Building Back Better: Development of Health System Resilience in Liberia During and After the Ebola Virus Disease and COVID-19 Outbreaks

by

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Abstract

It is widely accepted that fostering resilience in health systems is a crucial measure to increase preparedness to public health emergencies, preserve the health system's functions, and protect population health. International organisations and individual global health actors have long endorsed efforts to understand the determinants of health system resilience in hopes of developing operational guidelines. However, much of the scientific work has so far focused on establishing conceptual approaches to frame resilience in health systems, and in measuring resilience as a set of cross-sectional indicators that cursorily assess the system's aptitudes.

Through a descriptive case study, this paper looks at the transformative dimension of health system resilience in Liberia (understood as functional and structural changes to the system's institutions to improve resilience) to identify drivers and determinants organised under an operational framework and guided by the health system's main functions. A literature review is used to develop a theory, and primary data collection through key informant interviews and technical document reviews explore evidence to refine the theory and draw conclusions.

This study finds that, in operationalising transformative resilience, the Liberian health system fostered institutional evolution in nine areas (leadership and governance, health financing, health workforce, health service delivery, health infrastructure, health information systems, medical products and technologies, community trust and ownership, and interinstitutional collaboration). The study also concludes that policy mechanisms to enable resilience must be embedded into health system planning to successfully undertake transformative change in the system's institutions and improve their performance during public health emergencies.

Preface

This thesis is an original work by Hector Villarroel Ocando. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board 1, Project Name “Building Back Better: Development of Health System Resilience in Liberia During and After the Ebola Virus Disease and COVID-19 Outbreaks,” No. Pro00138967, February 22, 2024.

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This achievement was made possible by many invaluable contributions, far too many to list within these confines. I will attempt to acknowledge a few of these in the following lines, apologise to any I miss, and express my absolute heartfelt gratitude to all.

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1. Introduction

1.1. Background and Conceptualisation

In the face of numerous challenges, health systems worldwide constantly grapple with the need to adapt and endure. Over the past decade, several public health emergencies of international concern have shaped the global health landscape in a way that highlighted the vulnerabilities of health systems and the shared consequences of unresponsiveness to situations that strain the system's capacity to plan and deliver services. The disruption caused by such situations, known as "shocks" or "stressors" has become the subject of study as a phenomenon that curtails the health system's capacity to meet its objectives and achieve its outcomes.

Of these shocks, the Ebola Virus Disease (EVD) epidemic that impacted West Africa between 2014 and 2016 remains one of the most studied phenomena in relation to managing crises from a health system thinking perspective. Not only is it the deadliest EVD outbreak to date, but it emerged at a time when the health systems of the three most affected countries: Guinea, Sierra Leone, and Liberia, were already fragile[1]. The grievous impacts of EVD in the affected countries, particularly during the first two years of the outbreak, generated urgency to mobilise health system research efforts with the goal of improving preparedness and learning from the fallout of public health disasters. These research efforts brought to the limelight a concept that quickly became of extreme interest in health system science: health system resilience.

Resilience was first defined in system science as part of social-ecological systems as "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."[2] While this research was applied to ecosystems and their interactions with human societies, the concepts that were developed around resilience thinking can inform the application of paradigms to other areas within system science, including health systems.

Early findings of that work discovered that complex systems (such as health systems and ecosystems) are influenced by a vast number of inputs that independently and collectively frame their functions and interactions. Thus, when a disturbance (or shock) is introduced to the system, resilience means more than returning to an original state of equilibrium, since the influences that shape the system will have been individually impacted as well. Resilience can therefore imply a shift in the system's original states to regain functioning.[3]

The framing of resilience as a process inherently involving change allowed researchers to identify two qualities that underlie resilience itself: adaptability and transformability. Adaptability is described as the system's capacity to incorporate new knowledge and modify its outputs to meet changing demands, whereas transformability represents the capacity to readily change the nature of the system's states and institutions. Put differently, a system is adaptable when it can modify its existent processes to relieve new pressures, and it is transformable when it can adopt new states to fundamentally change its processes.[3]

As previously mentioned, health system resilience was brought to the forefront of health system thinking research in the aftermath of the West Africa EVD outbreak. One of the leading definitions, and the one adopted in this study, describes health system resilience as "the capacity of health actors, institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and informed by lessons learned during the crisis, reorganise if conditions require it."[4]

Much like in other complex systems, health system resilience is conceptualised as a feature and capability of the whole system, rather than a siloed function. Previous researchers and health systems experts agree that understanding health system resilience necessitates an understanding of the interconnectedness of health systems and the complex dynamics that underlie the functioning of public health and health care service delivery systems,[4] as well as wider systems such as economic, political, educational, and global governance.[5]

An important distinction made in the existing body of evidence is that health system resilience and strength are not synonymous, but they do go hand in hand. Some experts argue that, in order to be resilient, a health system must have a previous context of robustness (understood as the system's inherent capacity to withstand shocks without major disruptions), from which adaptation and transformation can occur.[6] This is a similar perspective to that of Folke *et al.* when they described resilience as emerging from a "stability domain" or state of balance,[3] and its purpose as assuming either the previous state of balance, or a new one through transformative change.

Additionally, experts note that health systems can be strong or well-performing during stable times but be unable to manage shocks. Conversely, health systems may not perform well at baseline and yet show elements of resilience during times of crisis.[5] This highlights the interconnectedness of health system resilience and how its operationalisation depends on a multitude of complex influences which are not static, but rather obey stakeholder dynamics, historical and political contexts, and the system's agents' attitudes and behaviours.

However, there are also potential pitfalls in using a reductionist approach to conceptualising health system resilience as a solitary function or an outcome that can be observed and measured without consideration of its context. One such pitfall is that viewing resilience exclusively under the lens of indicators and service offering and utilisation frames the objectives of resilience as "returning to normality" without understanding the underlying characteristics of the system that made it vulnerable or fragile in the first place.[7] Another drawback of defining resilience in terms of its outcomes is that, without exploring the mechanisms that led to the outcome, the burden of operationalising resilience can be put on comparatively disadvantaged members of the system (such as patients and communities) who may need to resort to extremes to cope with the effects of the crisis and drive the improvement in outcomes.

Thus, it is paramount to understand health system resilience as both a process and a result, both a capability and an attribute, which is shaped by the complex interactions between actors, agents, institutions, and governance.[8] This conceptual approach enables us to examine health systems in terms of what allows them to become resilient, rather than just what proves that they are resilient, and to identify system dynamics within its components that lead to resilience.

1.2. Approaches and Frameworks for Health System Resilience

Previous researchers have made extensive advances in elucidating the nuances of health system resilience into conceptual frameworks that enable users to understand the features of resilience and its relationship to other elements of health systems thinking. These analytical efforts have yielded impactful studies on the nature of health system resilience, its determinants, its location within health system science, and its real-life applications. Some researchers have also attempted to produce performance measures and indicators that can be used by health managers, planners, and policymakers, to determine whether a health system is resilient.[9]

On this vein, the conceptual framework proposed by Blanchet *et al.*[10] introduced a characterisation of resilience building on previous definitions and exploring the concept further to define the inherent processes, or dimensions, that took place in relation to the nature of the shock that affected the health system and the intensity of the response that was needed to mitigate the impact of the crisis. In this multi-tiered and progressive model, the authors described three capacities as drivers of resilience: absorption, adaptation, and transformation.

The absorptive capacity lies at the base of health system resilience and is analogous to robustness, that is the capacity of the health system to withstand the shock and continue to deliver the same health services with the same quantity, quality, and equity, without the need to modify its processes.[6] Conversely, the adaptive capacity encompasses the health system's

aptitude to change its existing service delivery mechanism in response to the shock so that it can still deliver services with the same quantity, quality, and equity. Finally, the transformative capacity represents the highest order of change that a health system can implement to manage a shock, as it implies reshaping the system's capacities and institutions, or creating new ones, to neutralise the conditions that led to vulnerability as well as enable the system to regain balance by transcending current weaknesses and threats to sustained service delivery, during the shock and beyond.

The typification of the transformative capacity as the most complex procedure of resilience, in response to the most intense and prolonged shocks, echoes back to Folke *et al.*[3] when they spoke of transformability and transformative change in socio-ecological systems. As a capability and a function these are at the core of transformative health system resilience and form the conceptual basis to analyse the complexities involved in understanding how health systems reform their structures and processes to move away from disaster risk.

Transformative change has been widely analysed in organisational and system sciences. Within the realm of business, transformative change is defined as one form or organisational change involved the evolution of fundamental aspects of the organisation, including its structure, culture, and processes.[11]

This definition becomes all the more relevant to health systems when we lend a systems thinking perspective to all types of organisation, and note that transformative change is determined by major interactions within the organisation's environment in the context of a concern, challenge, and/or opportunity that create the urgency to transform the organisation's outputs and outcomes. This is analogous to a health system's stability domain, or baseline status, being threatened by the emergence of a shock.

Within systems science, Walker *et al.* highlight that transformative change involves a change in the very nature of the system's composition either by removing structural elements,

modifying existent elements or introducing new ones.[2] In health systems, these state variables are the service delivery mechanisms that allow the system to accomplish its objectives, from leadership, governance, and institutions, to health policy, protocols, guidelines, and relationships with its agents and wider systems.

In the context of health care services delivery, transformative change has been examined as a planned process whereby the service delivery mechanisms and their inputs (constitutive elements of the health system itself) are sustainably modified to enhance services, behaviours, products, processes, and outcomes, with the goal of improving the overall performance of the health care system when faced with demanding situations (often shocks).[12]

Witter *et al.*[5] build on Blanchet *et al.*'s[10] conceptualisation of the capabilities of health system resilience and proceed to specify the capabilities needed to manage different types of shocks. They explain that for short-lived shocks, the focus is placed on the acute response and absorptive functions with potential ex post facto reflection on the mitigation activities carried out. More persistent intense shocks, however, initially engage the absorptive and adaptive capabilities which can be depleted if the shock lingers. Managing the consequent toll on the health system (and wider systems, as shown by the COVID-19 pandemic) therefore necessitates the transformative capability.

Witter *et al.*[5] and Blanchet *et al.*[10] support the observation that transformative health system resilience involves the system's aptitude for change as well as the implementation of planned change tasks, activities that the system undertakes to transform its procedures and institutions. Thus, studying the determinants of success for transformative change is crucial for moving from a conceptual understanding of resilience to an operational approach that examines how the capability unfolds in real-life situations.

This more "on-the-ground" approach informed the framework developed by Kruk *et al.* where they typified five characteristic that define a resilient health system: awareness,

diversity, self-regulation, integration, and adaptiveness.[13] Within each of the five characteristics in this framework, the authors propose a suite of performance measures which can be used to assess the health system's aptitude for resilience, but also provide a high-level list of operational elements that, when looked at under the lens of transformative health system resilience, can be seen as definitions of change tasks to develop resilience.

A measure of both frameworks' conceptual strengths is that, even though they take different approaches, they coincide in several elements identified as drivers of resilience. Blanchet *et al.*[10] identify a health system's capacities to manage resilience including knowledge, which matches Kruk *et al.*'s[13] awareness; self-regulation; and integration, management of uncertainties, which matches adaptiveness, interdependence, which matches integration and diversity, and legitimacy, which matches self-regulation and adaptiveness.

Both previous frameworks converge similar elements as determinants of resilience and offer researchers an avenue for exploration of resilience in operational settings. By characterising the nature of resilience and the features that constitute a resilient health system, the intersection of both frameworks provides a solid foundation to start exploring the processes and activities that underlie transformative change and transformative resilience.

