling the EVD transmission in Liberia.
3. To analyze the main factors that contribute to sustaining transmission control measures in health service delivery and community.
4. To formulate recommendations to the Liberian health authorities and stakeholders to sustain, control, and prevent disease transmission in health service delivery and community.

3.0. Methodology

3.1. Study type

This study is a literature review. It evaluates challenges, measures, successes, and sustainability strategies to control transmission in service delivery and community during the EVD outbreak in Liberia (2014-2015). The review specifically focused on 2014 - 2015 because this period was the highlight of the epidemic. Relevant literature from the sub-region was considered because of similar cultural and healthcare service delivery practices. Literature review chosen for feasibility, thesis timeline constraints, and the situation created by the novel coronavirus pandemic.

3.2. Search strategy

PubMed and African Journals Online (AJOL) were databases searched for review, Google search engines, and the Vrije University Library. Additional resources were directly obtained from the WHO, Center for Disease Control (CDC), and the Liberia Ministry of Health (MOH) websites. The literature search considered eleven years (2010-2021) for sufficient literature and evidence-based analysis of transmission control and its outcome. The literature search was limited to the English language and included relevant literature on the transmission and control of EVD in Liberia and the West African region. The region shares similar cultural and social practices and the experience of the EVD epidemic. Key search terms included 'Liberia' or 'West Africa' or 'health service delivery' or 'community engagement' AND 'EVD transmission' 'EVD transmission control' OR 'disease transmission control' or 'disease transmission control challenges' 'transmission control measures' or 'measure to control transmission' AND 'sustainability of transmission control measures' or 'influencing factors for control measures' (Table 1) Summary of keywords Combination and Medical Subject Heading (MeSH) per Study Objectives.

Table 1: Summary of Keywords, Combinations, and MeSH per Study Objectives

Study Objectives	Key Words, Combination, and MeSH
To describe control measures taken to control transmission in Liberia during the EVD epidemic	Liberia, West Africa, health service delivery, community engagement, Ebola virus disease transmission, transmission control measures,
To identify the main successes and challenges (as well as the lessons learned) in controlling disease transmission in Liberia between 2014-2016	Transmission control, challenges, successes, lessons learned, control measures, Ebola impact,
To identify the main factors that contribute to adherence to transmission prevention measures in health service delivery and at community	adherence to transmission prevention, sustainability of transmission control measures, influencing factors for the sustainability of prevention measures

3.3. ***Inclusion and exclusion criteria***

The region of interest included Liberia, West Africa, and any other region, provided that the literature was comparable and relevant to the thesis topic. Literature that did not meet these criteria was excluded. (Table 2) Summary of the criteria used for the literature review.

Table 2: Summary of Criteria for Literature Review

Criteria	Included	excluded
Type of literature	Peer-reviewed and credible grey literature	
Period considered	2010-2021	
Language	English	Any other language
Region of interest	Liberia, West Africa, and any other region provided that the literature is comparable and relevant to the thesis topic	

3.4. ***Conceptual Framework***

The health system building blocks as a conceptual framework are combined with community resilience and the social determinants as fundamental for strengthening and managing threats to public health (Figure 3) (6). The framework provides strong guidance for analyses and shows the issues influencing the control and prevention of infectious disease transmission in health services and communities (6). The framework was selected as it indicates elements

that affect resilience in the health system and put them into three categories (the health system building blocks, community, Disaster Risk Management (DRM), and health determinants), showing their interlinkages to health outcomes (Figure 3). It also provides insight for a cost-effective approach to resilience at all health system levels in a resource-limited setting such as Liberia. The framework guides the approach needed to control and prevent infectious disease transmission or has the potential to do so.

Criteria for the framework used - With this framework, the thesis focused primarily on the health service delivery component of the health system building blocks in combination with the community resilience in the outer circle; two components at a decentralized level that contribute significantly to a resilient health service delivery in the health system. Resilience in communities and health service delivery can be proven to minimize or control the transmission of infectious diseases (50). The description of other components of the health system building blocks was considered where pertinent and influences primary health service delivery and community resilience in the analysis. And as resilience in health service delivery and community have an interlinkage to other components of the framework.

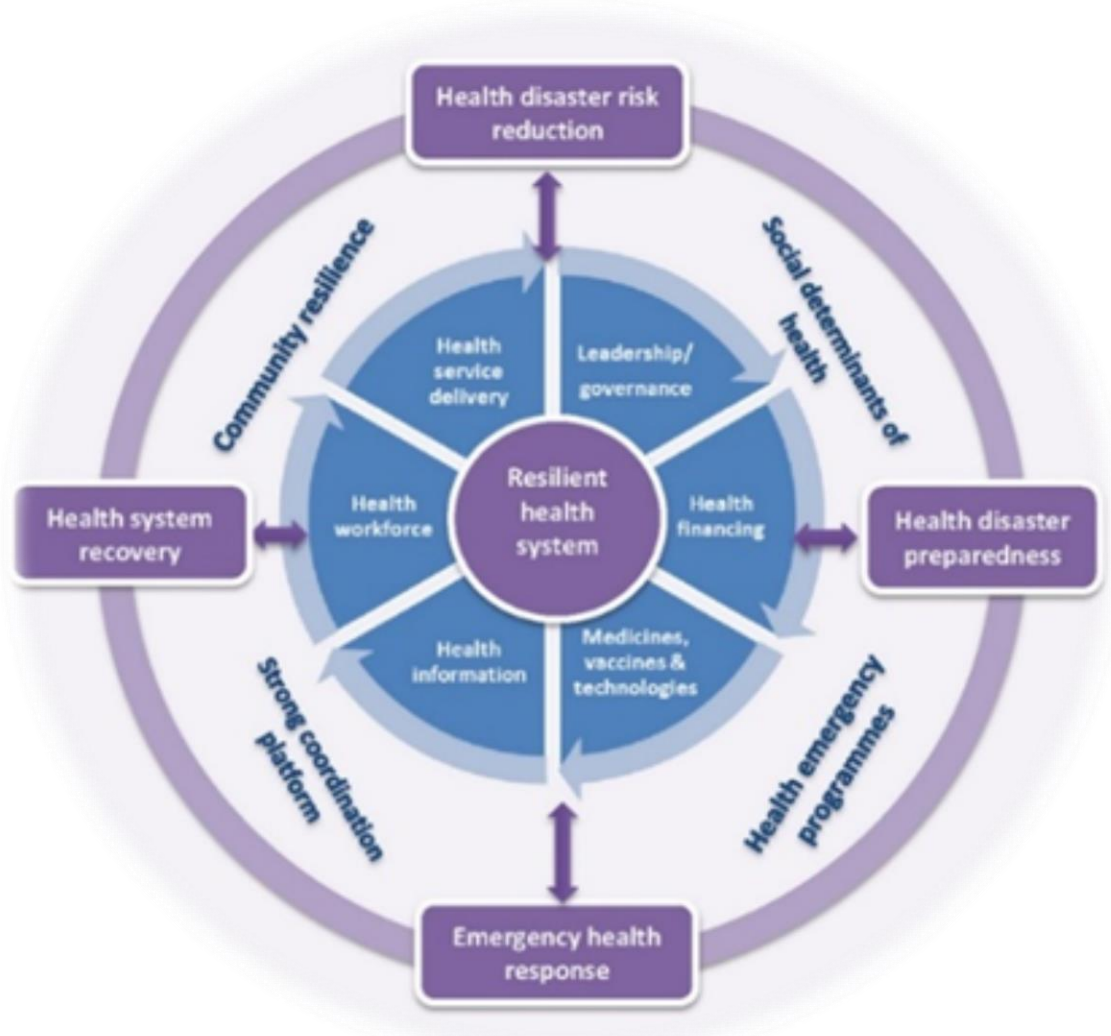


Figure 3. Health system building block as a conceptual framework for public health disaster risk management (6).

Chapter Two

4.0. Results

4.1. *Introduction*

The analyzes are organized according to two framework components described in the method section, service delivery and community resilience to disease transmission (3.4.). The results are also analyzed in line with the first three thesis objectives, describing the control measures taken and analyzing successes and challenges to control and prevent transmission during the EVD epidemic (2.2.2). Specifically, the analysis follows three themes. The first is the analysis of the situation of the health service delivery and the community at the onset of the epidemic; the second concerns the measures taken under the situation to control transmission, while the third is the challenges impact, adherence, and sustainability of the measures.

Several barriers and enablers challenged health service delivery and community resilience in controlling the EVD transmission 2014-2015 (51). In the analysis that follows, these are captured under the captions: 4.2. "The situation of service delivery and Liberian communities during the EVD epidemic of 2014-2015"; 4.3. "Health service delivery and community resilience measures to control the transmission of the EVD epidemic 2014-2015"; 4.4. "Impact of transmission control measures in health service delivery and community" 4.5 "Challenges and sustainability of measures."

4.2. ***The Situation of Service Delivery and Liberian Communities During the EVD Epidemic 2014-2015***

4.2.1. The Situation of Service Delivery During the EVD Epidemic of 2014.

The situation of the health service delivery in Liberia at the onset of the EVD epidemic of 2014 was challenging. The challenges were several and affected crucial areas (52). These are compounded by the partial participation of communities (4.2.2. community situation) in the delivery of health services (38); the result was the collapse of routine health services in 2014 (52).

The health service delivery suffered major deficiencies in controlling disease transmission among patients and staff (52). It lacked, among others, a sufficiently trained health workforce and needed supplies (PPEs, disinfectant, and medical supplies, amongst others). There existed no standardized guidelines for IPC practices to control transmission; the lack of adequate infrastructures such as triage system and inadequate hygiene behavior (WASH) also contributed to deficiency in the quality of care (53)(52). The consequences of this lack in the delivery of health services were that health workers were not capacitated by resources and lacked the competencies (knowledge, practices, and attitudes) to control and prevent disease transmission during the EVD epidemic. Similarly, communities had a weak understanding of the preventive measures for the EVD. They were also incapable of controlling transmission skills and resources, putting them at risk of being infected (54)(55).

4.2.1.1. The Situation of Health Service Delivery and the Health System Building Blocks

The Major challenges for service delivery to control disease transmission found their roots in other supporting components in the health system. Leadership and governance were lacking in policies formulation at the national (MOH) level to control infectious disease transmission (54). There were no committees nor/ or focal persons at the healthcare facilities and in communities to enforce transmission control measures (54). Before the EVD epidemic, access to healthcare services in Liberia for all income levels had been fragile and unpredictable. The

health system lacked funding. Healthcare services were either unaffordable and or unacceptable regardless of income. Health facilities lack essential medical and non-medical supplies, skilled staff, and inadequate care quality (56).

The health system also lacked funding. The Liberian government's total spending on health from 2011 to 2013 was 16%,10%, and 4%, respectively, while out-of-pocket spending was 48%, 45%, and 48% of the national health budget over the same period. External support was 32%, 41 %, and 44% (57). Health expenditure in the national health account report of 2017 has a government contribution at 16% compared to external aid, which was 44%. Out of pocket payment at 39% with a pre-paid expenditure (insurance) of 1%, this put the population's demand and use of health care services at a very high cost (57)(58) (Figure 4).