A more foundational, if perhaps more generic, framework is the World Health Organisation (WHO)'s Building Blocks, which provides a description of the components (or building blocks) of a health system along with the goals and objectives of the system as whole.[14] The building blocks are leadership and governance, health information, health financing, health workforce, health service delivery, and access to medical products and technologies. The framework also sets out a list of performance measures which can be used to evaluate the outcomes of each building block as they relate to the achievement of the high-level goals of the health system.

Although the Building Blocks framework predates the establishment of the concept of health system resilience, its operational approach has been used by researchers to evaluate health systems' performance both in general and in response to shocks, at the level of the whole system (including the global stage)[15] as well as at the health facility level.[16] This performance measurement approach provides a good introduction to understanding the operationalisation of health system resilience by examining under a systems thinking lens the common elements that enable a health system to achieve its objectives, which resilience aims to preserve.

There is widespread consensus amongst the scientific community that the Building Blocks framework is a sound structural approach to defining a health system, which has made it withstand the test of time in terms of usability, both for research and for planning and design of system-level legislation, policy, and interventions. However, the model is not without criticism, particularly stemming from its static and siloed nature which is not completely reflective of the dynamics in modern health systems,[17] especially after the COVID-19 pandemic, and does not include components that encompass the health system's relationships with its agents and beneficiaries,[18] as well as with wider systems.[19]

With these considerations in mind, previous researchers have used adapted versions of the Building Blocks framework to examine health system resilience in specific contexts, highlighting the framework's strength as a structural model to elucidate the system-level components that need to be engaged to build resilience, or at least a part of them. One benefit of such frameworks compared to the more conceptually focused ones outlined before is that the former allows researchers to think about health system resilience in terms of processes, services, and system capacities, which align with a more operational viewpoint.

This approach was used by McKenzie *et al.* to show how the government of Nigeria sought to enhance health system resilience to improve its service offering and delivery, particularly around maternal and newborn care, in the context of the West Africa EVD

outbreak.[20] The authors highlight the activities undertaken by the two programmes examined, organised under the Building Blocks framework, and discuss how the implementation of these activities (some of which can be regarded as change tasks) improved the health system's resilience.

Haldane *et al.* developed a conceptual framework grounded on the Building Blocks to review and comparatively analyse the responses of 28 countries to the COVID-19 pandemic.[21] The authors use their framework to assess the policies undertaken by the countries in their study to respond to COVID-19 and classify these policies under the Building Blocks through a resilience lens. The framework is then used to synthesise the information obtained into four areas that underlie effective responses to the health crisis, namely activate comprehensive responses, adapt health system capacity, preserve health system functions and resources, and reduce system vulnerability. Those identified areas inform the authors' conceptualisation of health system resilience in the context of acute responses to infectious disease outbreaks.

From an approach adapted specifically to the African context, Olu developed a framework to define resilient health systems in support of Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) initiatives.[22] Their framework draws heavily on the Building Blocks to identify DRM elements and public health interventions at the level of disaster preparedness, disaster response, and post-disaster recovery. The practical application of this framework is underpinned by a list of proposed activities and framed by the social determinants of health, community resilience, health emergency preparedness, and a strong coordination platform, although the study does not elaborate much further into these dimensions.

Notably, all three of the previous frameworks introduce modified versions of the Building Blocks that, to some extent, include considerations of community involvement as an element of resilience. This is compatible with research findings that highlight the role of

community engagement in facilitating the success of strategies to improve resilience.[23, 24] Additionally, including communities (and by extension, individuals) in conceptualisations of resilience is aligned with the WHO's framework for a person-centred approach to the design and delivery of health services, which ties into the operational elements of resilience.[25]

Related to community involvement is the issue of trust. Although this has received less attention in the published literature, it has been well established that a lack of community trust in health services was one of the major challenges in the Liberian health system's response to the EVD outbreak.[10, 13] Kittelsen and Keating undertook an empirical review of trust in the health system resilience literature and defined three drivers that underpin trust in the health system:[26] the net benefit for the user of interacting with the system, the probability of the interaction being successful, and the direct and opportunity cost of interacting with the system.

1.3 Context for the Case Study – EVD and COVID-19 in Liberia

The first case of the 2014-2016 EVD outbreak in West Africa was identified in Guinea in late 2013, from where it quickly spread to neighbouring Liberia and Sierra Leone.[27] The first case in Liberia was identified in Lofa County in March 2014, and by July it had reached the capital city of Monrovia. Before the outbreak, 14 years of internal armed conflict from 1989 to 2003 decimated the public infrastructure and health workforce, leaving less than 200 physicians in the country by 2009.[28]

Throughout the course of the outbreak and until the country was ultimately declared Ebola-free on June 1, 2016, Liberia had a total of 10,678 cases, only 3,358 of which were laboratory-confirmed, and a total mortality of 4,810.[29] The hardest-hit counties in Liberia were Lofa, where the outbreak started, and Montserrado, where Monrovia is located. These two counties accounted for well beyond 50% of the total cases in the country, which made them the clear targets for intervention. [28]

The response from the Liberian government was based on specialised treatment centres called Ebola Treatment Units (ETUs). The initial coverage of ETUs was low due to public mistrust of the healthcare system and low perceived benefits of seeking EVD treatment given the high mortality of the illness. Health information systems were initially unable to effectively gather epidemiologic data to assess the incidence of disease as under-resourced services prioritised case management, safe burials, and community education efforts rather than data collection and reporting.[28]

Laboratory capacities were overwhelmed in the early stages as the country did not have the technical capabilities to process all the samples of potential EVD cases. Although laboratories were eventually established in Montserrado, Lofa, and Bong counties, the capacity to process samples in the first three months of the outbreak was below 50 samples per week.[30]

The response in Liberia was highly aided by international partners both directly and acting through international non-governmental organisations (NGOs). The United States of America provided technical and logistical support through the Centres for Disease Control and Prevention (CDC) and offered technical guidance as well as provide security measures, case identification, and contact tracing.[30]

Almost half a decade later, Liberia would face yet another shock to its health system with the emergence of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that sparked the COVID-19 pandemic. This unprecedented outbreak represented a significant threat to Libera's recovering health system and, much like for the rest of the world, has strained the country's public system in ways that created the utmost urgency to prioritise essential services delivery, and allocating resources in a strategic manner to build early resilience to the crisis.

SARS-CoV-2 was introduced to Liberia on March 16, 2020, through the first case of COVID-19 diagnosed: a government official returning to the country from Switzerland.[31]

Contact tracing efforts began immediately, and, on the following day, a second case was identified as a close contact to the first case. The third case was another returning traveller with no epidemiological links to the first two cases, diagnosed on March 20.[32]

What followed was a swift response from the Liberian government in declaring a national state of emergency on April 8, which included infection prevention and control (IPC) measures like restrictions on public and private gatherings, temporary travel restrictions and a coordinated response between the national government and international partners.[33] The national state of emergency was successfully lifted on July 12, 2020.

The multilateral response involved several global actors like the United Nations (UN), the World Health Organisation (WHO), and the International Federation of Red Cross and Red Crescent Societies (IFRC), as well domestic agencies like the Liberian Ministry of Health, and donor partners.

The early response included targeted interventions like clinical case management and contact tracing supported by the WHO and US-CDC, and general measures like provision of food to vulnerable sectors of the population and rebates of water, electricity, and telecommunication bills. The Liberian Government also enlisted the support of the Liberian Red Cross Society in conducting risk communication, community engagement, health and hygiene promotion, and IPC both at the health facility and community levels.

The systematic approach to the outbreak in the country, heavily informed by the surveillance and communication efforts of the WHO months prior, hinged on high-level advisory and executive bodies that made strategic decisions and mobilised resources in the early stages of the crisis, such as the Special Presidential Advisory Committee on COVID-19, the National Response Committee, an Incident Management System (IMS), and local Incident Command Systems (ICS) that mirrored the governance structures established during the EVD outbreak.[26]

Additionally, community-level interventions were deployed at the outset of the crisis as part of the National COVID-19 Preparedness and Response Plan. Community-level efforts included training and deploying community testers and contact tracers for early case identification, risk communication and education on IPC, and health promotion. Community health workers (CHWs) were also instrumental in ensuring continuity of essential services such as immunisations and malaria prevention and treatment.[26]

International stakeholder engagement, particularly with the US-CDC, USAID, World Bank and GAVI, along with participation in the COVAX scheme, were essential in securing access to vaccinations and rolling out immunisation programs.[34] As of December 2022, the Liberian population's COVID-19 vaccination rate stood at 81%.[35.] According to the WHO Country Office in Liberia, between January 3, 2020, and November 8, 2023, there had been a total 7,930 confirmed cases of COVID-19 and 294 deaths.[35]

1.4. Research Questions, Objectives, and Justification

Using an embedded case study approach as described by Yin,[36] this research seeks to answer the following questions: (1) In the context of the Ebola Virus Disease outbreak of 2014-2016, in what sense did the Liberian health system demonstrate transformative health system resilience? (2) In the context of the COVID-19 outbreak of 2020-2023, in what sense did the Liberian health system demonstrate transformative health system resilience? (3) How can the approach of the Liberian Ministry of Health, Montserrado County authorities; health service delivery institutions, and non-governmental organisations, be summarised in an operational framework? (4) How did the elements of transformative health system resilience in the Liberian national health system change between the Ebola Virus Disease and COVID-19 outbreaks? (5) What institutions and/or services in the Liberian health system experienced transformative change in response to the Ebola Virus Disease and COVID-19 outbreaks? and (6) How did

institutions and/or services incorporate sustainable transformative change into their structures, processes, and culture?

By answering these questions, this study intends to build on the existing literature around health systems resilience applied to the Liberian context during and after the EVD and COVID-19 outbreaks, and demonstrate the existence of transformative change in support of theories positing the transformative dimension of health systems resilience. This research also aims to provide context-specific evidence on the operationalisation of transformative health system resilience under a framework that accurately captures the areas where the Liberian national health system implemented transformative change for resilience, as well as enable the exploration of the processes that underpinned the accomplishment of transformative change.

Previous research has developed proposals to operationalise the concept of resilience, but practical applications and specific measures are still not comprehensively defined. Given that the concept of health systems resilience is fairly new, there is still debate on whether it has been sufficiently elaborated on, and if the dimensions of resilience are fully understood.[5]

Most previous research and frameworks have focused on the absorptive and adaptive capacities of resilience, and the transformative dimension, while acknowledged, has yet to be widely taken into consideration in the operational frameworks that have been applied so far. Thus, as observed by Biddle *et al.,*[37] transformative resilience, especially as it pertains to institutional legitimacy of health and healthcare organisations, defined by Blanchet *et al.*[10] as the "capacity to build or develop legitimate institutions that are socially accepted and contextually adapted", has not been developed in research to the same extent as absorptive or adaptive resilience.

In response to this need for further exploration into the applications of the concept of transformative resilience, this research examines the response of the Liberian national health system to the EVD and COVID-19 outbreaks, as well as the post-shock recovery efforts, to

generate evidence of the existence of transformative health system resilience and the processes that guided transformative change, thus contributing to the existing body of evidence on resilience and the ongoing efforts to operationalise the concept.

1.5. Outline

The rest of this manuscript is organised as follows: Chapter 2 presents the literature review on the concept of resilience applied to systems science and health systems and develops the operational framework and theory of the case study. Chapter 3 presents the study's methods. Chapter 4 presents the results from the key informant interviews and key document reviews analysis. Chapter 5 provides a discussion on the implications of the findings, refines the study's operational framework and theory, and identifies steps for future research. Chapter 6 details conclusions on the research findings.

2. Literature Review and Theory of the Case Study

2.1. Challenges with Current Frameworks

Although the Building Blocks framework has proven to be a sound approach to explore health systems resilience,[15, 16] there are gaps in the current literature in terms of how the framework is implemented. Regarding community involvement and trust, adaptations of the Building Blocks have introduced these elements as framing principles or embedded into the existing components of the framework, which enables exploration of high-level concepts related to community engagement but does not allow researchers to examine operational elements and implementation mechanisms that facilitate community involvement as an element of resilience.

As previously mentioned, the inherently static nature of the Building Blocks has been cited as a limitation for health systems thinking, which also applies health system resilience. The framework's focus on objectives and outcomes, as well as lack of integration of each of

its components, hinder the ability to examine resilience in terms of processes and mechanisms, which are essential to understanding how the elements of resilience are operationalised.

These conditions have resulted in the Building Blocks being used as a tool to create conceptual frameworks that elucidate concepts and build on theory, but touch less on operational elements and implementation processes to improve the system's resilience capabilities, with perhaps one exception focusing on resilience as a function of DRR and DRM.[22] Thus, some evidence has been produced on potential markers of a resilient health system, but not much on what processes enable a health system to go from fragility to resilience.[38]

2.2. Literature Review

The first stage of this study involved a scoping literature review using a modified version of the methodological approaches proposed by Arksey & O'Malley[39] and Dobbins[40], which enabled exploration of the literature under the lens of this case study's research questions to obtain relevant studies and reports from indexed and non-indexed sources and summarise the search results, as well as assess their quality and relevance to the study questions.

The literature search was conducted on three electronic indexed databases (PubMed, Scopus, Embase) and one search engine for grey literature (Google Scholar). After the initial search, an additional exploration was run through the artificial intelligence-powered scientific publication search tool Semantic Scholar to corroborate the previous search results and identify any additional records which may have been missed.[41] The literature searches were conducted at two points in time (2022 and 2023) to account for newly published studies between the time when this study was designed and when the final body of literature for the study was selected.

The search strategies used context-specific forms of Boolean operators following the formula "(health* system*) OR (health policy (MeSH Term)) AND (resilien*) OR (adapt*)

OR (transform*) OR (preparedness) AND NOT (psychological resilience (MeSH Term)) OR (coping).” Database-specific operators and statements were used as necessary. For Google Scholar and Semantic Scholar, the generic “health system resilience” search string was used.

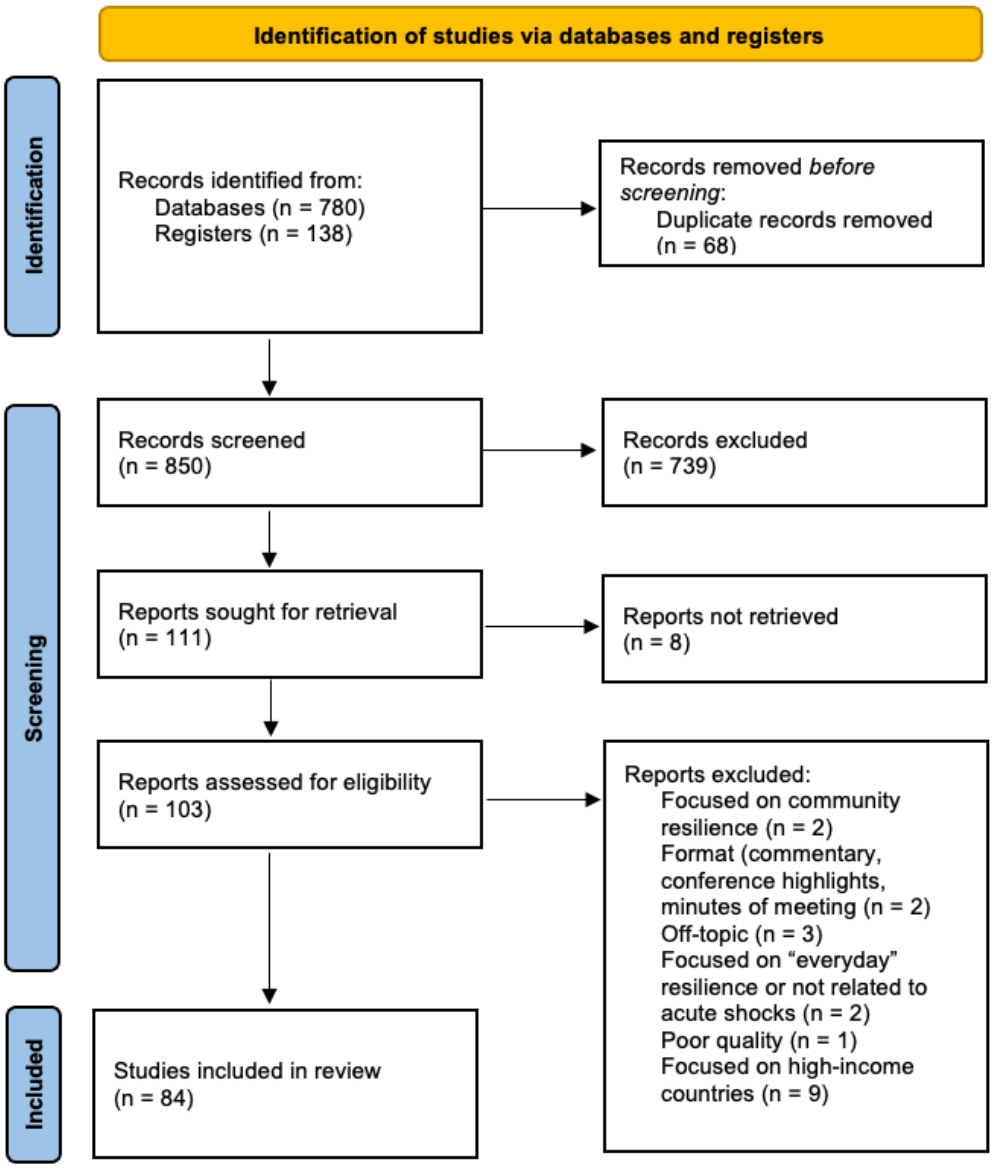

Figure 1: PRISMA diagram for literature search results.[42]

Under the lens of this study’s research questions, studies were included if they fulfilled the following criteria: 1) were published between 2014 and 2023 (to capture research on health system resilience published during or after the West Africa EVD outbreak of 2014), 2) were

written in English, 3) had full text articles accessible, 4) focused on health system resilience in low- and middle-income countries, 5) focused on health system resilience to acute shocks.

Records were excluded from this research for the following reasons: 1) did not have full text articles accessible, 2) focused on personal resilience, psychological resilience, or community resilience, 3) consisted solely of commentary pieces or conference/meeting records, rather than formal studies or editorial reviews, 4) were only tangentially related to health system resilience, 4) focused on resilience to chronic shocks not representing public health emergencies ("everyday" resilience), 5) focused on high-income country settings. These exclusion criteria sought to guarantee the relevance of the chosen records to this case study's research question and case itself (the Liberian context during and after the EVD and COVID-19 outbreaks).

Critical appraisal of evidence was conducted using the Critical Appraisal Skills Programme (CASP)'s Qualitative Studies, Cohort Studies, and Case-Control Studies Checklists to determine the validity, rigour, and relevance of the selected studies.[43, 44, 45] After critical appraisal, one additional study was excluded from this research beyond the ones covered in the exclusion criteria due to being deemed poor quality using the CASP tool. After screening, selection, and critical appraisal, studies were retrieved in full and organised into a data summary matrix for review.

A total of 84 reports were selected for inclusion in this research, which informed the development of the case study questions, theory, propositions, and operational framework. The identified literature provided evidence on the conceptualisation of resilience in general and applied to health systems, as well as current applications and gaps in the existent literature.

The identified literature was then catalogued in a data extraction matrix for analysis (see Appendix A) and used to inform the case study's objectives and narrow the focus on

transformative health system resilience. The study's operational framework, theory and propositions were developed from the results of the data synthesis.

2.3. Towards an Operational View on Health System Resilience

A first step to operationalising the concept of transformative health system resilience is to approach exploration under the lens of transformative change and build the research theory based on change tasks (activities that enable transformation).[46, 47] Given the complex and interconnected nature of health systems, this requires a nuanced understanding of the structural components of the system, the functions that are fulfilled by each component, and the relationships between each component and how they feed into another.[48, 49, 50]

Through this approach, the first finding from the available literature is that the Building Blocks framework as described by the WHO alone does not provide an adequate basis for this study's operational framework in defining the components of the health system, i.e., the parts that make up the system's institutions.[17] As observed in the literature, there are important gaps in the Building Blocks framework which, in synthesis of previous research, can be remedied by adding two additional components.[17, 19, 51]

The first additional component, Community Trust and Ownership, aligns with previous research findings and observations from health systems experts that there is a need to capture the objectives of trust building, public engagement and legitimacy as functions of the health system rather than a consequences of the other components' adequate functioning.[20, 22, 23, 24]

The second new component, Interinstitutional Collaboration, allows exploration of the relationships between the institutions that make up the health system, as well as wider systems, in recognition of the interconnected nature of health systems, and particularly accounting for the Liberian health system's strong relationships with partner organisations and donors from the public and private sectors.[19]

Thus, this study's operational framework considers eight components of the health system that need to be engaged when introducing transformative change for resilience to acute shocks: Leadership and Governance, Health Financing, Health Workforce, Health Service Delivery, Health Information Systems, Medical Products and Technologies, Community Trust and Ownership, and Interinstitutional Collaboration.

The second step in building the operational framework is categorising functions within each component of the health system. Functions are understood to be specific tasks that enable the health system (under each component) to achieve its goals and make up targets for intervention to introduce transformative change. To do this, this study draws on the findings by Meyer *et al.*, who developed a typology of the capacities, capabilities, and processes that health systems need to undertake to develop resilience which serves as a proposed suite of measures to capture the state of the operational elements of resilience in a health system at a given time.[52]

Synthesising the previous research, the theory of this study identifies the following categories of functions for the development of transformative change for health system resilience: Core Functions; Sustainable Command Structure; Sustainable Funding; Allocation and Planning; Health Workforce Planning; Access to Health Services; Public Health Surveillance; Research; Procurement; Supply Chain Management; Strategic Communication; Community Engagement; Trust Building; Collaboration, Coordination and Partnerships.

Thus, this study's framework organises the 14 function categories found to be related with developing transformative resilience under the eight components as illustrated below. It is important to note that this functional classification does not imply the included functions are independent or that exploration can happen in isolation of other functions. The purpose of categorising the functions is to enable systematic exploration of operational activities in each category, recognising the interconnectedness of each function in the overall health system.