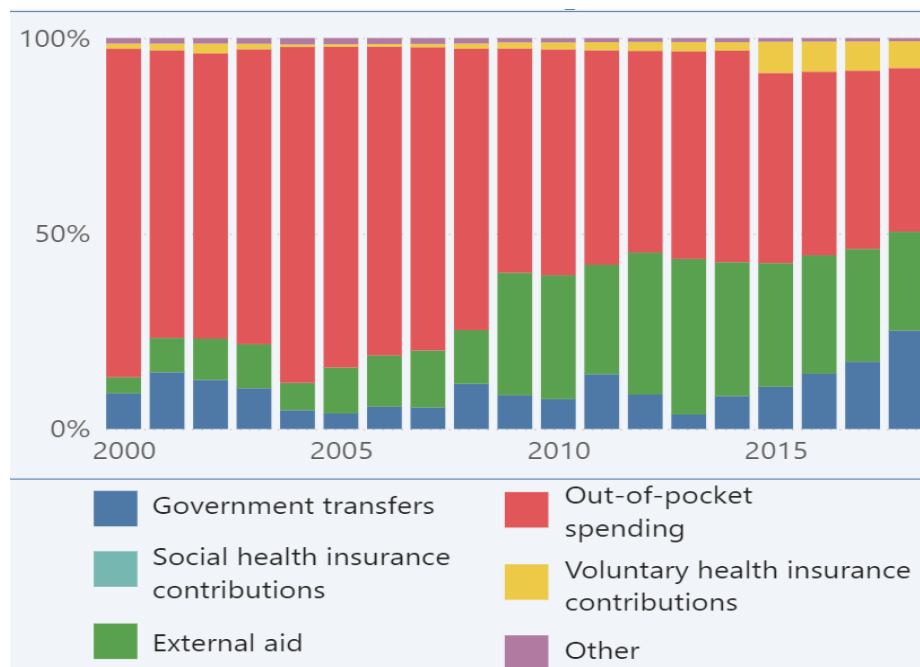


Figure 4: Sources of health expenditure (59).

Health services suffered frequent stock out of essential supplies for diagnosis and materials used for controlling transmission—the nonexistence of the capacity for laboratory testing of infectious diseases such as Ebola and Lassa Fever. The laboratory capacity was limited; for example, Lassa Fever samples were tested in neighboring Sierra Leone (60) (61)(62). The laboratory and pharmaceutical systems were uncoordinated, with an almost non-existent public health laboratory suffered technical and financial support (61)(62). Additionally, the shortage of and absence of proper medical diagnostic equipment (microscope and reagents) and IPC (PPEs) materials were serious hindrances to respond adequately to the EVD epidemic (54).

The quality of health data and the process of data management were questionable. The data quality was generally poor: “active case findings primarily based on the assumption of humans as the portal for sporadic outbreaks or emerging infections” (60). At the start of the epidemic, EVD cases were recorded on paper and manually entered in an electric system at the central level (MOH) by staff (53). Manual data entry caused an accumulation of paper-based data as the transmission cases increased, compromising the response to the epidemic (53). The lack of an effective communication system (phone, email, or open data kit) also delayed sharing

information on other diseases of epidemic potential. These situational challenges hindered appropriate mitigation measures to control the rapid transmission (53)(61).

The health information system was weak, uncoordinated, paper-based, collected monthly from health facilities, and entered in a database at the MOH. The health data generation system was Parallel (NGOs generated program-specific data) and often not merged with the health information system, thus hindering informed health decision making. For example, the Liberia health management information system (HMIS/ DHIS2) had not yet developed components in its system to capture activities implemented by some health partners at community levels (63). Routine health data were untimely and lacked data quality. Untimely reporting of sporadic outbreaks or emerging infections caused rapid transmission, and humans were assumed to be the portal (64).

4.2.1.2. Health Service Delivery: Routine Services and Transmission Control

The Liberian health service delivery experiencing these challenges mentioned above led to the rapid transmission of the EVD infection in the health service and communities during the epidemic. Health workers stopped rendering essential health services (deliveries, surgeries, etc.); some health facilities closed; all these affected the delivery of essential services gravely (52)(54)(51)(35).

The delivery of health services during the EVD outbreak experienced a lack of transmission control strategies that overpowered it and caused the closure of essential routine services. Health facilities became a source of infection; health workers, on the other hand, became agents of disease transmission. The health workers fell sick, and some died; their infection risk was 21-32 times more than the public. Health services became fearful and avoided by the public (65)(54)(66).

At this time under consideration, the health services lacked the skilled health workforce to control the transmission. At the onset of the epidemic, the response lacked the expertise, health workers' supply, and movement became increasingly difficult. Poor logistics system and fear of becoming infected hindered the movement of health workers from urban areas to hard-to-reach areas with no or limited qualified health workers. These challenges contributed to the delay and prolonged the already rapidly spreading transmission of the EVD infection (67)(55).

4.2.2. The Situation of Liberian communities During EVD Epidemic

At the start of the EVD epidemic, the community situation can be described as determined and kinship bonds among members that ensure resilience to shocks and traumatic events through collective actions (66). However, the social and economic conditions of many communities were incredibly challenging. Some lived in underprivileged circumstances and lacked access to safe water and quality health services (68)(69).

The communities' understanding of the origin of the EVD and the health services was marked with fear, confusion, and doubts. In communities, especially rural communities, there were misunderstandings of the origins of the virus. The Liberian community depended on wild animals for their regular meal; bats and monkeys, considered hosts of the virus, have been eaten for generations. The advice of not eating or touching these animals added to the confusion and distrust in health authorities by communities around the country (70)(69)(66). The idea of zoonotic infections was confusing to the communities; for generations, they had eaten the animals (bats and monkeys) that host the virus causing the EVD, and their forefathers did not experience such disease. The advice from the health authorities that wild animals were not to be eaten, especially monkeys and bats, increased communities' distrust and skepticism of health authorities. EVD cases in communities were not reported because of not recognizing the disease, and communities were sometimes hostile to health workers

becoming physically violent. Unfriendly messages such as “Ebola has no cure,” “if you get Ebola, you will die” fueled community fear and distrust (71)(72).

Hence, many communities around the country lived in fear at the early stage of the EVD epidemic, especially regarding the disease's emergence and devastating spread. The fear and misunderstanding of community members Center around the utilization of health care services and the stigma associated with the virus's origins. They regarded health services as the sources of infection (66)(72). At this time of the crisis, the perceived fear of the communities outweighed the potential benefits of preventing the transmission (67). The social and cultural context of communities made them resist compulsory cremation and Ebola treatment units (ETU) (67)(72).

4.3. Health Service Delivery and Community Resilience Measures to Control Transmission of the EVD epidemic 2014-2015

4.3.1. Introduction

Below are some relevant measures of the health service delivery and community engagement to control and prevent the transmission during the EVD epidemic in Liberia 2014-2015. To facilitate understanding of the classes of measures, the first sets of measures are here termed ‘system measures’ (policies), while the second set is the ‘field measures’ (operational).

4.3.2. System Measures in Health Service Delivery to Control the EVD Transmission

The findings show seven primary health system measures taken to support health service delivery in controlling and preventing the transmission of EVD during the epidemic. The measures are as follows:

1. The establishment of the National Task Force for Ebola - This group coordinated all activities for controlling the spread of the transmission nationwide. Its tasks included establishing and sustaining a national culture of IPC practices in health facilities and communities. This response strengthened health governance and leadership in setting up a strong coordinating body to better address the epidemic (73)(55)(54).
2. As the cases of infection increased in July of 2014, with more partners and donors contributing to the response efforts, the MOH changed the response structure and set up the Incident Management System (IMS) for better organization and collaboration, guided by an EVD response framework (Figure 5). This IMS was the coordinating body of the response and had six technical working groups – Laboratory, surveillance, case management, contact tracing, safe burials, and social mobilization. Each of these groups collaborated with a well-defined authority and responsibility. As the cases of infection continue to increase, the IMS updated its framework in August to include psychosocial and treatment units under the case management pillar (72) (Figure 6). As the transmission continued, the IMS also set up the Emergency Management System (EMS) and the psychosocial for the organization and supervision of emergency activities and consoling of infected persons and families. The Centre for Disease Control (CDC) and other health partners supported the setup of the Emergency Operating Centers (EOCs) (74) (62)(51).
3. The Emergency Treatment Units (ETUs) were set up under the EMS based on the need around the country. The treatment unit aimed to isolate and manage infected patients (74).
4. The establishment of the Quality Management Unit (QMU). This unit formation within the MOH was to specifically ensure the practices of adequate and standardized field measures that, in real-time, control and prevent the disease transmission at health facilities (75).

5. The Liberia Supply Chain Management System (LSCMS) upgrade included developing the Logistics Management Information System (LMIS). The purpose was to ensure health supplies and pharmaceuticals are effectively and efficiently distributed and tracked in the health system (76)(77). A regular and prompt supply of medical products and transmission control materials became a realizable measure when the LMIS became functional within the LSCMS. The LMIS focused on recordkeeping and ordering consumption data for medical and other essential supplies at health facilities that included a list of materials for control of disease transmission (77)(78)(62).

6. Policies and Protocols Development to Control the EVD transmission

Guidelines and assessment tools (minimum standard tools (MST), national infection prevention guideline 2018) were developed to standardize control measures, supervision, and mentorship at different levels of and periods in health services (district and facility, monthly, quarterly, and bi-annually) (55)(65).

7. Revision and adaptation of the Integrated Disease Surveillance and Response (IDSR) to international standards.

This led to about 1500 health workers training after the outbreak to detect and report priority diseases, conditions, and events at facilities and in communities with the frequencies of 14 immediately reportable epidemic-prone disorders, conditions, and events (62)(64).

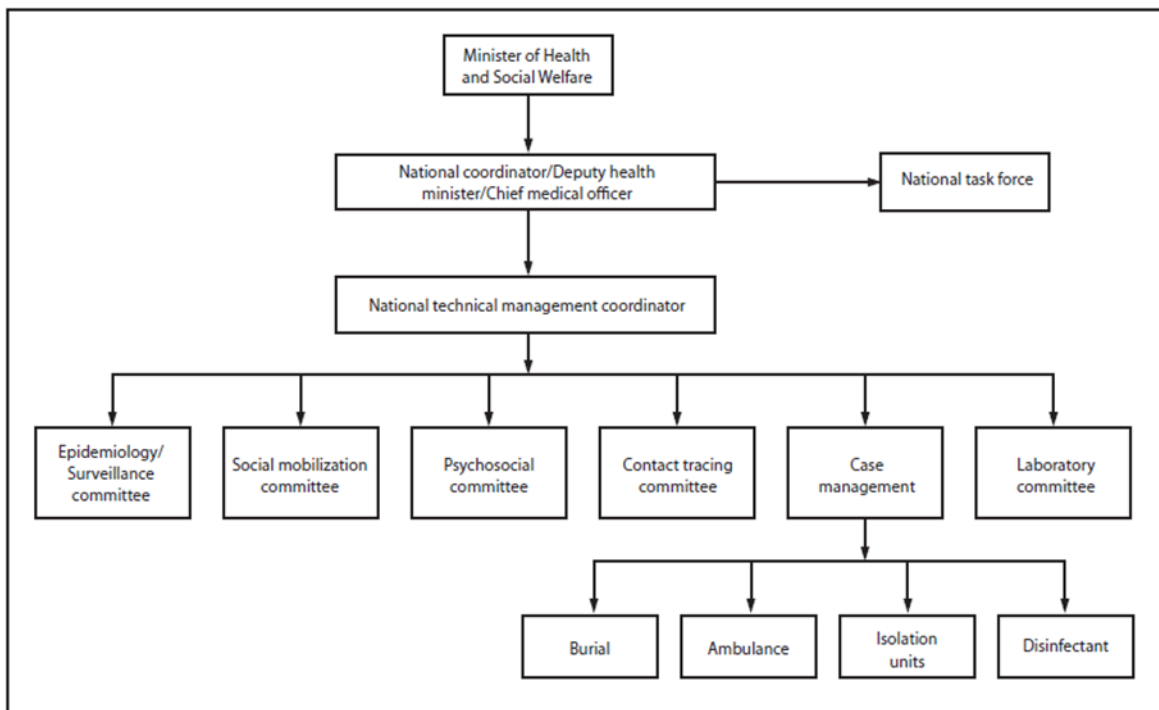


Figure 5: MOH/SW Ebola Response Framework, July 2014 (79)