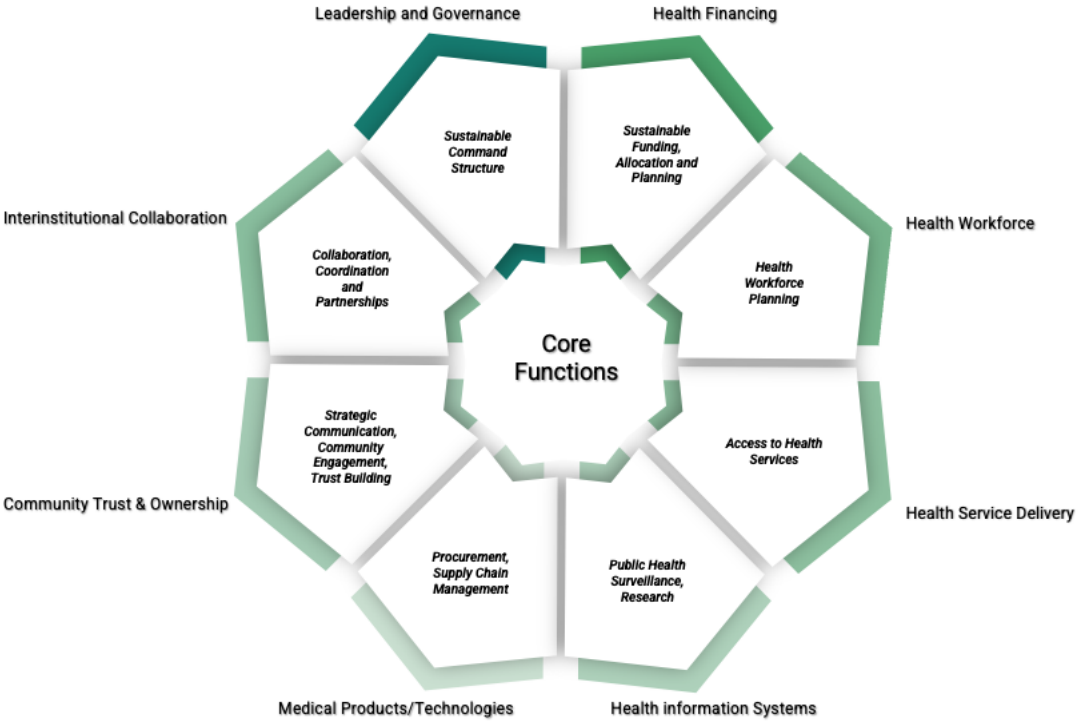

Figure 2: Operational Framework for Development of Transformative Health System Resilience

As seen in the operational framework above, the eight components of the health system, containing the categories of the components' functions are organised around core functions which include the routine and day-to-day capabilities that allow the health system to deliver services such as preventative and curative care at all levels, and routine public health functions like epidemiological surveillance, health promotion, and immunisations.

The theory of this case study posits that the development of transformative resilience in the Liberian national health system was underpinned by the national government's assessment of the threats and opportunities during and after the EVD outbreak to identify

targets and priorities for change, which were disseminated throughout the system and positioned as priorities with decisionmakers. Further, to facilitate the implementation of transformative change, the national system identified barriers and minimised their impact on the proposed changes,[53] leading to the consolidation of change tasks after implementation, as well as sustainable adoption of change by the institutions, agents, and partners of the health system.[54]

This study also hypothesises that the institutional and service transformation, trust building, and community involvement that took place during the development of transformative resilience in response to the EVD outbreak improved the Liberian health system's preparedness for future infectious disease outbreaks, and ultimately enabled a more efficient response to the COVID-19 outbreak where components of the health system were more easily engaged in management of the public health emergency.

The next sections will discuss each component of the framework along with the functions for resilience in more detail, as well as present the theory and propositions of the case study related to each corresponding element of the operational framework.

2.3.1. Core Functions

This category represents basic functions that underlie the performance of health systems during crises, aligned with what Haldane *et al*.[21] described as "public health functions"[21] and Meyer *et al.* categorised as "core capacities".[8, 51] Core functions are hence not classified into specific components of the health system, because rather they enable and facilitate all components. This includes Infection Prevention and Control, Laboratory Capacity, Emergency Preparedness and Response, and Waste Management.

2.3.2. Leadership and Governance

Leadership and governance are essentials components of health systems as conceived by the Building Blocks framework. Leadership and governance are a crucial enabling component as they determine the policies and approaches followed in terms of how resilience capabilities are developed and supported.[5, 55] As highlighted by Blanchet *et al.*[56] leadership serves a vital role in managing the relationships, actors, institutions, and interactions with society that enable the health system to achieve its objectives and, in the context of resilience,

For the Liberian context, paying close attention to the nuances of leadership and governance gains an additional layer of relevance given the multifaceted nature and diverse backgrounds of the stakeholders that influence the health system, ranging from domestic to international. This introduces complex dynamics of power both implicit and explicit that can impact decision- and policymaking, core objectives and mandates of institutions and officials, and technical expertise and advice. Remaining sensitive to these power dynamics in leadership and governance is essential for operationalising the concept of resilience in health systems.[56]

The functions of leadership and governance for health system resilience are categorised in this study under Sustainable Command Structure, which refers to stewardship to manage the system's response to the shock(s).[57] In this sense, one of the main functions in this category is establishing a central structure to manage the response, aligned with what is referred to in DRM as a Public Health Emergency Operations Centre (PHEOC) as described by the WHO.[58]

Establishing a PHEOC enables the fulfilment of subsequent functions for transformative health system resilience, namely consolidating oversight mechanisms to engage local facilities into the unified response efforts and developing and disseminating a national plan or strategy to develop resilience.[8, 59]

This research also proposes that the implementation of a PHEOC was facilitated by national government efforts to introduce necessary changes in the regulatory framework such

as legislation and policy, as well as building institutional legitimacy for the PHEOC and its agents and implementing partners through stakeholder and public engagement.[60, 61]

2.3.3. Health Financing

As one of the main inputs that enable health systems to achieve their outcomes,[62] financing receives a constant stream of attention in ordinary times, and even more when public health crises emerge. In the Liberian context, health financing is a particularly complex function given the country's multidimensional network of funding mechanisms, ranging from domestic revenue to support by bilateral and multilateral donors, which influences the way funds are allocated and when funding is mobilised to respond to emergency situations.

Financing for health system resilience requires targeted investments on system capabilities that enhance the service delivery mechanisms as well as the structure of the system itself, enabling it to not only deliver essential services, but to evaluate the efficiency of allocations and continuously improve its funding mechanisms.[63, 64]

Informed by the previous notions and guided by observations in available literature, this study proposes that financing for health system resilience was an active and intentional part of Liberia's response to the EVD outbreak and provided sustainable transformative change that improved their health system's preparedness for the COVID-19 outbreak.

The functions of this component are compiled in two categories in this study's framework. Firstly, Sustainable Funding comprises the health authorities' functions to develop and/or preserve sustainable funding mechanisms, including appropriation of funds. This involves conducting situational assessments to understand the funding pressures introduced by the public health emergency, revising the revenue streams and allocation policies to promote resilient funding, prioritising funding for essential needs, and ensuring equitable distribution to avoid introducing disparities in health outcomes due to unbalanced funding.

Secondly, Allocation and Planning encompasses the functions of identifying essential services and what financial support should be prioritised to maintain the baseline level of functioning for the system, using this information to develop a national plan that prioritises funding for resilience (meaning sustainable funding for essential services and emergency response) to prioritise revenue streams and secure additional sources of funding where necessary, disseminating these plans to partners and donors to ensure cohesive actions are taken across sectors, and devising plans to reallocate existing funds based on critical needs.

Given that efforts to strengthen transformative health system resilience require considering the post-crisis environment as much as the acute response, funding sustainability becomes a particularly salient issue. To ensure that the change initiatives have time to realise their full impact and that the system improves its capabilities to respond to further crises, it is necessary to ensure sustained commitments from funders (whether these be part of the national system or external donors).[65] Hence, the national health funding strategy must include negotiations to secure sustainable funding agreements with clear expectations and goals which are reflective of transformative change initiatives.

2.3.4. Health Workforce

The health workforce plays a direct and indispensable role in developing resilience from the perspective of service delivery and planning. It is the individuals, accurately referred to as frontline staff, who represent the point of contact between the users of the health system and the direct outputs of the system itself. Accordingly, an operational framework that enables exploration of transformative resilience must accurately capture the way a shock to the health system impacts the health workforce, but also how the health workforce influences the implementation of the response.

It has been observed that the acute phase of a public health emergency, whether due to a short-lived shock or the beginning stages of a more persistent trauma, can have a bolstering

effect on the capacities of the health workforce, particularly by increasing staff morale, commitment, and a shared sense of responsibility[8, 66]. However, in an almost Newtonian fashion, the initial boost will eventually give way to staff attrition, burnout, and demoralisation, which can be exacerbated by disproportionate impacts of the outbreak on healthcare personnel.[28]

Developing transformative resilience in the workforce therefore requires strategies to ensure an adequate supply of health workers, but also that health workers are protected from bearing the brunt of the toll that continued stress takes on the health system, particularly on service delivery.[1, 22, 27, 67, 68] Such strategies must include transformative change functions that enhance the health system's workforce strategy for training, recruitment, tracking and retention, and promote government policies, processes, and culture that are supportive of the workforce.

The functions in the Health Workforce component are grouped in a single category: Health Workforce Planning. This broad category reflects this study's proposition that an imperative function of national authorities is developing or enhancing a workforce strategy that enables a strong contextual awareness of national and local provider availability at the national during regular times. Coupled with awareness, a crucial function is enhancing production pipelines by training health workers on both a routine and extraordinary basis, to ensure that existing capacity is robust and new capacity can be added in a timely manner.

In turn, a national workforce strategy supports the function of targeted recruitment and reassignment when service delivery needs change as a result of the shock, including community involvement to facilitate training and deployment of CHWs. Finally, provider safety must be an inherent function of the overarching strategy, including regular training and continuing education for health workers to guarantee appropriate infectious disease management and IPC guidelines are in place.

2.3.5. Health Service Delivery

Health service delivery is focused on the main output of the health system, which is also the main point of interaction between users and providers. The functions in this component are categorised under Access to Health Services, which comprises strategies to ensure the availability, safety, quality, timeliness, effectiveness, and equity of health service delivery Since service delivery is the primary tool at the system's disposition to ensure its goals are met, service continuity is vital to advance population health goals during normal times and crises and must comprise a defined minimum basket of services that directly tie into the system's goals and objectives regarding the population health priorities.

This study's theory finds that functions of health service delivery for resilience are focused on addressing immediate health needs related to the shock on top of preserving the essential basket of services needed during ordinary times.[2, 69] As noted by previous authors, an understanding of priority health services grounded on primary health care must be coupled with an ongoing assessment of emergent health needs, ranging from public health interventions such as preventative care and immunisation, to direct therapeutic interventions at appropriate facilities to address the public health emergency[5, 22].

Accordingly, this component's functions for resilience involve developing situational awareness of the location and distribution of health facilities and services, which will enable planners to determine capacity and additional need.[18, 51,] After this, the response strategy must include plans to support current essential health services and establish temporary health facilities for emergent needs related to the shock.[51] This approach must be supported by the development of surge capacity in acute and emergency care settings, as well as ongoing

assessments to determine how population health needs shift as a result of the crisis, and sustainably transform the service delivery strategy.[70]

2.3.6. Health Information Systems

Health intelligence is a critical function of the health system that allows for the planned development of transformative resilience to infectious disease outbreaks, and it hinges on health information systems.[71] Without information, it is impossible to understand the current challenges and plan a way forward. Thus, health information systems are a critical component that underlies all functions under this study's operational framework by enabling engagement with and between elements of the system, health workers, and communities.

Hence, a resilient health system is, necessarily, a health system which has the capability of becoming aware of a shock immediately after it emerges. The first category of functions in this component, Public Health Surveillance, highlights the cardinal function of developing a surveillance strategy that allows health workers and health authorities to obtain opportune information on key pathogens of epidemiologic relevance, including those with epidemic potential. Along with surveillance standards, this function involves creating robust reporting guidelines to ensure information is relayed in a timely manner to support decision-making.

The scoping review findings identify six studies that directly discuss health information systems as an enabler of health system resilience.[7, 20, 22, 57, 72, 73] Of these, four studied mentioned the previously described functions of public health surveillance when describing initiatives to develop resilience in the Liberian health system and, in one case, the Nigerian health system. Fridell *et al.*[73] highlight that robust health information systems are critical to improve preparedness through early outbreak detection and warning, as well as improving transformability by facilitating learning from previous experiences to inform future responses.

The theory of this study proposes that in order to fulfil the need for a robust health intelligence strategy, the functions of enhancing reporting guidelines for specific conditions and ensuring adequate training for health workers on public health surveillance and epidemiology are crucial, as well as capacity building in communities to guarantee individuals can identify cases where they present and encourage their peers to seek healthcare.

In line with observations made by Kruk *et al.*,[13] health information systems also crucially support appraisal of health facilities and service delivery centres which enable the functions of facility mapping and triaging for public health emergencies.

The second category of functions in this component, Information Dissemination, stems from finding extracted from two studies that specifically mentioned communication in health information systems as a critical driver for capturing, analysing, and using data and information.[29, 57] The results from the scoping review highlight that health systems need to have a strong communication strategy and reliable channels to disseminate information to all elements of the health system to enable informed decision-making by health authorities.[20]

To ensure that information is used effectively, health systems need reliable channels for disseminating regular reports on epidemiological updates, preventive measures, and clinical guidelines. Consistent procedures should be established for health facilities to communicate with each other and with health authorities. This facilitates real-time assessments of capacity, service availability, and immediate intervention needs.

By clearly separating systematic data gathering from communication and information dissemination, and understanding their distinct yet interconnected roles, health systems can more effectively harness health intelligence to enhance resilience.[71, 74] Data gathering provides the foundational information necessary for effective response, while communication strategies ensure that this information is utilized across all levels of the health system.[22]

2.3.7. Medical Products/Technologies

The health system's ability to implement interventions hinges, in part, on the availability and access to appropriate medical products and technologies. These take the form of essential supplies for diagnostics, therapeutics, and case management, as well as preventive interventions such as immunisations and prophylaxis. It also covers health protection measures like personal protective equipment (PPE) and supplies to conduct screening.

During complex public health emergencies, the interconnectedness of health and wider systems can play a role in limiting the access to medical products and technologies through supply chain disruptions, loss of inventory, infrastructure limitations (such as storage and cold chain preservation), and transport obstacles due to traffic disruptions. These situations can create a feedback loop where low availability of essential products leads to poor population health outcomes, which encourages the diversion of what stock is available out of the public system and into irregular channels, leading to increased disparities on social determinants of health.[27, 75]

Seven studies identified through the scoping review identify interventions to improve the availability, affordability and management of medical products and technologies.[20, 21, 22, 37, 57, 73, 76.] Most of the studies mention medical products and technologies around the ideas of resource availability and surge capacity, which therefore constitutes the first category of functions in this study's operational framework.

Haldane,[21] and Fridell[73] highlight the need for access to affordable products, which refers to the function category of Procurement and involves building the capacity for thorough resource tracking in the supply chain to understand resource availability and gaps at strategic points, something that Olu points at when discussing Vulnerability and Risk Assessment and Mapping.[22] Along with situational awareness gained from resource mapping, this study proposes that the Liberian health system mitigated the deficiencies in their resource

management capacity after the EVD outbreak by establishing critical pathways for procurement including agreements with donor partners and international alliances for resource distribution, in line with Haldane's findings.[21]

The second category, Supply Chain Management, points broadly to the need for strong institutional processes to manage stockpiling, warehousing, maintaining, and distributing resources, which involves logistics guidelines as well as infrastructure, as noted by Olu.[22] Within this category, the high-level function of managing supply chain disruptions refers to having institutions and processes that are responsible for ensuring appropriate storage, inventory, quality assurance, and equitable distribution of critical supplies.

2.3.8. Community Trust & Ownership

As mentioned, previous research has extensively noted the vital importance of community involvement in making a health system resilient. The addition of community trust and ownership as a component of the health system in this study's operational framework follows key observations made by Kruk *et al.*[13] and Nyenswah *et al.*[28] where they highlight the role that community health workers played in the Liberian health system's response to EVD, but also the fact that community mistrust in the health system was a driver of early adverse outcomes by discouraging individuals from identifying cases in the community, interacting with the health system, and implementing health promotions interventions.

On a more general perspective, Gebremeskel *et al.* identify engagement with community members and community health workers as one of the main challenges addressed in African health systems when building resilience.[51] This aligns with findings from Mackenzie *et al.* who specifically added community engagement to their modified version of the WHO Building Blocks as a focus area for building resilience in the Nigerian health system.[20]

Community involvement is thus theorised in this study's operational framework as not just an enabler to resilience, but as a component and a function of the health system that must be systematically incorporated to achieve resilience.[77]

Beyond this, the scoping review findings identify 10 studies that include community engagement as part of frameworks to explain the development of resilience in health services and/or systems.[9, 26, 27, 33, 57, 78, 79, 80, 81, 82] Drawing from findings by Barker *et al.*[23] that community-based interventions were crucial to enhancing resilience in the Liberian health system during the EVD outbreak, this study proposes that a key function of transformative change for resilience in Liberia was enhancing the strategic communication initiatives to prioritise tailored messages for communities with identified health disparities.

Ensuring meaningful community participation as stakeholders in public health interventions and users of the health systems begins with legitimacy, which goes beyond mandated authority and entails social acceptance of, and confidence in, health authorities and providers.[55, 70, 83, 84] Hence, as mentioned by Blanchet *et al.*,[10] building legitimate (understood as socially accepted) institutions is a vital function for the health system to realise the potential for resilience and provide services in which communities and individuals feel involved and represented.

The first category of functions in this component is Strategic Communication which reflects the operationalisation of the idea that communities need to be informed in order to be engaged with the health system[23, 85]. To achieve this, this study proposes that the Liberian health system implemented the functions of developing a risk communication strategy with key messages to mitigate the community impacts of the EVD outbreak and disseminated these messages through community-sensitive channels. Furthermore, this study posits that the existence of this communication strategy facilitated the community engagements efforts during the COVID-19 outbreak to improve outcomes and capitalise on previous learnings.

Secondly, Community Engagement encompasses the functions of effectively establishing bonds with relevant community actors and using community health structures to deploy public health interventions. This is achieved by conducting assessments at the national and local levels to identify subsectors of society who are particularly vulnerable and at risk of being disproportionately impacted by the public health emergency to enable health planners to understand priority areas to engage and incorporate into the national and local response plans.

Identified key sectors of the population must be purposefully engaged to enhance their participation in health intervention planning and implementation. This can be achieved by establishing working relationships with what Blanchet *et al.* termed "social brokers",[10] who are individuals in positions of influence in their communities who can act as local representatives. Reciprocal relationships with social brokers must be established in the health system to ensure community-level needs and expectations are represented, and that the intent and goals of health authorities are properly communicated to individuals.

In the same vein, effective public communication depends on community trust and ownership and vice-versa,[26, 74] which must be intentionally cultivated by health planners to ensure that members of the society, including key sectors, are given a voice on intervention design as well as receive appropriate key messages to support implementation of public health interventions.[86]

Social brokers also play a crucial role as touchpoints in communicating the needs and expectations of individuals back to the system so that intervention design, implementation, and monitoring can be tailored to appropriately reflect the local context.[10, 26, 74] In this sense, having health workers originating from and embedded in the community would be an effective strategy to increase legitimacy of the interventions and improve trust in the health system.

To mitigate the risk of pushback against the health system and to foster relationships of trust in evolving situations, it is also crucial that health authorities fulfil the functions of

capitalising on community health workers to locate health interventions in the community, increasing legitimacy.[23, 78, 82, 87] Finally, the function of incorporating communities into decision-making tables at the health facility and local government levels highlights the importance of giving communities agency over their own health journeys as a facilitator of trust, ownership, and legitimacy.[25, 88]

2.3.9. Interinstitutional Collaboration

The final component of this study's operational framework is reflective of the interconnectedness of health systems with wider systems in its national and international contexts. As evidenced by recent public health emergencies, it is essential for national responses to be coordinated with international efforts. Moreover, in order to become resilient, health systems must transform their cooperation to facilitate information sharing, technical advice, resource allocation, and monitoring.

The inclusion of this component and the functions within it represent this study's contribution to the gap identified through the scoping review. While Takian and Raoofi made the case for inclusion of inter-sectoral collaboration into the WHO Building Blocks,[19] the functions in this area were not found to be explored in the literature. Moreover, the scoping review finds six studies which discuss concepts of interdependency and the need for collaboration, [10, 51, 78, 38, 89] but only Meyer *et al.*[51] and Foroughi *et al.*[78] specifically refer to stakeholder coordination (a key element of collaboration) as a health system function to drive resilience. To address this gap, the scoping review's findings through the data synthesis identified common concepts in the approaches presented by previous researchers when describing the need for multisectoral approaches to respond to public health emergencies into the functional category for this component: Collaboration, Coordination and Partnerships.

Drawing from Saulnier *et al.*'s description of interdependency,[38] the first function identified in a robust multisectoral approach is to engage the appropriate stakeholders at the right time, followed by setting up agreements ahead of public health emergencies, to facilitate technical cooperation and, in the case of funding partners, secure sustained investments that are responsive to the health system's goals for developing resilience.[59] A stakeholder engagement plan that foresees the shift in relationships during shocks to the health system will more appropriately harness these resources in proactive ways.[90, 91]

As discussed by Meyer *et* al.,[51] beyond individual stakeholder negotiations, it is important to create a coalition for change and include representation of the various actors with influence on the response, both bilateral and multilateral, in planning and decision-making tables. The theory of this study proposes that strong interinstitutional collaboration not only assisted in the Liberian health system's response to the EVD outbreak, but also enabled national authorities to transform the health institutions to facilitate future collaborations, such as the response to the COVID-19 outbreak, therefore improving the health system's resilience.

Table 1 below summarises the operational framework's conception of the components of the health system, the functions embedded within them, and the transformative change tasks that facilitate the development of transformative health system resilience.

Table 1: Summary of operational components, functions, and change tasks for transformative health system resilience.

Component	Category	Functions for Transformative Resilience
Leadership and Governance	Sustainable Command Structure	Establishing a central command structure aligned with a PHEOC.
		Consolidating local facilities into the response efforts.
		Developing and disseminating a national plan or strategy to develop resilience.
		Supporting PHEOC through appropriate legislation, regulations, and policy.
		Building institutional legitimacy through stakeholder and public engagement.
Health Financing	Sustainable Funding	Revising the system's revenue streams and allocation policies, including accountability, to build resilience to funding pressures.
		Conducting situational assessments to understand funding pressures.
		Triaging funding needs.
		Ensuring equitable funding distribution.
	Allocation and Planning	Developing awareness of what services are essential and where financial supports could provide immediate relief and achievement of long-term goals.
		Disseminating resilience financing plans to funders and implementing partners.
		Producing a national plan to prioritise revenue streams and secure additional sources of funding where necessary
		Reallocating existent funding to better serve priority initiatives
		Securing sustainable funding agreements with clear expectations and goals which are reflective of transformative change initiatives.

Table 1: Summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Health Workforce	Health Workforce Planning	Establishing a national workforce strategy that enables a strong situational awareness of national and local provider availability.
		Establishing strategic partnerships with relevant institutions to train health workers on both a routine and extraordinary basis.
		Supporting recruitment and reassignment when service delivery needs change.
		Facilitating training and deployment of community health workers.
		Providing regular training and continuing education for health workers to guarantee appropriate infectious disease management and IPC guidelines are in place.
Health Service Delivery	Access to Health Services	Developing a defined minimum basket of services that directly tie into the system's goals and objectives.
		Typifying priority health services grounded on primary health care,
		Ongoing assessment of emergent health needs.
		Developing situational awareness of the location and distribution of health facilities and services.
		Implementing national and local service continuity strategies.
		Establish temporary health facilities for emergent needs.
		Developing surge capacity in acute and emergency care settings.