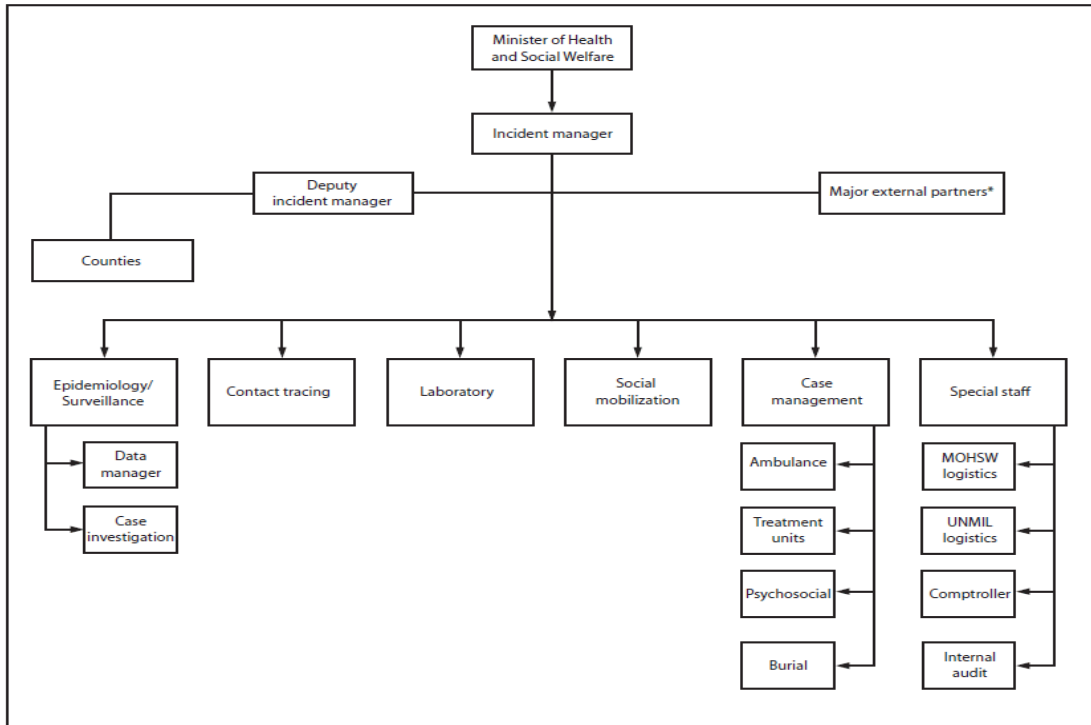


Figure 6: MOH/SW Ebola Response Incident Management System, August 2014 (79).

4.3.3. Field Measures to Control and Prevent transmission in Health Service Delivery and Community

Unlike the system measures based on policies and organizational (administrative) structures, the field measures are practical standardized measures to control and prevent the transmission of diseases. Some of these are IPC (standard operating procedures (SOP)) and safe burial practices that can be replicated in health facilities and communities. It is worth a note that health service delivery is a crucial area of applying transmission control practices. The rapid transmission of the EVD infection at the onset of the epidemic due to the absence of essential control measures in health facilities and communities presented the need for the institution of preventive measures (51). Below are the primary field measures employed during the EVD epidemic in Liberia:

1. The National Infection Control Training Programs for Health Workers

The national IPC program trained about 8500 Training of Trainers (TOT) and facility-based health workers in 'Keep Safe, keep Serving' (KSKS) and the 'Safe Quality Services' (SQS), transmission control, supportive supervision, and mentorship to address the knowledge gap and to ensure safety for health workers and the public during and after the EVD epidemic (51). The proper use of PPE, an essential but crucial measure of protection when assessing and caring for patients, especially those with infectious disease, was a vital component of the measures taken at primary healthcare facilities, hospitals, ambulance services, and emergency centers. The pieces of training aimed at restoring confidence in the health service and alleviating fear from health workers and the public (80)(51).

2. Triage System

Triage systems were set up at health facilities to separate patients with potentially infectious diseases and isolate them for further management and control the risk of transmission. Patients entering health facilities suspected of EVD and any contagious disease were separated from the non-suspected ones and isolated for further testing and treatment. General IPC measures were incorporated into the triaging system, handwashing buckets and concrete basins with soap were supplied to entrances and screening areas (51)(81). Communities [households] also isolated sick persons. They were placed in a separate room and observed for signs and symptoms of Ebola with a designated family member to care for the sick using local materials such as a plastic bag as gloves. In cases where isolated persons developed Ebola signs and symptoms, the community called the emergency team (4455). The households were then quarantined for 21 days of observation. The establishment of triage and sustaining a safe health facility for service delivery contributed to reducing EVD transmission (67)(82).

3. Instituting Transmission Control Committees and Focal Persons in the Country

The institution of committees and focal persons for IPC measures at county health teams (CHT) and health facilities. Their responsibility was to ensure all control measures were followed, beginning from the availability of supplies to practices of frequent hand washing by all health workers and all who entered and leave facilities (75). These committees and focal persons had a supervisory role in monitoring IPC practices, outbreak alertness, and hygiene measures (75).

The committees also shared feedback between health facilities, county pharmacy and national pharmacies for an efficient and adequate supply of medical and other essential supplies in the healthcare delivery system. This regular and prompt supply was also possible because the IPC supply list was combined with the medical supply list into the LMIS (77)(75).

4. Water, Sanitation, and Hygiene (WASH) Measures

WASH services were inserted into routine health service delivery at health facilities to prevent the transmission of infection, improve the quality of services offered and engage health workers in maintaining a safe environment for health service delivery. Hand washing services were available at the entrances of health facilities, including public and private buildings, and everyone was required to wash hands before entry (75).

5. Waste Management Programs in Health Facilities

Protocols for waste management were developed, and healthcare workers were trained to segregate and dispose of health facility waste appropriately. Incinerators, placenta pits, and hand pumps were constructed at health facilities (80) (83).

At the community level, some measures implored, especially in urban communities, included but were not limited to:

1. Contact Tracing and Isolation

Contact tracing and isolation were among the initial measures taken to control the transmission during the EVD epidemic. A team of investigators traced contact. The initial team consisted of health workers and later recruited community members. The teams used adapted guidelines from WHO and CDC for identification, listing, and monitoring. The investigative team interviewed and identified cases and or relatives for a list of potential contacts by six exposure types: Sleeping or eating in the same house, touching fluid from the body, direct physical contact with the body, clothing and other objects, breastfeeding, and mass funeral attendance) (84)(85).

2. Quarantining of Identified Contacts.

Community contact tracers located and listed identified contacts and any addition that may have been missed during the investigation for reporting. The contacts of identified cases were quarantined for 21 days, and contact tracers monitored all contacts twice daily, physically and over the phone, for any signs and symptoms developed during isolation. Contact tracers used physical observation and self-report of fever, weakness, nausea, diarrhea, headache, pain in the throat, red eyes and bleeding from the mucus membranes, and joint pain to monitoring quarantine and isolated contacts (86)(84).

3. Measures to Improve Service Delivery and Community Collaboration.

At the start of the epidemic, control measures were top to bottom approaches. It brought resistance from communities. Forceful cremation and quarantines were culturally unacceptable and seen as disrespect to loved ones (87). The restrictions of movements brought about brutal clashes between law enforcers and some communities. This increased the mistrust of authorities and was regarded as an effort of the government to reduce the population to increase ill-gotten money from the West. Communities did not cooperate with health teams; in some instances, they physically attacked health workers (88)(72). To alleviate the fear and mistrust of the communities, the health response team used the community agency to engage community leaders and involve them in the design and implementation of the response activities, especially social mobilization, community surveillance, and contact tracing (72)(67).

4.4. *Impact of Transmission Control Measures in Service Delivery and Community*

4.4.1. Introduction.

Section 4.2. describes the situation of health service delivery and the community during the EVD onset. Section 4.3. presents the measures taken to address the EVD epidemic. Section 4.4. analyze the effects of these systems and field measures. Following the thesis focus areas, the impact of the measures is divided into those affecting service delivery and communities. It is worth noting that Success, as a term used in this thesis, means progress in the right direction to a sustainable transmission control system than indicating a completion of a task.

4.4.2. Impact of Transmission Control Measures in Service Delivery

The containment of the EVD transmission in Liberia can be ascribed to several measures taken and the collaborative efforts of local and international stakeholders(89). Among the measures were those considered in the previous section (4.3). The establishment of a National IPC Program that included WASH, triaging, waste management systems, and community participation in health services for sustaining a safe, healthy environment to deliver health service during the EVD response aided in the control of the transmission (82)(90)(91).

The health System measures instituted at the national level ensure the organization and systematic approach to activities implemented by all health actors to control the transmission of the disease. The National Task Force for Ebola response led to the successful formation of the IMS (Figure 6). The IMS, a technical pillar, enhanced the coordination of the response activities among health partners (90).

The IMS, during the response, appointed the national Ebola coordinator and instituted daily briefing by all heads of technical committees (51)(90). The IMS and EOCs decentralized into the counties and worked with health services to control disease transmission through overall response management and logistics and information dissemination coordination. The IMS

establishment was a significant achievement because these IMS and EOCs' coordinated response activities ensured that all technical committees efficiently carried out their functions to control the rate at which the EVD transmitted at local levels (49)(92).

Likewise, the National EOC headquarter relocation from a temporary structure at the start of the EVD epidemic to a permanent structure on the grounds of the MOH was a significant achievement for the health system. Significantly the delivery of needed health services to the population in the fight to control the EVD transmission (79)(93). The national EOC's headquarter hosted and currently serves as the National Public Health Institute (NPHIL) of Liberia and the IMS. These entities working in proximity facilitate greater collaboration and coordination that were desperately required to control the disease spread. These entities were crucial for controlling EVD and other infectious diseases such as measles and Lassa fever (41)(90).

Enhancing the country's laboratory ability and laboratory-specific staff skills training is another crucial success during and beyond the EVD epidemic (94). At the onset of the EVD, as mentioned earlier, the national laboratory diagnosis of virus samples was (still are) sent to an international reference laboratory for confirmation (95). As the outbreak continued, laboratory abilities were built to use the Gene Xpert platform and rapid diagnostic testing. The tests are vital for supporting surveillance, ruling out other diseases (96)(97). The timely assessment of infected persons is also crucial for the control of the virus spread. This measure proved helpful in 2016 in testing and diagnosing the first case of Ebola during the final phase of the EVD response to the epidemic (98). The evaluation and diagnosis were conducted by hospital staff in Monrovia. The skills of staff in the laboratory were also improved to understand the transmission of Ebola through semen and other body fluids (94). Skills in sequential testing of Ebola also enabled local laboratory staff to understand and evaluate the sequence of RBS genome in finding clusters of Ebola in 2015 (98)(94). The National Reference Laboratory (NRL) was also enhanced to test for Lassa Virus (LASV) through Real-Time Polymerase Chain Reaction (RT-PCR) test, a gold standard for diagnosis of LASV which detects virus' Rabo Nucleic acid (RNA). In 2017, cases of undetected Lassa Fever from primary facilities were also confirmed through the diagnosis of the RT-PCR at the National Reference Laboratory (99)(100).

The response and recovery efforts also improved the surveillance system for EVD and epidemic-prone diseases (94)(101). Liberia's Surveillance System is now a comprehensive system that includes Event-Based Surveillance (EBS); it works as an Integrated Disease Surveillance and Response (IDSR) and documents 14 priority diseases and conditions. The IDSR team has a strategic plan with trained surveillance officers at the national and county levels using a standardized guideline for case definition and an open data kit on mobile phones for timely reporting (101)(98). The Community Event-Based Surveillance (C-EBS), as part of the IDSR, has a focal person based in the community; this person reports unusual health events in the community to the nearest health facility for an onward report to the District Surveillance Officers (DSO) for further investigation. The DSO then reports to the County Surveillance Officers (CSO) for the weekly surveillance report to the Disease Prevention and Control Unit (DPCU) at the National EOC level (101). As part of strengthening the system, the timeliness and completeness of data (reporting) improved to include an electronic early warning system for alert notification and response. The current effort of reporting now averages about 99% as of 2015 (102).

While it remains difficult to measure precisely the impact of a skilled health workforce for the control of disease, public health response quality depends on the skills of the personnel trained during and after the epidemic (103). In August 2015, Liberia launched the field epidemiology training program and trained about 120 surveillance officers. By 2017, all 15 counties and their 90 health districts had received trained surveillance officers (104). The capacity

development of health workers in Liberia included a wide range of coaching and mentoring on the control of transmission and standard practices. (104)(41). The ring-IPC approach was one of the capacity-building strategies that trained facility-based staff in clusters using standardized IPC procedures to control transmission (104). The ring approach method has been incorporated into the Integrated Joint Supportive Supervision (JISS) adapted during the epidemic and now conducted monthly by district health teams, quarterly by county health teams, and bi-annually by the national health team (105).

4.4.3. Impact of Transmission Control in Communities

With about 120 international, national, and local government organizations involved in social mobilization activities, the community's confusion and distrust of health care increased at the onset of epidemic response. The social mobilization pillar of the IMS coordinated the actions of these partners. It focused on the engagement of trusted community leaders in designing and implementing MOH-approved messages such as 'Ebola is Real, Ebola must Go!' (72)(106). These community leaders worked closely with their communities and helped control community transmission using precise, reliable, and culturally accepted messages. Communities and individuals' participation in social mobilization activities increased knowledge of Ebola control measures and reduced the risks of behavior and stigma associated with Ebola during the epidemic (107)(72). As a result of community engagement through their leaders to disseminate messages on control measures and behavioral change practices, communities and individuals avoided physical contact with other individuals, regularly washed their hands with soap and water, and limited in and out of country travels (72)(107).

The approach to involve communities members, especially the leadership, has a positive outcome (108). Communities adopted a promising approach to controlling the transmission of the virus during the crisis. They showed the ability to adapt to changing situations in the wake of the epidemic (109). Some urban communities developed several coping measures to include community surveillance (strangers were not allowed to overnight, house-to-house watch for sick people) and referred suspected EVD cases to ETU in the absence of needed public health services (67)(69). The traditional burial rites (bathing the dead and sprinkling the water as a sign of respect for the dead and blessing for the living) changed to cremation, seen as sending the dead to live in fire. Communities adapted transmission control measures and avoided their day-to-day life to prevent and control EVD transmission(66)(67).

4.5. **Challenges and Sustainability of Measures**

While the measures taken during the EVD epidemic yielded a great result in containing the transmission of the EVD, there remain some challenges in the continuity of these measures' implementation (87). International and national health actors became aware of the potential for global health threats. Priorities for containing the transmission directed resources to response activities. Substantial financial and material contributions became consistently available for implementing IMS and EOCs (110). Restrictions of donors on the use of funds limited the activities to mostly temporary solutions rather than a long-term measure. For example, some Non-governmental Organizations (NGOs) focused on constructing temporary triage, isolation units, ETUs, and some came late and could not be used. A permanent structure would have sustained the practices of sorting outpatients and controlling diseases with the potential for transmission of infections (111)(112).

Most donors prioritized different aspects of the control measures and design interventions for immediate remedy. Considerations for immediate and long-term measures would have instituted sustained control measures, such as constructing permanent triage structures or re-directing finances for unused ETU to improve IPC infrastructure at health facilities (113)(114). Significant dependence on external aid and out-of-pocket payment for support to healthcare services create room for missed opportunities as funders depict the aspect of

healthcare service their funds are to be spent (115)(114). The Ebola epidemic illustrates this by receiving one-time funding through an emergency appropriation to support laboratory capacity, surveillance, and workforce capacity development during the Ebola epidemic (116).

It was also uncertain that health partners (INGOs) would sustain the level of material and financial support established at the onset of the crisis. Neither was it sure that other donors can maintain resources for capacity building or possibly sustain some community-based activities established during the epidemic (116)(117). The inadequate number of non-specialist health workers in the country also remains a challenge. The health system records an adequate number of non-specialist nurses, but it remains a challenge to trace them at their assigned posts (118). Sustaining the improvements made in laboratory capacity is delicate, as the country relies on external partners for maintenance, supply of reagents, and replacement of laboratory equipment. Local laboratory functions remain sub-optimal; the need for reference laboratory testing is persistent with the involvement of international partners. The outbreak of meningococcal meningitis in May 2017 offered an excellent example (119)(120).

Weak synchronized community engagement in response activities can also contribute to mistrust and difficulty in implementing planned activities and neglect of successfully implemented activities (121). Community participation in the fight against Ebola took different forms in different locations in the country. Some counties' health teams give communities autonomy to organize local surveillance teams. In contrast, in other communities, NGO and government respondents relied on volunteer information from community members for planning and implementation (122). Some urban communities felt the need to be trained in practical measures of controlling and preventing the spread of the EVD rather than be presented with constant messaging of Ebola etiology (50). As experienced during the EVD epidemic, efforts of local caregiving served as both pathways for the containment of the disease and ways for new infection potential. This experience can be used positively to sustain preventive measures that are localized and, to some extent, cost-effective (122)(67).

Chapter Three

5.0. Discussion

5.1. *Summary of Results and Lessons Learned*

Globally, health systems that lack resilience experience the collapse of essential health services when confronted with health emergencies or shocks due to their lack of ability to detect, interpret warning signs, isolate the threat, and preserve essential functions in a health crisis (123). The Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) showed developed nations such as Canada and South Korea's health systems unprepared to control the transmission and unable to provide other essential health services (124)(125)(126). The results show the situation of the health system of Liberia with existential public health challenges for transmission control, especially at the onset that contributes to the EVD rapid spread, the collapse of routine health services, the devastation of the health sector, the economy, politics, and the people way of life. Thus, the situation showed that Liberia's Health System was not robust but easily penetrable.

The health sector needs community input to achieve public health goals. Community engagement with the health sector is imperative for positive health outcomes, especially during transmission control (127). The Liberian communities' cohesiveness, unfortunately, was not exclusively positive at the onset of the epidemic. Community members lacked confidence in health services that hindered their collaboration to control EVD transmission. Moreover, health authorities' EVD response approaches for community inclusion were one of the top to bottom. The lack of community engagement and communities harsh social and economic conditions such as underprivileged circumstances, crowdedness, and poor hygienic conditions combined with lacked access to safe water and quality health services favored the transmission of infection or worsened the challenge to transmission control.

Not all measures employed strengthened the health services; donors implemented ad hoc measures during the response period. Specific measures aimed to enhance weakly and or malfunctioning components of health services, such as the incident management system, which strengthened health governance and leadership for IPC, while other measures targeted behavioral change, surveillance, WASH, and hygiene practices at health facilities and in communities. The application of the measures was challenging that require external expertise and financial support. Hence, the Liberian government relied on multiple support-based and collaborations of which community engagement, innovations, and cooperation were crucial. Several lessons were learned regarding transmission control, public health concern, and shaping interventions for better transmission control and prevention response.

This section now thematically discusses some of the key challenges of controlling EVD transmission (2014-2015). Before these, however, are two classes of lessons learned at and community and health service delivery levels that are both of importance to transmission control:

A lesson learned from the EVD is the challenge and importance of community engagement to control transmission.

1. Community agency. The inclusion of the community in the design and planning of response activities such as contact tracing and social mobilization shifted messaging to more culturally appropriate prevention and control messages and built trust in the health service.
2. Assisting communities design and plan their approach to controlling transmission strengthens health authorities' trust, leading to behavior change and active participation in social mobilization.

Another lesson learned from the EVD is the challenge and importance of health service delivery strategies.

1. National and local leadership play a prime role in the organization of response activities, leading to a positive direction for controlling the transmission; however, the success of the organization and implementation relied heavily on the international support for finance, experts, and coordination.
2. Efforts for strengthening health service delivery should focus on active engagement and building community capacities and a diverse health workforce

5.2. Sustaining Effective Measures for Transmission control in Liberia.

The results show that the success of control measures during the EVD epidemic cannot be attributed to a specific intervention or set of interventions. Some measures were likely more effective in helping to reduce the spread of the EVD infection than others (121). The combination of Policy and Operational Measures strengthens several components of Health Service Delivery and Community Resilience; it systematized and implemented each measure. These Measures controlled and stopped the transmission of EVD infection in the country.

The involvement of all stakeholders was also vital in the decline of the number of cases and deaths. However, measures such as community engagement should have been employed from the start. In contrast, others may have been more long-term focused on controlling future outbreaks than a short-term solution to control and contain the transmission (121).

The surveillance practices, knowledgeable and skilled health workforce, and sufficient IPC materials are essential to sustain a vital health service delivery prepared to control the transmission of emerging diseases. Adequate funding is also critical for functional laboratories and infrastructure in health service delivery and community to control threats to transmissible diseases (128).

During the epidemic, the measures employed were undoubtedly crucial for controlling the transmission of the EVD. It is important to note that short-term measures are suitable and have an immediate impact. They often do not target the root cause of the crisis. While they bring immediate relief to epidemics such as the EVD and other disasters, they remain a resource diversion solution strategy, especially in underfunded health systems such as the Liberian health system (6). Short and long-term measures are essential for effective control of transmission in Liberia. These approaches need to be more dynamic and all-inclusive at the very start to ensure effective coordination for continual transmission management in health service delivery. Both the 'system' and 'field' measures need to focus on and target precise health service delivery areas and involve local actors [Community] heavily affected by the disease and the policies for control measures. While emergency measures bring about quick solutions, they often do not address or prevent the root causes of the problems. In minimizing any transmission, the strategy must address the causes of the spread effectively to the extent that the root causes reduce the transmission of infectious diseases. Addressing the causes makes both short- and long-term measures important (129).

In the Ebola outbreak in Liberia, the application of policy measures developed during the outbreak worked effectively, but one may query its continuity. The health services rely heavily on donors for effective functioning in the country. To an extent, the EVD epidemic response built and strengthened some health system components (Health Governance and Leadership), such as establishing and sustaining the IMS for solid coordination and effective functioning of its technical pillars in response to a health crisis. The IMS still functions during this COVID-

19 crisis to reduce the spread and effect of COVID-19. Application of transmission control policies depends on the ownership of national government efficiency and, with assistance from donors, for the sustainability of transmission control measures. In the case of the Liberian Health System, this is not sustainable due to underfunding. It is also due to different priorities of donors who are the more prominent contributors at other times. These essential control measures become functional only during an emergency when donors' contributions are available (130). Health funding frequently emerged as a challenge to effectively control and sustain disease transmission control and prevention measures. It is the first set of challenges.

5.3. Sustainable Short-term Measures as a challenge to transmission control.

The construction of temporary ETUs and triages were an essential aspect of control and prevention of the transmission. It helped to isolate and treat infected persons in a more controlled way. While these measures were helpful in the treatment and separation of Ebola cases and helped control the transmission, these temporary measures cannot be sustained for long-term use. The ETUs and most triages were constructed from impermanent materials and burnt down right after the epidemic (131). These momentary measures brought about a quick solution or response to the epidemic to isolate and treat infected persons. The health services remain vulnerable to the containment of rapid transmission if confronted with public health threats such as infectious disease transmission. Indeed, permanent and durable structures can aid in strengthening the infrastructural needs of the health service delivery [system]; and has the potential to be cost-effective for a low-income country such as Liberia in providing adequate and timely transmission control measures in the health service delivery without unduly risks to public health.

Placing plastic buckets and soap for handwashing at health facilities and public buildings was vital for frequently disinfecting the hand. This temporary measure contributed to controlling the spread of the EVD but was forgotten with the containment declaration that the epidemic has ended (131). Health workers became reluctant with the practices of hygienic measures. While health facilities returned to the pre-EVD era, struggling for soap and handwashing facilities. Provision of permanent and functional water sanitation and hygiene (WASH) facilities may not change behavior but can constantly remind hand hygiene. Other temporary measures such as 'No hand shaking' were soon forgotten and eradicated with the EVD containment. Once instituted in health facilities with available and functional WASH facilities, these hygiene practices may be consistent with or without alerting public health threats like the EVD. Consistency in hand hygiene may also aid in behavioral change and become embedded into transmission control practices.