Table 1: Summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Health Information Systems	Public Health Surveillance	Developing robust epidemiological surveillance and case reporting guidelines.
		Building community capacity for case identification and referral to health facilities.
		Providing comprehensive epidemiological training for healthcare providers.
		Tracking nosocomial infections.
		Mapping and appraisal of health facilities and service delivery centres.
	Information Dissemination	Developing a strong communication strategy and reliable channels to disseminate information to all elements of the health system, relevant external stakeholders, and the general public.
		Implementing consistent procedures to deliver regular reports to healthcare providers on epidemiological updates, preventive measures, and clinical guidelines.
		Supporting health facilities to communicate with each other and with health authorities to facilitate assessments of capacity, burden, available services, and opportunities for immediate intervention.
Medical Products & Technologies	Procurement	Implementing resource and supply chain tracking to understand resource availability and gaps
		Establishing purchasing agreements through public-private partnerships, donor assistance, and participation in purchasing coalitions
	Supply Chain Management	Managing supply chain disruptions including access and distribution of essential supplies

Table 1: Summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Community Trust & Ownership	Strategic Communication	Deploying risk communication and engagement strategies to reassure the public about the safety and appropriateness of health facilities and interventions, maintain communities informed of service availability, and provide regular situational updates.
		Considering and choosing the proper risk communication strategy, which is culturally relevant, appropriate, and sensitive to the social context and community issues.
	Community Engagement	Conducting assessments at the national and local levels to identify subsectors of society who are particularly vulnerable and at risk of being disproportionately impacted by the public health emergency.
		Establishing relationships with community social brokers.
		Engaging social brokers as disseminators of public-facing key messages and to enable community feedback for health authorities to inform intervention design, implementation, and monitoring.
	Trust building	Deploying public health interventions with community health workers to improve legitimacy.
		Involving the community in local decision-making tables at health facilities and local government bodies.
Interinstitutional Collaboration	Collaboration, Coordination & Partnerships	Engaging the appropriate stakeholders at the right time
		Setting up agreements ahead of public health emergencies, to facilitate technical cooperation and, in the case of funding partners, secure sustained investments
		Establishing a stakeholder engagement plan that foresees the shift in relationships during shocks
		Including the various actors with influence on the response, both bilateral and multilateral, in planning and decision-making tables

3. Case Study Methodology

This research uses the case study methodology proposed by Yin[36] to establish the basis and protocol that informed the research activities. As a method for scientific inquiry, a case study is well suited for exploring an organisational phenomenon in its "real-world context" and allows for the exploration of the study subject with regards to many unfolding variables as they interact with their environment, including their relationships. This enables case studies to engage multiple sources of evidence to answer research questions *in vivo*.

Considering that a case study is particularly powerful in answering questions of "how" and "why" as they relate to a phenomenon, it is an appropriate research methodology for studying how the concept of transformative health system resilience is operationalised on the ground and uncovering the underlying processes as they relate to an operational framework. Case study methodology also provides a nimble research design that builds theory *a priori* and remains capable of modifying its propositions and assumptions based on research findings.

The theory of this case study was informed by the literature review that was conducted during the design stage (and updated once afterwards) which helped establish the definition of health system resilience used in this study as well as the approach used to conceptualise its dimensions, features, and unique characteristics as opposed to resilience used in other disciplines. The theory of this study also considered paradigms of institutional responses to public health emergencies based on DRR and DRM to understand and define the case itself: the response of the Liberian national health system to the EVD and COVID-19 outbreaks.

To ground the theory on evidence, this study first developed general and specific study objectives and research questions which were reflective of the current landscape and further avenues for research identified in the existent literature. While several studies still signal the need for further conceptual exploration of health system resilience[5, 89] the findings from this study's literature review identify several well-established concepts that share notable

commonalities. Therefore, rather than pursuing further conceptual exploration, focuses on integrating previous research to derive operational functions – tangible actions that influence the development of transformative resilience.

The case study theory forms the basis of the operational framework presented here and builds on the literature review findings which support the approach of identifying functions and capacities for resilience through adaptations of the Building Blocks framework while remarking the need for a person-centred approach. The functional aspects of the theory were developed through the exploration of studies that assessed on-the-ground features of health system resilience and case studies of specific initiatives found to build resilience.[15, 44.]

The theoretical base is supported by study propositions that function as the units of theory to be tested, and which are explained in detail in Chapter 2 of this paper. The study propositions link the study's research questions with its theory by establishing assumptions, grounded on the literature review findings and the theory itself, of what processes and mechanisms allow the research questions to explain the phenomenon that is the object of the case study in its own context. Additionally, study propositions informed the types of evidence required to answer the study questions as well as data collection and analysis strategies to be included in the study.

In synthesis, the theory of this case study builds on organisational theory to explain health system resilience as an continuous process rather than a state, which obeys laws and patterns that originate in the institutions of its organisation (the health system), but is not determined exclusively by the organisation, but rather encompasses the inputs and influences of actors, behaviours, relationships, and adjacent systems to improve the capabilities for resilience while accounting for the context.[92, 93]

Thus, the study's theory builds on previous observations that health system resilience cannot be studied in isolation from its broader context,[89] and proposes that the operational

framework introduced in this research will facilitate a systematic investigation into resilience-building activities within health systems. By establishing principles that can be integrated with resilience considerations in other systems, this framework aims to advance research into health system resilience as a phenomenon.

This research also used findings by previous researchers and draws from organisational theory to home in on the transformative capability of health system resilience and will show that institutional transformation for resilience is an intentional process driven by decision or necessity. It involves engaging health system functions in resilience-specific tasks and is sustained through implementation that emphasizes legitimacy and person-centeredness.

Accordingly, this research proposes an embedded single-case study of the response implemented by the Liberian Ministry of Health and partner institutions in the face of the 2014-2016 EVD and the 2020-2023 COVID-19 outbreaks, analysing the response as a phenomenon within the boundaries of the national health system, but also the components of the response considered under three levels: health authority/non-governmental partner level, health facility/healthcare provider level, and community level.

The scope of the study covers transformative health system resilience and institutional legitimacy within the processes implemented by the Liberian health system to respond to the aforementioned public health emergencies. By embedding two points in time as subunits of the overall case, this study seeks to generate evidence on the implementation and impact of transformative change tasks in building resilience through time comparisons, reflecting on the participants' key learnings of the system's evolution between both outbreaks.

The single-case study design in this research coupled with the selection of multiple sources of evidence to be triangulated (scoping review, key informant interviews, key document reviews), and the capacity to modify the existent theory by findings from the data analysis process itself, contribute to this study's construct validity through clearly articulated

definitions of health system resilience and transformative change, and considering markers of transformative change supported by theory and identified in the published literature.

Threats to validity were controlled during the data analysis stage of this study through strategies aiming to guarantee that the conclusions reached show a real causal process between the research questions, study propositions, and findings. By building explanations for the findings supported by the theory, considering rival theories as potential explanations, and using a logic approach to link the study findings with the propositions, this research ensured the integrity of the conclusions and minimize the risk of bias during data analysis.

Additionally, credibility of the study's findings is achieved by having a structured theory built based on previous theories and appropriately derived study questions, establishing a case study protocol, and documenting the data collection and analysis processes, and triangulating data sources from the literature review, key informant interviews, and key document reviews.

3.1. Data Collection

The primary data collection for this study was conducted through semi-structured interviews as defined by Galletta.[94] Semi-structured interviews were selected to collect data on the processes, enablers, and barriers to the implementation of transformative health system resilience in Liberia in the context of the EVD and COVID-19 outbreaks according to the experience of the participants and contrasted with theory.

The semi-structured interviews collected evidence on the participants' accounts of the implementation of transformative health system resilience according to their own experience as well as through the lens of this case study's operational framework.

Semi-structured interviews were selected for their ability to answer a wide range of research questions and facilitating space for shared meaning making between the interviewer

and the participant,[95] which is an optimal approach to defining the operational elements of health system resilience in the Liberian national health system in the context of the research questions.

Additionally, semi-structured interviews allow for the flexibility to obtain data based on the participant's experience, as well as guide questions to probe for viewpoints based on theory.[94] Furthermore, properly designed semi-structured interviews can provide a space where the experiential learnings provided by the participant's account can be contrasted with the theoretical concepts identified through the previous literature review.[94] In doing so, theoretical concepts can be compared against "real-life" phenomena, which ultimately facilitates "hypothesis testing" of the propositions in the theory of the case study.

For the semi-structured interviews, key informants were selected for their affiliation with relevant institutions/elements of the health system during and/or after each outbreak. To reflect a breadth of viewpoints, key informants were selected from each of the following areas: Liberian Ministry of Health – a senior public health officer in the IMS during the EVD and COVID-19 responses, Montserrado County Health Authorities – a senior public health officer implementing response activities at the county level and representing the counties' leadership in the central EOC during the EVD and COVID-19 responses, National Public Health Institute of Liberia – a divisional director during the COVID-19 response, Non-Governmental Organisations – a senior program officer with the WHO providing technical advice during the EVD response, Health Service Delivery Institutions (Hospitals and Community Clinics) – a director with Last Mile Health coordinating service delivery during the EVD and COVID-19 responses. One key informant was selected from each area to reflect the scope of the study's operational framework.

Participants were selected through a network sampling strategy by identifying initial participants through their involvement with previously published research on the topic of health

system resilience in Liberia and/or their affiliation with organisations that directly participated in the responses to the EVD and COVID-19 outbreaks.

A master interview guide was developed for general use in the semi-structured interviews (see Appendix I) comprising eighteen questions and adapted to the characteristics of each responder. For instance, if the responder was not affiliated with a Liberian government agency, questions regarding the Liberian government's processes and policies were omitted. The full interview guide was piloted with the study's supervisor and one additional participant who provided technical guidance and expertise.

Semi-structured interviews were conducted remotely over videoconferencing software, each interview lasted approximately one hour. Prior to the interview, informed consent was elicited from each participant whereby they were advised of rights and guarantees as participants, provided with detail information regarding the data collection procedures, and informed of the knowledge dissemination strategy after the study's findings were collected and analysed and conclusions were established. Participants were also given an opportunity to review their responses after their interview and request to amend any statements as necessary or withdraw their participation from the study altogether.

Audio from the interviews was recorded and transcribed verbatim using the videoconferencing software's built-in capabilities. Interview transcripts were reviewed and compared against the audio recordings individually by the investigator to check for quality and accuracy of the statements as well as for general readability and transcription errors. Interview transcripts were also shared with the respective responders, and they were given the opportunity to request any amendments or resolve any inaccuracies.

Supplementary data collection was done through document review as described by Bowen.[96] Document review provides the capacity to supplement existing bases of knowledge and evidence with targeted data to provide insights into operational and policy-based aspects

of the research questions. Additionally, evidence obtained from document review can be used to confirm the findings derived from other data sources.

Document review and analysis has been used in conjunction with interview data through case study methodology to supplement and confirm findings and increase the robustness of the theory and conclusions reached in the study.[96] Thus, document analysis provides an appropriate research mechanism to consolidate key informant data with policy and program evidence on health system resilience in Liberia.

Selection of the records to include in the document review and analysis followed a similar approach to the selection of key informants. Purposive selection of key program documents allowed identification, through searches of official records, of two documents which directly provide evidence on the policy and strategic vision for the responses to the EVD and COVID-19 outbreaks: the Investment Plan for Building a Resilient Health System (2015-2021), and the National Public Health Institute of Liberia's Strategic Plan 2023-2028.