All the EVD Epidemic measures taken are essential for controlling and preventing transmission. These measures can be sustained for future control of transmission if response move beyond epidemic-based solutions to health system strengthening measures to includes constructing permanent and functional IPC infrastructures structures for triaging, treatment of infected cases, and persons with the propensity to spread infectious disease. The provision of soap and or hand sanitizers is crucial for controlling transmission and, therefore, can form a part of the priorities in the supply of essential commodities in the supply chain system of the health service delivery (132)(20).

The community's involvement in contact tracing and social mobilization during the epidemic was crucial for behavioral change and control of the transmission. Community engagement in health service delivery for the use of their agency to address an apparent health need is a vital engagement measure for effective health service delivery. This approach has been attested to in literature to address health crises (133)(134).

The results also show that community participation in surveillance and contact tracing in Liberia was vital to controlling the EVD transmission. This type of engagement is an example of how the health system response effort can increase trust and meaningfully communicate

to utilize community agency for building a resilient health service delivery. Critical to finding an effective solution to health problems during epidemics is a dialogue with the community (133)(135). An essential social mobilization strategy for developing a culturally acceptable EVD message in Liberia came because of discussions with the community. Fear of and mistrust of the health authorities caused some communities to resist response workers. It was in part due to inappropriate cultural EVD messages developed without community contribution. Community consultation brought about a more tailored messaging that was geared toward controlling the EVD transmission (50)(133)(136).

National and international health actors can use this strategy for coordination to position the community at the Center of epidemic control planning to reflect effectiveness in responding to disease transmission. Transmission control measures can use community engagement to collect helpful information on infectious disease transmission trends for proper planning and efficient transmission control measures. This type of engagement can be used to understand how the community operates and respond to health threats to help design future control of infectious transmission (136)(134).

The mistrust and difficulty encountered by health responders at the state of response activities during the epidemic were evident in the lack of community involvement by health authorities (135) (137). It is essential to understand the perspective of local communities during a health crisis for addressing critical issues that can serve as an obstacle to achieving the goal of response activities. Communities can serve as both the sources of rapid transmission and control measures during epidemics. The results present that active participation of communities at different times and places in Liberia during the epidemic contributed to both rapid transmission and, controlling, EVD transmission. For example, when communities collectively took the stance to wash hands frequently, social distance, and avoid traditional burial rituals, the transmission of infection reduced. Some of the decline in transmission during the epidemic resulted from community interventions, although not measurable (67)(135). The results also reveal a second of the challenges: lack of appropriate and effective community engagement in the design, planning, and implementation of transmission control measures.

5.4. *Capacity for Sustained Control and Prevention of Diseases Transmission*

One of the challenges to controlling EVD transmission was the shortage of skilled personnel in the country. During the EVD epidemic, the ministry of health (MOH) was implementing phase one of the Essential Package of Health Services (EPHS). Health service delivery did not fully meet the requirements of the EPHS in reality; primary and secondary health facilities lacked skilled personnel and essential medical and non-medical supplies for controlling infectious transmissions (21)(22).

In 2010, the number of health workers per 10,000 people was 6.3%, and by the start of the epidemic, there was a 37% increase [2014, 8.6% per 10,000], which still was not sufficient to meet the country's health needs (132). To address the issue of shortage of and equal distribution of the right cadre of health workers, a 2015 MOH count estimated that the health service delivery needed 5,889 nurses and midwives in addition to 1,754 doctors (132). While it is necessary to have the correct number of health workers to meet the needs of the health services, it is equally vital to have the right skill mix. An analysis is required for the number and right combination of skills in each health field. The health policy estimates an adequate number of non-specialist nurses in the country, which in reality cannot be tracked (138). Training for health workers in the country will have to be synchronized and linked to staff development based on the needs of the health service. The ministry (MOH) needs a well-synchronized and functional tracking system that ensures the number, specialty, and status of the health workforce in the country. It requires coordination with health training institutions and regulatory bodies (139)(140).

Another vital aspect to consider for maintaining a balanced health workforce is a commitment from health system managers and the health workforce. Strong governance for health requires sustained finance for operations in building and maintaining resilience at all levels of the health system. Health workers' demotivation just before the onset of the EVD epidemic was due to low and delayed salaries and civil servants' status, amongst other needs. Health authorities' unfavorable responses to these demands further demotivated health workers and caused lengthy strikes (25). Those working at the time of the Ebola also demanded increased risk fees, health insurance for health workers, and an adequate supply of IPC materials [PPE amongst other things] (141). The third sets of challenges to sustaining effective transmission control measures are functional surveillance systems, skilled mixed health workforce availability, and adequate IPC and medical supplies.

5.5. *Relevance of the framework*

The framework (6) was helpful in the analysis of the results. The challenges of transmission control in Service Delivery and Community did fall into the Health System building blocks and Community resilience. The framework identified the challenges and measures of control within the health system and their links with the community; it linked health governance and leadership with community resilience for better control and prevention of infectious disease transmission. The IMS better coordinated the response activities directing the focus of implementation in health services and community. The six technical pillars with focus persons and specific tasks ensured the real-time application of policies for control of the EVD transmission.

The System (Policy) Measures and Field (Operational) Measures certainly apply the conceptual framework. There is an interface between the health system building blocks [the inner circle] which develops policies that practicalized in health service delivery, and the community [the outer ring] (Figure 3). The latter measures are a result of the health system interventions.

The framework was also helpful in showing the relationships of all elements, the six building blocks, Community, Disaster Risks Management, and the essential health determinates in the Measures used to control the EVD transmission. The framework demonstrates that to prevent transmission with minimum challenges, all the elements it contains must be functional to achieve resilience in health service delivery and the health system at large.

5.6. *Limitations*

This thesis is a literature review that considered peer-reviewed and grey literature sources, ranging from peer-reviewed articles to health organizations' documents. It may have missed relevant articles published in other languages and at a period not included in the criteria for inclusion. Literature that discussed social, behavioral science, and epidemiology was included to address transmission challenges broadly.

The literature search mainly produced resources about the process and intervention carried out during the containment of the EVD in Liberia. Much of the literature focus on the processes and interventions and not the impact of the processes and interventions. The search was limited to available literature and may have missed Some literature due to keywords combinations.

The focus of the EVD as the significant transmission control challenge experienced in the country may have restricted the search and introduced bias. The study did not describe all processes and interventions in the resources. The study did not analyze all transmission infections in Liberia, so the knowledge about transmission challenges in service delivery and community may not have been fully addressed in this sense.

Chapter Four

6.0. Conclusion and Recommendations

From the situation succinctly presented above, the findings show that System and Field Measures were put in place to control the EVD transmission. These mitigations to control EVD transmission by the Liberian Health Service Delivery and by community engagement were twofold. The first set of measures was regarding the components of the health system building blocks and was measures at policy levels; they were measures taken in the health system geared towards controlling the transmission for the rendering of quality health services. The second set of measures is operational, and the operationalization of policy measures is the practical execution to control transmission at health facilities and in communities. They also include surveillance and IPC Measures that affect health services within health facilities and communities.

Despite the success in controlling and eliminating the EVD in the country, transmission control remains a challenge and threat to public health. As seen in the results, the situation before the EVD changed. Still, sustainability remains a significant challenge due to several factors, including the heavy reliance on external aid for the effective functioning of System (Policy) and Field (operational) Measures. The success of effectively controlling the EVD transmission between 2014 and 2015 mainly was an emergency focus. However, establishing an Ebola Task Force followed by an Incident Management System gives the disorderly Ebola response direction. Healthcare workers' capacity building in IPC, triaging, contact tracing, and other operational measures helped reduce the virus's speed in health facilities and communities. Although not quantifiable, the training led to an augmentation of knowledge, skills, and confidence amongst healthcare workers for delivery of health services during the epidemic and prepared them to respond promptly to controlling infections in the instance of a subsequent health crisis as the current Corona Virus Pandemic (Covid-19).

Control measures such as training are vital for strengthening healthcare workers' capacity to control and prevent (infectious disease) transmission and improve quality of care in health service delivery.

Community involvement in the EVD epidemic response alleviated their fear and mistrust of health authority and enabled more culturally acceptable health messaging for EVD. The engagement of the community agency strengthened their resourcefulness. It allowed their conscious adaptations of burial rites, hand washing, control/isolation of a sick family member, and other initiatives to control the spread of the EVD.

In the light of the results, discussion, the lessons learned, and the purpose of this literature review to know the challenges to transmission control during the EVD epidemic in Liberia 2014-2015, I make the following two classes of recommendations:

6.1. *Policy Recommendations*

1. MOH and NPHIL should include active community engagement in future transmission control strategy through response activities design and planning at the start of the crisis.
2. The MOH should maintain a high level of synchronization and direction of response activities among national and international organizations for sustained implementation of field measures to control and prevent the transmission of infections in service delivery and community.
3. The MOH, in collaboration with health partners, should organize social mobilization to improve health, especially messages that are clear and culturally acceptable to

- avoid confusion in messaging that creates fears and distrust of health authorities in the population.
4. Response activities such as hygiene and sanitation should construct permanent structures and behavioral change communication for sustained hygiene practices in health facilities and communities.
 5. Idealistic but essential for efficient health service delivery: The national government should develop all mechanisms for generating funds for health, including an increase in the fiscal budget to health for improved quality of health services.

6.2. Operational Recommendations

1. The Quality Management Unit (QMU), in collaboration with the District Health Teams (DHTs), should increase attention to IPC practices through the supply of IPC materials and regular supportive supervision and mentorship for sustaining IPC at health facilities.
2. District Health Teams (DHT) should ensure the provision and proper use of hygiene services through community agencies at health facilities and communities to control transmissions for sustaining hygiene practices from the EVD epidemic.
3. D H T should use the community agency for reporting early warning signs of outbreaks, monitor traditional burial rites, and advise on the proper handling and use of wild animals as meat to avoid the escalation of a containable infectious transmission in the health services and community.
4. Health Facilities Administrations should control transmission and recognize patients with the potential to spread infection through practical use of triage at all times of patient service.

6.3. Research

1. There is a need for more research on transmission control challenges in Liberia. This research should include strategies for sustaining control and prevention measures in a resource-limited health setting like Liberia.
2. More research is needed on knowledge, attitude, and practice of IPC in the Liberian health service delivery and community, and how the quality of IPC practices can be supported.