3.2. Data Analysis

Analysis of interview data was conducted through qualitative content analysis as described by Mayan[97] and supported by the process outlined by Kiger and Varpio[98] as this data analysis method is particularly well suited to elucidate processes from qualitative data related to individuals' experiences. As the semi-structured interviews captured the respondents' theoretical conceptions and lived experience of the operationalisation of health system resilience in Liberia, building categories and theory from the data will allow for contrast with the study's propositions, underlying theory, and research questions.

Data from the responders' interviews were consolidated into a master list where each individual responder was de-identified. Beyond data collection and organisation under the master list, no identifiable personal data was included in any part of this study. Transcripts

from each interview were read in full by the investigator at the initial stage of analysis to build familiarity with the data and organise responses in an optimal way for analysis.

Interview data were input into the qualitative data analysis software NVivo 14 for processing and analysis. Data were visualised and classified by respondent before coding. The coding strategy implemented a hybrid approach; deductive codes reflected the components of the case study's operational framework and were descriptive in nature, while inductive codes captured structural, descriptive, and process aspects of the data.

The coding structure supported analysis by typifying the results to identify the question, respondent descriptive deductive code, structural inductive code, descriptive inductive code, process inductive code, and text containing the code. Before categories were built, the data were coded once and results were categorised according to deductive codes, and then coded a second time where the results were stratified by the inductive codes. This enabled preliminary analysis of trends and ideas to establish initial patterns. To avoid introducing bias in the creation of categories, the identified patterns were not used to inform the category-building but were kept as separate data to discuss during the narrative analysis of the results.

Codes were organised into topics, and these were correlated with the case study's research questions to build categories. Categories were created to reflect how the coded data relates to the research questions and explains the processes that underpin the study's propositions. In this sense, categories were defined and organised in a way that mirrored the research questions on the one hand, and the operational framework on the other.

After defining and organising categories, the relationships amongst them were explored through the lens of the data and the results of the literature review in order to build a theory. The categories were assigned theoretical significance, and a third round of data review was conducted to confirm linkages between the thematic concepts, the interview findings, the

literature review, and the research questions. Where conflicts between the data and the thematic concepts could not be reconciled, both perspectives were kept in the analysis as separate ideas.

Finally, concepts were connected through explanatory relationships grounded on the research findings and the results from the literature review. This informed the development of theory using a modified version of the approach presented by Naeem *et al.* to create abstract concepts and group them into theory from the identified categories.[99] Connections between categories were corroborated by considering rival explanations and only keeping concepts that reasonably explained the categories and processes captured in previous stages of analysis.

Subsequently, analysis of the data obtained from the document review was conducted through thematic analysis in an analogous way to the interview data analysis, where the same hybrid coding approach was implemented. However, the deductive codes for document analysis included the descriptive codes aligned with the elements of this study's operational framework, as well as codes previously established through the interview data analysis. Inductive coding was dedicated to process aspects of the data not previously captured during interview analysis.

Thus, as proposed by Bowen,[96] thematic analysis of the document data was used to integrate this source of evidence with the results from interview data analysis. Identified categories were then leveraged to either confirm or refine theory elements previously developed, and to otherwise assess the propositions underlying the theory of institutional processes related to implementation of the change tasks defined within this study's operational framework.[96]

Once the theory was developed from the data, it was compared against the theory of the case study and the operational framework and used to either accept or reject the study propositions and introduce additional elements to the framework as pertinent. This was contrasted against the rival theory that the development of transformative health system

resilience in Liberia happened in a way that is not explained by this case study's theory, and once enough confidence had been achieved on the postulates, conclusions were drawn to answer the research questions.

4. Results

4.1. Key Informant Interviews

Five key informant interviews were conducted with subject matters experts with lived experience in Liberia responding to the EVD or COVID-19 outbreak, or both, from the perspective of the institutions outlined in the previous chapter's descriptions of the case study methodology. Interview data were analysed and coded using a hybrid coding structure that included pre-existing categories from the operational framework's components of the health system, and new codes used to capture emerging ideas and organise them into the framework.

Table 2 below presents a summary of the coding structure used for the initial round of coding.

Table 2. Coding Structure for Qualitative Data Analysis

Coding Structure	
Question # > Descriptive Code (deductive) > Structural Code > Descriptive Code (inductive) > Process Code (inductive) > Text	
Deductive codes	Inductive codes
Descriptive (components of the operational framework): Leadership and Governance, Health Financing, Health Workforce, Health Service Delivery, Health Information Systems, Medical Products and Technologies, Community Trust and Ownership, Interinstitutional Collaboration.	Structural: 40 codes. Descriptive: 47 codes. Process: 10 codes.

The coded data yielded 29 categories that emerged through a second round of analysis focusing on common ideas expressed by respondents and organised under the same categories as the codes, following the components of the health system in this study's operational framework. After considering codes that could not be categorised under the existing components of the framework, a new category was added: Health Infrastructure, for a total of nine categories.

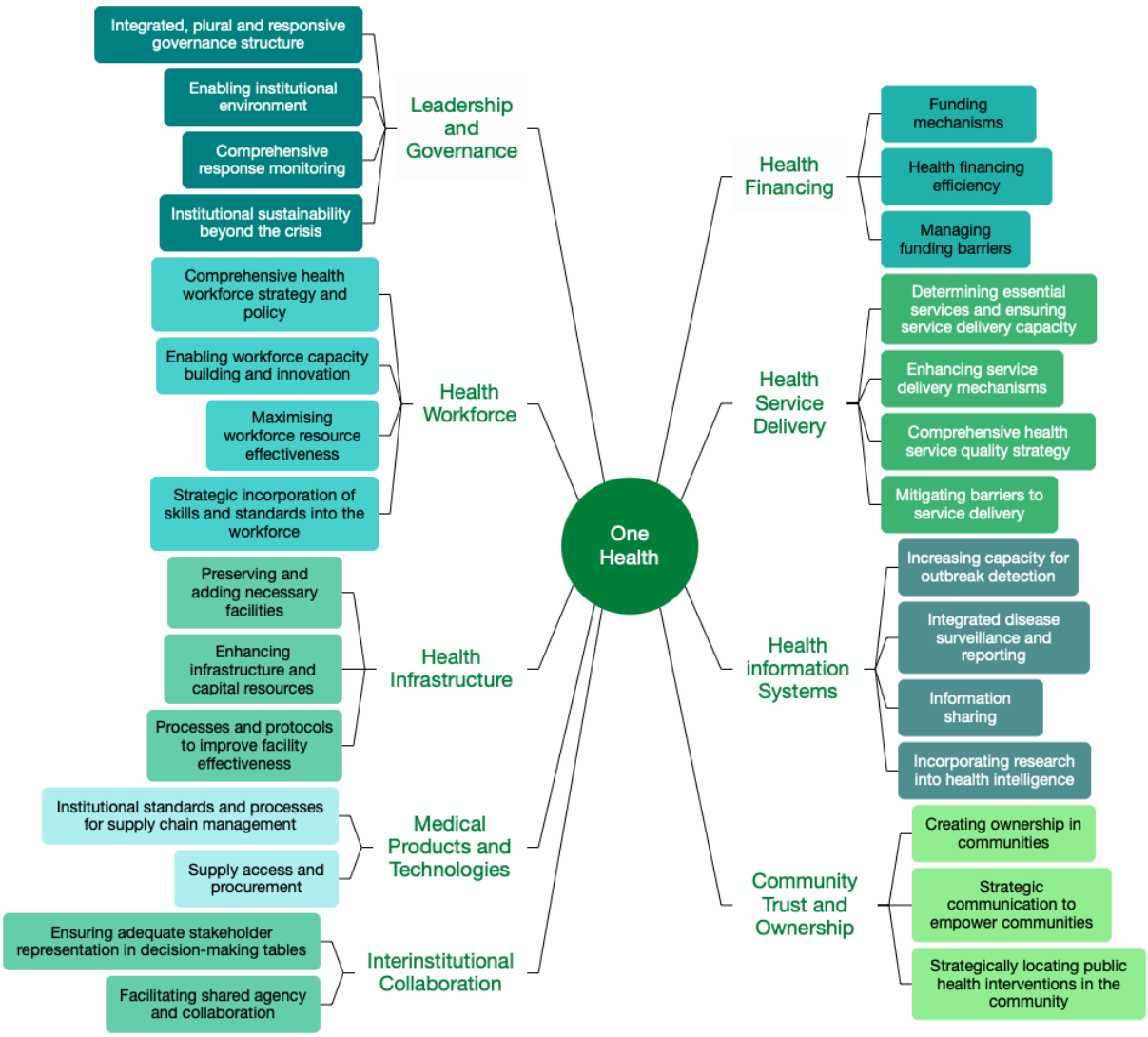

Figure 3: Summary of categories identified through analysis of key informant interviews.

Data analysis revealed that the Liberian health system implemented critical functions to develop resilience after the EVD outbreak that could not be captured under the original

theory and operational framework of the study. Thus, to refine the case study's theory, Health Infrastructure was added as a category of categories and as a component of the health system in a revised version of the study's operational framework.

The findings from each category are discussed below under each component of the framework to provide an organised view into the theoretical and operational ideas that emerged from the key informant interviews. These findings are then related to the case study's research questions to reflect the emerging ideas in the data and refine the study's initial theory.

4.1.1. One Health

One Health emerged as a new category that captures all the functions previously classified as Core Functions and includes additional considerations. Key informant interviews revealed that the One Health approach was adopted in Liberia after the EVD outbreak as the guideline to deploy public health functions and engage with other sectors as partners. As expressed by a respondent from the National Public Health Institute of Liberia (NPHIL):

> We are also including other people from the animal health sector and the environment health sector because we have had this over the years, we have had this one health approach in the country, and we are trying to propagate that.

Insights from respondents involved in public health planning in Liberia shows that the One Health approach is consolidating public health functions such as infection prevention and control; water, sanitation, and hygiene (WASH); and preventive care incorporating the social determinants of health; as well as functions of engagement with animal health authorities for vector control and environmental health authorities for impact assessments and DRM.

The adoption of the One Health approach marks a shift in Liberia's strategic planning for public health and has been embedded into the health system's institutions through a renewed organisational structure which includes, as noted by study participants, a One Health

Platform overseeing Technical Working Groups at the national and subnational level on Epidemiologic Surveillance, Laboratory Capacity, Antimicrobial Resistance, Preparedness and Response, Workforce, Risk Communication and Community Engagement.

Hence, this study finds that the implementation of the One Health approach is a significant transformative change in the Liberian health system's strategic policy after the EVD outbreak which enables the system to undertake DRM and disaster response with a holistic view. As discussed later on this paper, the data signal that this innovation facilitated the Liberian health system's response to the COVID-19 outbreak through improved institutional processes.

4.1.2. Leadership and Governance

The executive function of leadership and governance to develop health system resilience in Liberia was an integral enabler of the health system's response including through policymaking, intervention design and implementation, stakeholder engagement and coordination, development and innovation of institutions, and strategic planning to ensure the sustainability of the health system's transformation in the face of the public health emergencies.

The first category that emerged in this category was the integrated, plural, and representative governance structure implemented by the Liberian government and spearheaded by the president during the EVD outbreak. Study participants highlighted the government's involvement at the highest level as a crucial enabler for effective policymaking and intervention implementation. According to one respondent from a national healthcare delivery organisation:

> I think one key thing that came from the leadership was when the President of the country at the time, Ellen Johnson Sirleaf, decided to insert herself into the response and lead the response on a day-to-day basis. I think it was at that point the country leadership intensified.