References

1. Seventer JM van, Hochberg NS. Principles of Infectious Diseases: Transmission, Diagnosis, Prevention, and Control. Int Encycl Public Heal [Internet]. 2017 Oct 6 [cited 2021 Jul 21];22. Available from: /pmc/articles/PMC7150340/
2. Principles of Epidemiology | Lesson 1 - Section 10 [Internet]. [cited 2021 Jul 21]. Available from: <https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section10.html>
3. Ebola virus disease [Internet]. [cited 2021 Jul 21]. Available from: <https://www.who.int/news-room/fact-sheets/detail/ebola-virus-disease>
4. Ebola (Ebola Virus Disease) | CDC [Internet]. [cited 2021 Jul 21]. Available from: <https://www.cdc.gov/vhf/ebola/index.html>
5. Infection prevention and control GLOBAL [Internet]. [cited 2021 Jul 21]. Available from: https://www.who.int/health-topics/infection-prevention-and-control#tab=tab_1
6. Olu O. Resilient Health System As Conceptual Framework for Strengthening Public Health Disaster Risk Management: An African Viewpoint. Front Public Heal. 2017;5(September):1-6.
7. Liberia - The World Factbook [Internet]. [cited 2021 Mar 23]. Available from: <https://www.cia.gov/the-world-factbook/countries/liberia/>
8. UNFPA - United Nations Population Fund [Internet]. [cited 2021 Aug 2]. Available from: <https://www.unfpa.org/data/world-population/LR>
9. Political Map of Liberia - Nations Online Project [Internet]. [cited 2021 Apr 21]. Available from: <https://www.nationsonline.org/oneworld/map/liberia-map.htm>
10. About Liberia | UNDP in Liberia [Internet]. [cited 2021 Apr 19]. Available from: <https://www.lr.undp.org/content/liberia/en/home/countryinfo.html>
11. The world's ten poorest countries | Concern Worldwide [Internet]. [cited 2021 Apr 19]. Available from: <https://www.concern.net/news/worlds-ten-poorest-countries>
12. Map Liberia - Population density by administrative division [Internet]. [cited 2021 Apr 7]. Available from: <http://geo-ref.net/ph/lbr.htm>
13. Varpilah ST, Safer M, Frenkel E, Baba D, Massaquoi M, Barrow G. Rebuilding human resources for health : a case study from Liberia Rebuilding human resources for health : a case study from Liberia. 2011;11(May).
14. Tornorlah Varpilah S, Safer M, Frenkel E, Baba D, Massaquoi M, Barrow G. Rebuilding human resources for health: a case study from Liberia [Internet]. Vol. 9, Human Resources for Health. 2011. Available from: <http://www.human-resources-health.com/content/9/1/11>
15. Kruk ME, Freedman LP, Anglin GA, Waldman RJ. Rebuilding health systems to

- improve health and promote statebuilding in post-conflict countries : A theoretical framework and research agenda. *Soc Sci Med* [Internet]. 2010;70(1):89–97. Available from: <http://dx.doi.org/10.1016/j.socscimed.2009.09.042>
16. LDHS 2013. Liberia Demographic and Health Survey. *Statistics (Ber)* [Internet]. 2013;535. Available from: http://www.zimstat.co.zw/sites/default/files/img/publications/Health/ZDHS_2015.pdf
 17. Ministry of Health and Social Welfare Republic of Liberia (MOHSW), Liberia R of. Basic Package of Health and Social Welfare Services for ... - basics [Internet]. 2008 [cited 2021 Jun 7]. Available from: <https://www.yumpu.com/en/document/read/48190196/basic-package-of-health-and-social-welfare-services-for-basics>
 18. Varpilah ST, Safer M, Frenkel E, Baba D, Massaquoi M, Barrow G. Rebuilding human resources for health: A case study from Liberia. *Hum Resour Health*. 2011;9(May 2014).
 19. Liberia Ministry of Health and Social Welfare. Republic of Liberia Ministry of Health and Social Welfare National Health and Social Welfare Policy and Plan 2011–2021. 2011.
 20. Zolia Y, Musa E, Wesseh CS, Harris B, Gebrekidan MZ. Setting the Scene for Post-Ebola Health System Recovery and Resilience in Liberia : Lessons Learned and the Way Forward. 2017;1–9.
 21. Ministry of Health Liberia. Essential Package of Health Services_Secondary and Tertiary. 2011.
 22. Liberia M of H. ESSENTIAL Package of Health Services Primary Care : The Community Health System. 2011;(June).
 23. Kesselly RY, Kwenah NK, Gonyon E, Byepu S, Bawo L, Jacobs G, et al. The status of health services in the 15 counties of Liberia. *Southeast Eur J Public Heal*. 2018;10:1–17.
 24. Essential Package of Health Services (EPHS). Secondary & Tertiary Care: The District, County & National Health Systems - Liberia, 2011 (Includes the Essential Drug List, Page 36) [Internet]. 2011 [cited 2020 Mar 12]. Available from: <https://apps.who.int/medicinedocs/en/m/abstract/Js19420en/>
 25. By Jennifer Lazuta. Liberian Government Talks with Striking Health Workers | Voice of America - English [Internet]. 2013 [cited 2021 May 23]. Available from: <https://www.voanews.com/africa/liberian-government-talks-striking-health-workers>
 26. Liberia | Institute for Health Metrics and Evaluation [Internet]. [cited 2021 Apr 19]. Available from: <http://www.healthdata.org/liberia>
 27. UNDP. Socio-Economic Impact of Ebola Virus Disease in West African Countries. A call for national and regional containment. *United Nations Dev Gr - West Cent Africa*. 2015;1–95.
 28. WHO | Revised Global Burden of Disease (GBD) 2002 estimates. WHO. 2014;
 29. Durski KN, Osterholm M, Majumdar SS, Nilles E, Bausch DG, Atun R. Shifting the paradigm: Using disease outbreaks to build resilient health systems. Vol. 5, *BMJ Global Health*. BMJ Publishing Group; 2020.

30. Mboussou F, Ndumbi P, Ngom R, Kamassali Z, Ogundiran O, Van Beek J, et al. Infectious disease outbreaks in the African region: an overview of events reported to the World Health Organization in 2018. *Epidemiol Infect* [Internet]. 2019 Nov 11 [cited 2020 Nov 6];147:e299. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6873157/>
31. Yamin D, Gertler S, Ndeffo-Mbah ML, Skrip LA, Fallah M, Nyenswah TG, et al. Effect of Ebola Progression on Transmission and Control in Liberia. *Ann Intern Med* [Internet]. 2015 Jan 6 [cited 2020 Nov 20];162(1):11. Available from: <http://annals.org/article.aspx?doi=10.7326/M14-2255>
32. Althaus CL. Estimating the Reproduction Number of Ebola Virus (EBOV) During the 2014 Outbreak in West Africa. *PLoS Curr* [Internet]. 2014 [cited 2020 Nov 20];6. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4169395/>
33. Wesseh CS, Najjemba R, Edwards JK, Owiti P, Tweya H, Bhat P. Did the Ebola outbreak disrupt immunization services? A case study from Liberia. *Public Heal Action* [Internet]. 2017 Jul 19 [cited 2021 Aug 8];7(Suppl 1): S82. Available from: </pmc/articles/PMC5515569/>
34. Korkoyah DT, Wreh FF. Ebola Impact Revealed: An assessment of the differing impact of the outbreak on the women and men in Liberia. 2015 [cited 2021 Aug 8]; Available from: <http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/case-counts.html>
35. Kennedy SB, Dogba JB, Wasunna CL, Sahr P, Eastman CB, Bolay FK, et al. Pre-Ebola virus disease laboratory system and related challenges in Liberia. *Afr J Lab Med*. 2016;5(3):1-5.
36. Agua-Agum J, Allegranzi B, Ariyaratna A, Aylward RB, Blake IM, Barboza P, et al. After Ebola in West Africa - Unpredictable risks, preventable epidemics. *N Engl J Med*. 2016 Aug 11;375(6):587-96.
37. Liberia NPHI of. Press Release #001-2020 – Continuous Lassa Fever – signed copy – National Public Health Institute of Liberia [Internet]. 2020 [cited 2020 Aug 9]. Available from: <https://www.nphil.gov.lr/press-release-001-2020-continuous-lassa-fever-signed-copy-2/>
38. WHO. WHO | Lassa Fever – Liberia. WHO [Internet]. 2018 [cited 2020 Jul 10]; Available from: <http://www.who.int/csr/don/22-february-2018-lassa-fever-liberia/en/>
39. Leary MK. The socio-economic impacts of Ebola in Liberia. World Bank [Internet]. 2015 [cited 2020 Feb 1];1-3. Available from: <http://www.worldbank.org/en/topic/poverty/publication/socio-economic-impacts-ebola-liberia%5Cnhttp://www.worldbank.org/en/topic/poverty/publication/socio-economic-impacts-ebola-liberia.print>
40. JW E, C C, P N, J W. The health impact of the 2014-15 Ebola outbreak. *Public Health* [Internet]. 2017 Feb 1 [cited 2021 Jul 21];143:60-70. Available from: <https://pubmed.ncbi.nlm.nih.gov/28159028/>
41. Elston JWT, Cartwright C, Ndumbi P, Wright J. The health impact of the 2014e15 Ebola outbreak. *Public Health* [Internet]. 2016 [cited 2020 Nov 20]; Available from: <http://dx.doi.org/10.1016/j.puhe.2016.10.020>
42. Scott JT, Sesay FR, Massaquoi TA, Idriss BR, Sahr F, Semple MG. Post-Ebola Syndrome, Sierra Leone. *Emerg Infect Dis*. 2016 Apr;22(4):641-6.

43. Report W. Health worker Ebola infections in Guinea, Liberia, and Sierra Leone A PRELIMINARY REPORT 2 Health worker Ebola infections in Guinea, Liberia, and Sierra Leone: a preliminary report. 2015.
44. Fauci ASM. PERSPECTIVE 1085 Ebola-Underscoring Global Disparities. PERSPECTIVE [Internet]. 2014 [cited 2020 Nov 20]; Available from: <http://www.cdc.gov/>
45. World Health Organization. Health Systems situation in 1 . State of the health system / Pre-Ebola. 2014.
46. Van Bortel T, Basnayake A, Wurie F, Jambai M, Koroma AS, Muana AT, et al. Effets psychosociaux d'une flambée de maladie à virus ebola aux échelles individuelle, communautaire et internationale. Bull World Health Organ [Internet]. 2016 Mar 1 [cited 2020 Nov 21];94(3):210–4. Available from: <https://www.pmc/articles/PMC4773931/?report=abstract>
47. World Food Program. How can we estimate the impact of Ebola on food security in Guinea, Liberia, and Sierra Leone? Ebola Special Focus Ebola. 2014.
48. Dreisbach T, Gbanya MZ. Building a More Resilient Health System after Ebola in Liberia Creating a resilient health system Skilled Manpower; Lack of Commitment; Donor-Governmental Relations; Basic Infrastructure CASE STUDY.
49. Ottar Mæstad, Eskindir Loha Shumbullo. Ebola outbreak 2014-2016: Effects on other health services. C Br. 2020;(3).
50. Barker KM, Ling EJ, Fallah M, Vandebogert B, Kodl Y, Macauley RJ, et al. Community engagement for health system resilience: Evidence from Liberia's Ebola epidemic. Health Policy Plan. 2020;35(4):416–23.
51. Bemah P, Baller A, Cooper C, Massaquoi M, Skrip L, Rude JM, et al. Strengthening healthcare workforce capacity during and post-Ebola outbreaks in Liberia: an innovative and effective approach to epidemic preparedness and response. Pan Afr Med J. 2019;33(Suppl 2):9.
52. Nuzzo JB, Meyer D, Snyder M, Ravi SJ, Lapascu A, Souleles J, et al. What makes health systems resilient against infectious disease outbreaks and natural hazards? Results from a scoping review. BMC Public Health [Internet]. 2019 Oct 17 [cited 2020 Nov 21];19(1):1–9. Available from: <https://link.springer.com/articles/10.1186/s12889-019-7707-z>
53. Brugnara L, Pervilhac C, Kohler F, Dramé ML, Sax S, Marx M. Quality improvement of health systems in an epidemic context: A framework based on lessons from the Ebola virus disease outbreak in West Africa. Int J Health Plann Manage. 2020;35(1):52–67.
54. Cooper C, Fisher D, Gupta N, Macauley R, Pessoa-Silva CL. Infection prevention and control of the Ebola outbreak in Liberia, 2014-2015: Key challenges and successes. Vol. 14, BMC Medicine. BioMed Central Ltd.; 2016.
55. Storr J, Twyman A, Zingg W, Damani N, Kilpatrick C, Reilly J, et al. Core components for effective infection prevention and control programs: New WHO evidence-based recommendations. Antimicrob Resist Infect Control. 2017;6(1).
56. Svoronos T, Macauley RJ, Kruk ME. Can the health system deliver? Determinants of rural Liberians' confidence in health care. Health Policy Plan. 2015;30(7):823–9.
57. World Health Organization. Global Health Expenditure Database [Internet]. [cited 2020 Aug 9]. Available from:

https://apps.who.int/nha/database/country_profile/Index/en

58. World Health Organization Country Office. WHO Country Cooperation Strategy 2018 – 2021, Liberia. 2021. 43 p.
59. World Health Organization (WHO). Global Health Expenditure Database [Internet]. Global Health Expenditure Database. [cited 2021 Jan 15]. Available from: https://apps.who.int/nha/database/country_profile/Index/en
60. Kennedy SB, Wasunna CL, Dogba JB, Sahr P, Eastman CB, Bolay FK, et al. The laboratory health system and its response to Liberia's Ebola virus disease outbreak. *Afr J Lab Med* [Internet]. 2016 Oct 1 [cited 2020 Jun 24];5(3):e1–5. Available from: <https://www.doaj.org>
61. Bell BP, Damon IK, Jernigan DB, Kenyon TA, Nichol ST, O'Connor JP, et al. Overview, Control Strategies, and Lessons Learned in the CDC Response to the 2014-2016 Ebola Epidemic. *MMWR Suppl.* 2016;65(3):4–11.
62. World Health Organization (WHO). Joint External Evaluation of IHR Core Capacities of the Republic of Liberia [Internet]. 2016. Available from: <https://apps.who.int/iris/bitstream/handle/10665/255268/WHO-WHE-CPI-2017.23-eng.pdf?sequence=1>
63. Health Ministry Government of Liberia. Investment plan for building a resilient health system in Liberia. Vol. 12, Monrovia, Ministry of Health. 2015.
64. Nagbe T, Yealue K, Yeabah T, Rude JM, Fallah M, Skrip L, et al. Integrated disease surveillance and response implementation in Liberia, findings from a data quality audit, 2017. *Pan Afr Med J* [Internet]. 2019 [cited 2020 Jun 24];33(Suppl 2):10. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6675580/>
65. Ministry of Health Liberia. National Infection Prevention and Control Manual. *Natl Serv Scotl.* 2018;(January):1–23.
66. Alonge O, Sonkarlay S, Gwaikolo W, Fahim C, Cooper JL, Peters DH. Understanding the role of community resilience in addressing the Ebola virus disease epidemic in Liberia: a qualitative study (community resilience in Liberia). *Glob Health Action* [Internet]. 2019 Jan 1 [cited 2020 Jun 24];12(1). Available from: </pmc/articles/PMC6746278/?report=abstract>
67. Abramowitz SA, McLean KE, McKune SL, Bardosh KL, Fallah M, Monger J, et al. Community-Centered Responses to Ebola in Urban Liberia: The View from Below. *PLoS Negl Trop Dis.* 2015;9(4):1–18.
68. Elmahdawy M, Elsisi GH, Carapinha J, Lamorde M, Habib A, Agyie-Baffour P, et al. Ebola Virus Epidemic in West Africa: Global Health Economic Challenges, Lessons Learned, and Policy Recommendations. *Value Heal Reg Issues* [Internet]. 2017;13:67–70. Available from: <http://dx.doi.org/10.1016/j.vhri.2017.08.003>
69. Tambo E, Chengho CF, Ugwu CE, Wurie I, Jonhson JK, Ngogang JY. Rebuilding transformation strategies in post-Ebola epidemics in Africa. *Infect Dis Poverty.* 2017;6(1):1–7.
70. Tremblay N, Musa E, Cooper C, Van den Bergh R, Owiti P, Baller A, et al. Infection prevention and control in health facilities in post-Ebola Liberia: don't forget the private sector! *Public Heal Action* [Internet]. 2017 Jul 19 [cited 2020 Aug 9];7(1):94–9. Available from: </pmc/articles/PMC5515571/?report=abstract>

71. Ebola: Q&A With Tolbert Nyenswah | Global Health NOW [Internet]. [cited 2020 Nov 21]. Available from: <https://www.globalhealthnow.org/2015-01/ebola-qa-tolbert-nyenswah>
72. (HC3) HCCC. Social Mobilization Lessons Learned : The Ebola Response in Liberia. Johns Hopkins Cent Commun Programs. 2017;(February):114.
73. Ansumana R, Keitell S, Roberts GMT, Ntoumi F, Petersen E, Ippolito G, et al. Impact of infectious disease epidemics on tuberculosis diagnostic, management, and prevention services: experiences and lessons from the 2014–2015 Ebola virus disease outbreak in West Africa. *Int J Infect Dis.* 2017;56:101–4.
74. Nyenswah TG, Kateh F, Bawo L, Massaquoi M, Gbanyan M, Fallah M, et al. Ebola and its control in Liberia, 2014-2015. *Emerg Infect Dis.* 2016;22(2):169–77.
75. Abrampah NM, Montgomery M, Baller A, Ndivo F, Gasasira A, Cooper C, et al. Lessons from the field Improving water, sanitation and hygiene in health-care facilities, Liberia. *Bull Soc Pathol Exot.* 2017;(January):526–30.
76. S. B. Kennedy, C. L. Wasunna, J. B. Dogba, P. Sahr, C. B. Eastman, F. K. Bolay, G. T. Mason MWSK. The laboratory health system and its response to the Ebola virus disease outbreak in Liberia | Directory of Open Access Journals [Internet]. *African Journal of Laboratory Medicine.* 2016 [cited 2020 Jun 24]. Available from: <https://doaj.org/article/30899d86c3234f1cb131e003ee961233>
77. Ministry of Health G of L. Supply Chain Master Plan 2010 – 2020 : Five Year Review and Update. 2020.
78. Siekmans K, Sohani S, Boima T, Koffa F, Basil L, Laaziz S. Community-based health care is an essential component of a resilient health system: Evidence from Ebola outbreak in Liberia. *BMC Public Health* [Internet]. 2017;17(1):1–10. Available from: <http://dx.doi.org/10.1186/s12889-016-4012-y>
79. Center for Disease Control and Prevention. Developing an Incident Management System to Support Ebola Response — Liberia, July–August 2014 [Internet]. 2014 [cited 2021 Jan 15]. Available from: <https://www.cdc.gov/Mmwr/preview/mmwrhtml/mm6341a4.htm>
80. Caeiro JP, Garzón MI. Controlling infectious disease outbreaks in low-income and middle-income countries. *Curr Treat Options Infect Dis.* 2018;10(1):55–64.
81. World Health Organization. Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level: Geneva: World Health Organization; 2016. License: CC BY-NC-SA 3.0 IGO.
82. Ratnayake R, Ho LS, Ansumana R, Brown H, Borchert M, Miller L, et al. Improving Ebola infection prevention and control in primary healthcare facilities in Sierra Leone: A single-group pretest post-test, mixed-methods study. *BMJ Glob Heal.* 2016;1(4).
83. Improving Infection Prevention and Control in Liberian Health Facilities, MCSP/RHS Liberia Case Study [Internet]. 2018 [cited 2020 Aug 2]. Available from: www.mcsprogram.org
84. Swanson KC, Altare C, Wesseh CS, Nyenswah T, Ahmed T, Eyal N, et al. Contact tracing performance during the Ebola epidemic in Liberia, 2014-2015. Althouse B, editor. *PLoS Negl Trop Dis* [Internet]. 2018 Sep 12 [cited 2020 Nov 22];12(9):e0006762. Available from:

<https://dx.plos.org/10.1371/journal.pntd.0006762>

85. Olu OO, Lamunu M, Nanyunja M, Dafaie F, Samba T, Sempira N, et al. Contact Tracing during an Outbreak of Ebola Virus Disease in the Western Area Districts of Sierra Leone: Lessons for Future Ebola Outbreak Response. *Front Public Heal*. 2016 Jun 22;4.
86. Health M of. Liberia Ebola Daily Sitrep no. 290 for 1st March 2015. 2015.
87. Pellicchia U, Crestani R, Decroo T, Van den Bergh R, Al-Kourdi Y. Social Consequences of Ebola Containment Measures in Liberia. Braunstein LA, editor. *PLoS One* [Internet]. 2015 Dec 9 [cited 2020 Nov 22];10(12):e0143036. Available from: <https://dx.plos.org/10.1371/journal.pone.0143036>
88. United Nations Office of High Commissioner. A human rights perspective into the Ebola outbreak. 2014.
89. Mobula LM, Nakao JH, Walia S, Pendarvis J, Morris P, Townes D. A humanitarian response to the West African Ebola virus disease outbreak. [cited 2021 May 17]; Available from: <https://doi.org/10.1186/s41018-018-0039-2>
90. Developing an Incident Management System to Support Ebola Response — Liberia, July–August 2014 [Internet]. [cited 2020 Nov 21]. Available from: <https://www.cdc.gov/Mmwr/preview/mmwrhtml/mm6341a4.htm>
91. World Health Organization. WHO | Ebola outbreak 2014 - present: How the outbreak and WHO's response unfolded [Internet]. [cited 2021 Mar 17]. Available from: <https://www.who.int/csr/disease/ebola/response/phases/en/>
92. Functions of an Emergency Operations Center [Internet]. [cited 2021 Jan 12]. Available from: <https://www.emergency-response-planning.com/blog/bid/56720/Functions-of-an-Emergency-Operations-Center>
93. Olu OO, Lamunu M, Chimbaru A, Adegboyega A, Conteh I, Nsenga N, et al. Incident management systems are essential for effectively coordinating large disease outbreaks: Perspectives from the coordination of the Ebola outbreak response in Sierra Leone. *Front Public Heal*. 2016 Nov 21;4(NOV).
94. Katawera V, Kohar H, Mahmoud N, Raftery P, Wasunna C, Humrighouse B, et al. Enhancing laboratory capacity during Ebola virus disease (EVD) heightened surveillance in Liberia: lessons learned and recommendations. *Pan Afr Med J* [Internet]. 2019 [cited 2021 May 17];33(Suppl 2):8. Available from: <https://www.pmc/articles/PMC6675925/>
95. Strengthening Public Health as the Foundation of the Health System and First Line of Defense - The Neglected Dimension of Global Security - NCBI Bookshelf [Internet]. [cited 2020 Nov 9]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK368392/>
96. Kassaye B, Desta T, Dogba JB, Garbo JT, Kessely DB, Eastman CB, et al. Integrated use of the GeneXpert Platform for TB, HIV, and EVD Testing in Liberia Integrated use of the GeneXpert Platform for TB HIV and EVD Testing in Liberia. 2020;(May).
97. Raftery P, Condell O, Wasunna C, Kpaka J, Zwizwai R, Nuha M, et al. Establishing Ebola Virus Disease (EVD) diagnostics using GeneXpert technology at a mobile laboratory in Liberia: Impact on outbreak response, case management, and laboratory systems strengthening. 2018; Available from:

<https://doi.org/10.1371/journal.pntd.0006135>

98. Marston BJ, Dokubo EK, van Steelandt A, Martel L, Williams D, Hersey S, et al. Ebola response impact on public health programs, West Africa, 2014–2017. *Emerg Infect Dis.* 2017 Dec 1;23:S25–32.
99. Raabe V, Koehler J. Laboratory Diagnosis of Lassa Fever. 2017 [cited 2021 Jun 24]; Available from: <https://www.doi.org/10.1128/JCM>
100. Woyessa AB, Maximore L, Keller D, Dogba J, Pajibo M, Johnson K, et al. Lesson learned from the investigation and response of Lassa fever outbreak, Margibi County, Liberia, 2018: Case report. *BMC Infect Dis.* 2019 Jul 11;19(1).
101. Kennedy SB, Wasunna CL, Dogba JB, Sahr P, Eastman CB, Bolay FK, et al. The laboratory health system and its response to Liberia's Ebola virus disease outbreak. *Afr J Lab Med.* 2016;5(3).
102. COLLABORATING, LEARNING & ADAPTING CASE ANALYSIS: DEEP DIVE Global Communities' Ebola Response in Liberia. 2014.
103. Dr. Tom Frieden. Protecting the World from the Next Pandemic | GE News [Internet]. [cited 2020 Nov 21]. Available from: <https://www.ge.com/news/reports/dr-tom-frieden-protecting-the-world-from-the-next-pandemic>
104. Rouse EN, Zarecki SM, Flowers D, Robinson ST, Sheridan RJ, Goolsby GD, et al. Safe and Effective Deployment of Personnel to Support the Ebola Response - West Africa. *MMWR Suppl.* 2016 Jul 8;65(3):90–7.
105. Liberia Collaborative Support for Health (CSH) Program End-of-Project Report. 2015.
106. 'EVERYBODY'S BUSINESS': MOBILIZING CITIZENS DURING LIBERIA'. 2017.
107. Rapid Response to Ebola Outbreaks in Remote Areas — Liberia, July–November 2014 [Internet]. [cited 2020 Nov 21]. Available from: <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6407a7.htm>
108. Pronyk P, Rogers B, Lee S, Bhatnagar A, Wolman Y, Monasch R, et al. The effect of community-based prevention and care on Ebola transmission in Sierra Leone. *Am J Public Health* [Internet]. 2016 Apr 1 [cited 2021 May 17];106(4):727–32. Available from: <http://www.ajph.org>
109. Gautier L, HOUNGBEDJI KA, UWAMALIYA J, COFFEE M. Use a community-led prevention strategy to enhance behavioral changes towards Ebola virus disease prevention: a qualitative case study in Western Côte d'Ivoire. *Glob Heal Res Policy* [Internet]. 2017 Dec 1 [cited 2021 May 17];2(1):1–12. Available from: <https://commons.wikimedia.org/wiki/File:C>
110. Ling EJ, Larson E, Macauley RJ, Kodl Y, VanDeBogert B, Baawo S, et al. Beyond the crisis: did the Ebola epidemic improve the resilience of Liberia's health system? *Health Policy Plan* [Internet]. 2017 Nov 1 [cited 2020 Jan 25];32(suppl_3):iii40–7. Available from: http://academic.oup.com/heapol/article/32/suppl_3/iii40/4621473
111. Siedner MJ, Gostin LO, Cranmer HH, Kraemer JD. Strengthening the Detection of and Early Response to Public Health Emergencies: Lessons from the West African Ebola Epidemic. *PLoS Med* 12(3) e1001804 doi10.1371/journal. 2015;(March 2014):1–8.
112. Onishi N. Empty Ebola Clinics in Liberia Are Seen as Misstep in U.S. Relief Effort - The New York Times [Internet]. The New York Times. 2015 [cited 2020 Nov 22]. Available

from: <https://www.nytimes.com/2015/04/12/world/africa/idle-ebola-clinics-in-liberia-are-seen-as-misstep-in-us-relief-effort.html>

113. Ryschon TW. Ebola control measures and inadequate responses. *Lancet* [Internet]. 2014 [cited 2020 Nov 23];384:1181–2. Available from: <http://www.msf.org/article/>
114. Ling EJ, Larson E, Macauley RJ, Kodl Y, VanDeBogert B, Saye Baawo, and MEK. Beyond the crisis: did the Ebola epidemic improve the resilience of Liberia’s health system? *Health Policy Plan* [Internet]. 2017 [cited 2020 May 21];(Health Policy and Planning, 32, 2017, iii40–iii47):8. Available from: https://kopernio.com/viewer?doi=10.1093%2Fheapol%2Fcx109&token=WzIyMTc1MTMsIjEwLjEwOTMvaGVhcG9sL2N6eDEwOSJd.Y72dB-Y8v3QFkA6WF_kDnAeJfig
115. Kieny MP, Dovlo D. Beyond Ebola: A new agenda for resilient health systems. Vol. 385, *The Lancet*. Lancet Publishing Group; 2015. p. 91–2.
116. Global Health Security Agenda| Advancing the Global Health Security Agenda: Progress and Early Impact from U.S. Investment [Internet]. 2016 [cited 2021 Mar 9]. Available from: <http://www.cdc.gov/dotv/sars/index.html>
117. Global Health Security Agenda Program | Fact Sheet | Liberia | U.S. Agency for International Development [Internet]. [cited 2020 Jul 19]. Available from: <https://www.usaid.gov/liberia/fact-sheets/global-health-security-agenda-program>
118. McPake B, Dayal P, Herbst CH. Never again? Challenges in transforming the health workforce landscape in post-Ebola West Africa. *Hum Resour Health*. 2019 Mar 7;17(1).
119. Meningitis suspected in Liberia’s mystery illness outbreak | CIDRAP [Internet]. University of Minnesota: CIDRAP, Center for Infectious Disease Research and Policy. 2017 [cited 2021 Mar 9]. Available from: <https://www.cidrap.umn.edu/news-perspective/2017/05/meningitis-suspected-liberias-mystery-illness-outbreak>
120. Marston BJ, Dokubo EK, van Steelandt A, Martel L, Williams D, Hersey S, et al. Ebola response impact on public health programs, West Africa, 2014–2017. *Emerg Infect Dis*. 2017;23(January 2018): S25–32.
121. Kirsch TD, Moseson H, Massaquoi M, Nyenswah TG, Goodermote R, Rodriguez-barrquer I, et al. impact of interventions and the incidence of Ebola virus disease in Liberia — implications for future epidemics. 2017;(October 2016):205–14.
122. Barker KM, Ling EJ, Fallah M, Vandebogert B, Kodl Y, Macauley RJ, et al. Community engagement for health system resilience: evidence from Liberia’s Ebola epidemic. *Health Policy Plan* [Internet]. 2020 [cited 2021 Apr 22];35:416–23. Available from: <https://academic.oup.com/heapol/article/35/4/416/5732805>
123. Kruk ME, Ling EJ, Bitton A, Cammett M, Cavanaugh K, Chopra M, et al. Building resilient health systems: A proposal for a resilience index. *BMJ*. 2017;357(May):1–8.
124. Chowell G, Abdirizak F, Lee S, Lee J, Jung E, Nishiura H, et al. Transmission characteristics of MERS and SARS in the healthcare setting: A comparative study. *BMC Med*. 2015 Sep 3;13(1).
125. Zumla A, Hui DS, Perlman S. Middle East respiratory syndrome. Vol. 386, *The Lancet*. Lancet Publishing Group; 2015. p. 995–1007.
126. Kumar VO, Pruthvishree B, Pande T, Sinha D, Singh B, Dhama K, et al. SARS-CoV-2 (COVID-19): Zoonotic Origin and Susceptibility of Domestic and Wild Animals. *J Pure*

- Appl Microbiol [Internet]. 2020 [cited 2021 Aug 7];14(1):741–7. Available from: <https://doi.org/10.22207/JPAM.14.SPL1.11>
127. Questa K, Das M, King R, Everitt M, Rassi C, Cartwright C, et al. Community engagement interventions for communicable disease control in low- A and lower-middle-income countries: Evidence from a review of systematic reviews [Internet]. Vol. 19, International Journal for Equity in Health. BioMed Central Ltd.; 2020 [cited 2021 Apr 26]. p. 51. Available from: <https://equityhealthj.biomedcentral.com/articles/10.1186/s12939-020-01169-5>
 128. Strengthening Public Health as the Foundation of the Health System and First Line of Defense - The Neglected Dimension of Global Security - NCBI Bookshelf [Internet]. [cited 2021 Apr 26]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK368392/>
 129. Durski KN, Osterholm M, Majumdar SS, Nilles E, Bausch DG, Atun R. Shifting the paradigm: Using disease outbreaks to build resilient health systems. *BMJ Glob Heal.* 2020;5(5):4–6.
 130. Evoh CJ, Development S, Consultant ER, Shumba UO. Integrated Health Governance and Sustainability : Rebuilding Livelihoods and Resilience in Post-Ebola Communities in West Africa *. 2016;(February 2015):1–4.
 131. Summary E. Building a More Resilient Health System after Ebola in Liberia. 2019;(April).
 132. Dreisbach T, Gbanya MZ. Building a More Resilient Health System after Ebola in Liberia Creating a resilient health system Skilled Manpower; Lack of Commitment; Donor-Governmental Relations; Basic Infrastructure CASE STUDY. 2019;
 133. Richards P. Ebola: How a People’s Science Helped End an Epidemic - - [Internet]. Google Books. 2016 [cited 2021 Feb 3]. Available from: <https://books.google.com/books?hl=en&lr=&id=5fRiDgAAQBAJ&oi=fnd&pg=PT8&dq=.+Ebola:+How+a+People’s+Science+Helped+End+an+epidemic&ots=CJlmuwCrjF&sig=ZCpzQBpMHVOUCyeAsaASf3XU1Jo#v=onepage&q=.+Ebola%3A+How+a+People’s+Science+Helped+End+an+epidemic&f=false>
 134. Abramowitz SA, Hipgrave DB, Witchard A, Heymann DL. Lessons From the West Africa Ebola Epidemic: A Systematic Review of Epidemiological and Social and Behavioral Science Research Priorities. *J Infect Dis.* 2018 Oct 20;218(11):1730–8.
 135. Dada S, McKay G, Mateus A, Lees S. Lessons learned from engaging communities for Ebola vaccine trials in Sierra Leone: Reciprocity, reliability, relationships and respect (the four R’s). *BMC Public Health* [Internet]. 2019 Dec 11 [cited 2021 May 3];19(1):1665. Available from: <https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7978-4>
 136. Parker M, Hanson TM, Vandi A, Babawo LS, Allen T. Ebola, and Public Authority: Saving Loved Ones in Sierra Leone. *Med Anthropol Cross Cult Stud Heal Illn* [Internet]. 2019 Jul 4 [cited 2021 Feb 3];38(5):440–54. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6607031/>
 137. Wilkinson A, Parker M, Martineau F, Leach M. Engaging ‘communities’: Anthropological insights from the west African Ebola epidemic. *Philos Trans R Soc B Biol Sci.* 2017 May 26;372(1721):20160305.
 138. Health F, Coalition W. COST OF SCALING UP THE HEALTH WORKFORCE IN LIBERIA,

SIERRA LEONE, AND GUINEA AMID THE EBOLA EPIDEMIC Frontline Health Workers Coalition Analysis - March 2015. 2015;(March).

139. WHO | The health worker shortage in Africa: are enough physicians and nurses being trained? [Internet]. [cited 2021 May 3]. Available from: <https://www.who.int/bulletin/volumes/87/3/08-051599/en/>
140. WHO | The health worker shortage in Africa: are enough physicians and nurses being trained? WHO. 2011;
141. Liberian Health Workers to Strike Over Ebola Hazard Pay | Voice of America - English [Internet]. [cited 2021 May 23]. Available from: <https://www.voanews.com/africa/liberian-health-workers-strike-over-ebola-hazard-pay>
142. Ministry of Health & Social Welfare Republic of Liberia. ESSENTIAL Primary Care : The Community Health System. 2011;(June).

Appendix

Appendix I: Health system levels of operation in Liberia (142)(24)

Health system levels of services	Services provided	Catchment population And catchment areas	Operational days and hours
Primary	Community services <ul style="list-style-type: none"> - Household health promotion and referral - Health volunteers (CHVs), - Trained Traditional Midwives (TTM), general Community Health Volunteers (gCHVs) Primary health care levels 1 and 2 <ul style="list-style-type: none"> - Integrated outreach services to isolated communities more the 5 km from clinics 	3500 to 12,000	Mondays to Fridays Eight (8) hours a day
Secondary	District health system <ul style="list-style-type: none"> - Health centers (HC) with about 40 beds capacity - Focus on maternal and child health - Receives referrals from community health systems and PHC levels 1 and 2 - Extended services within the secondary care are also provided Note: HC may upgrade to district hospitals with clinical capacity for emergency surgery and comprehensive emergency obstetrics and neonatal care (CEmONC) <ul style="list-style-type: none"> - 	25,000 to 40,000	Sundays to Saturdays 24 hours, seven days a week
	County Health Systems <ul style="list-style-type: none"> - County hospitals 		Sundays to Saturdays