Sustainable transformation is shown by the finding that this "hands-on" leadership, consolidated through the command structure centred around the IMS, was leveraged during the EVD outbreak and then again during COVID-19, and became institutionalised through incorporation into the NPHIL, which was created based on lessons learnt from the EVD outbreak and designed to be the country's top public health authority.

When speaking about the IMS, respondents signaled that it succeeded in creating decision-making tables where relevant stakeholders including the Government of Liberia, international NGOs, international donors, and service delivery organisations can come together to develop, review, validate, and endorse plans before making decisions on intervention design and implementation. One respondent from NPHIL expressed: "we definitely worked together with the subnational level to ensure that the incident management system and all of the key pillars that are responsible for [responding to] the outbreak are activated."

Findings indicate that the IMS was supported by the establishment of the Emergency Operations Centre (EOC) to assist in policy and strategy implementation. The analysis indicates that by developing standard operating procedures (SOPs), guidelines, and measures to provide a blueprint for implementation and accountability, the EOCs at the national and subnational levels built their capacity and facilitated operationalisation of the acute response plan and recovery plans with a vision to improve the health system's resilience.

Another category that emerged in the analysis is the health system's efforts to create an enabling institutional environment by developing a rapid response strategy that defined public health emergency management priorities known as the "pillars" of the response, which included the health workforce, health infrastructure, integrated disease surveillance and response (IDSR), management of supplies and diagnostics, quality health service delivery systems, information, research and communication management, sustainable community engagement, leadership and governance capacity, and efficient health financing systems.

A respondent from the Government of Liberia working with the EOC at the national level and local Montserrado County during the EVD and COVID-19 outbreak explained how the reporting and decision-making processes enabled effective action:

> We developed the rapid response plan at the national level, at the county level, then at the district level. These are clear road maps that were drawn out and validated.
>
> I will ensure that I have daily incident management system meetings at the county health team level, have meetings with all of the different pillars and make reports also on a daily basis to the national incident management system and then based on the action points, come back and implement.

Respondents also indicated that during the COVID-19 outbreak, the command structure established during the EVD outbreak, including the IMS, was utilised again. The IMS, initially chaired by the Ministry of Health, was incorporated into NPHIL shortly after the EVD outbreak and given clear mandate and authority. A respondent from NPHIL asserted that this change ensured robust planning and continuity, which was crucial to manage the COVID-19 response.

Thematic analysis also shows that comprehensive response monitoring allowed the Liberian health system to evaluate these transformative changes to support further decision-making. Accordingly, the different levels of EOCs routinely engaged in discussions of key performance indicators associated with the response. A respondent from an international NGO assisting the national responses showcased how monitoring and data were continuously used: "And in fact, there was a daily report of monitoring and report of the number of cases, the number of fatalities, the number of contacts and that was how they were able to do the contact tracing."

A final emerging category was that ensuring the sustainability of the new institutions beyond the public health emergencies was instrumental to the success of transformative change in the system. This was achieved firstly by incorporating the already existing expertise and

structures into the new institutions, such as the NPHIL uniting the surveillance and biomedical research offices and taking charge of the IMS and national EOC.

4.1.3. Health Financing

Health system financing is one of the most complicated components of the Liberian health system given the country's extensive history of underfunding in the aftermath of the armed conflict. Additionally, the continued reliance on donor funding to sustain even routine operations adds a layer of complexity to the financing structures that health system stakeholders need to consider when operationalising public health initiatives.

Respondents stressed that in the context of the public health emergencies considered in this study, the Liberian health system was faced with managing challenges related to insufficient domestic funding and difficulties with securing donor funding in the first stage of the EVD outbreak, significantly reduced donor readiness to commit additional funding during the COVID-19 outbreak due to the pandemic's impact on the global economy, a lack of needs-based resource allocation mechanisms to promote equitable funding for disproportionately affected counties and communities, and reduced ability for non-government partners to sustainably appropriate funds through alternative mechanisms for supplementary funding.

Study data elucidated the category of funding mechanisms for both domestic and donor contributions. Regarding domestic funding, respondents noted the positive evolution funding appropriation and distribution between the EVD and COVID-19 outbreaks, as highlighted by one participant from a national healthcare delivery organisation:

> Now, whatever funding that was coming through from the inception was all domestic funding initially, so they were limited. So, the President had to pull funding from the operational funding, the government had to invest into the health system.

In comparison, during the COVID-19 outbreak the findings show a more robust allocation and distribution approach for government resources that considers DRM and health system resilience, as noted by one participant from the Government of Liberia: “So for COVID, based on the experience we have for the outbreak, I think up to now the government did designate or allocate any budget for emergency preparedness and response.”

However, the findings suggest that this improvement in funding allocation has not yet been made extensive to public institutions that operate autonomously but depend on government funding, such as NPHIL, as one participant noted:

> We haven't had the budget for emergency preparedness and response. So, we are still fighting with lobbying and advocating that the budget for health be improved and increased, but we still have funding gaps in terms of helping us to carry on disease surveillance.

Consequently, this study finds that the progress made on stabilising the domestic funding mechanisms has not been sufficient to alleviate the significant reliance on donor funding that characterises the Liberian health system. A participant from the Government of Liberia highlights this situation:

> So I think we just leverage on some of the funding in the pipelines. We have a lot of support from WHO from US CDC that were all in the pipeline to support Ebola and COVID. We leverage on those international supports and then we had we had we had to bring them in our coordination meeting. So, it was an open meeting and then we were able to take advantage of the support including World Bank.

Although incomplete, the changes implemented to domestic funding structures show that increasing the responsiveness of domestic funding to emerging health needs allows decision makers to make targeted investments during emergencies to address salient issues. The category health financing efficiency captures the ideas emerging around this enhanced performance referring to streamlined revenue allocation procedures refined after the EVD

outbreak and leveraged to improve responsiveness during the COVID-19 outbreak, as observed by a respondent from a national healthcare delivery organisation:

> But in the COVID every single person knew the process. These stops were in place. Everyone knew what to do. And then finally, like I said, Ellen Johnson Sirleaf had continued to maintain stable funding to the health sector. When the IMS was activated the first meeting, the Government of Liberia gave $2,000,000. For the first case of COVID headline. That had never happened in all these cases but it happened because there was a system in place that says who needs to be responsible in case of outbreak.

This finding supports the idea that improved organisation, role clarity and accountability between the government and their stakeholders increased the efficiency with which funding was flowed during the response to the COVID-19 outbreak compared to the EVD response, particularly in the early stages of activation of the IMS.

A mature IMS structure that includes representation of donor partners was found to be a positive transformative change that enabled the increased efficiency mentioned above. Inviting donors to decision-making tables and collaborating on response coordination facilitated engagement and incentivised donors to commit additional funding during the COVID-19 response, as mentioned by a respondent from a national healthcare delivery organisation: “When the government gave the first $2 million other partners and donors in the room thought that OK now the government has demonstrated an interest into this. So, we need to follow.”

4.1.4. Health Workforce

The consensus amongst study participants is that, along with financing, workforce was the area that represented the biggest challenge to the Liberian health system due to the depletion after the conflict and the failure to implement sustainable strategies to improve the supply of health workers before the EVD outbreak. When the epidemic hit, poor accreditation and licensing

standards meant weak regulation for the few health workers available, and the workforce model failed to produce a fit-for-purpose workforce and ensuring performance and accountability.

Compounding these challenges, the EVD outbreak disproportionately impacted health workers due to inefficient IPC protocols, lack of proper PPE, and inadequate clinical management guidelines for patients with EVD. In turn, this generated fear amongst health workers leading to service shutdowns and, in cases, entire health facilities being left without providers.

The first category that emerged, related to addressing the initial deficiencies, was maximising resource effectiveness through policies that leveraged existing resources. Liberia implemented workforce needs assessments and streamlined recruitment for priority positions as well as just-in-time training with the little training capacity available.

Targeted recruitment in Liberia drew heavily from existing resources in the communities and, in this sense, the governance structure of the EOCs became the hierarchy to incorporate new health workers, as local recruitment was found to be more efficient than hiring and retaining workers at the central level. A respondent from NPHIL stated:

> Based on the need, we try to recruit people and train them and then be able to send them to those posts they will be very efficient in. So, all those things are embedded within our strategy. And by that we can also recruit and train the field epidemiologists, you know, and then also then we are taking the consideration of one health approach.

This study's findings indicate that, while both outbreaks necessitated targeted recruitment and training, the COVID-19 response saw more systematic implementation of workforce policies developed during the EVD outbreak. The use of community resources was effective in both contexts, though COVID-19 allowed for further refinement and integration of these strategies.

A central category identified was the development and implementation of a comprehensive health workforce policy and strategy, which enabled improvement of the workforce governance through standardised recruitment processes at the national government level and creation of a health workforce information system. Indeed, one of the major innovations implemented in Liberia after the EVD outbreak was the establishment of a national set of databases to track the supply of health workers at the national and subnational levels.

When discussing this innovation, a respondent from NPHIL highlighted: “So that's the idea that we have a database of the healthcare workforce in Liberia.”

The study’s data consistently points to innovation in the Liberian health workforce through the introduction of new cadres of health workers to sustainably fill critical gaps. This is aligned with producing a fit-for-purpose workforce, which was a commonly referenced objective of the workforce strategy and policy. The Liberian health system trained and deployed several innovative categories of health workers during and after the EVD outbreak, which have become an established part of the workforce and facilitated the response to the COVID-19 outbreak. A respondent from an international NGO providing training support detailed this:

> So, at the national level or at the county level or at the district level they have surveillance officers, they also have environmental health officers. Then you also have community health workers and the county surveillance officer from the health side, so at the national level similar structure exists.

Another important finding in this category was the implementation of a Field Epidemiologist Training Program (FETP), initially through bilateral collaborations with international partners during the EVD outbreak and eventually institutionalised in the Liberian health system by incorporating the program into NPHIL, as expressed by a respondent from the institution:

> We see that with the FETP program, like the Field Epidemiologist Training Program that was initiated and sponsored by the US CDC. Now as a country we are trying to transition. So now we've come up with the transitional strategy on ensuring that the FETP program is housed within the National Public Health Institute of Liberia.

Analysis of responses about the workforce environment showed a category of enabling workforce capacity building and innovation, which participants related to creating strong institutional supports for health workers as well as effective management. A respondent from a national healthcare service delivery organisation directly involved in workforce management highlighted the innovations after the EVD outbreak:

> So, for example, we had IPC for infection prevention, control, focal people helping us in each facility. So, the individuals that are there now were never there before Ebola, but now they are there, and they are responsible for identifying diseases of epidemic potential and be able to report it in real time so that people could respond.
>
> And then having a responsive team also letting them know that OK, you are not alone. You may be 1,000 kilometres away from the country capital, but you are not alone, this is a number that you can call that is 11 kilometres away from you and that person who is 1 kilometre away from you who can connect you with another person. They keep reminding them that there exists a chain where people are monitoring you and willing to help you once you have a situation.

Study participants, especially non-governmental stakeholders, highlighted that addition of workers was supported through regulatory improvements, which the data analysis identified in the category of strategically incorporating skills and standards into the workforce. This study finds that the Government of Liberia collaborated with their international partners to enhance their professional qualification standards and regulations, along with skills matrices for health workers. A respondent from the WHO described this process of innovation:

> So those professional guidelines were validated, they were launched, but now every professional body like the nursing board, the physician assistant board, medical and dental association, those different professional bodies, or associations need now to actually

> develop what we call a curriculum. So, what we have been encouraging them to do is in the meantime while you are thinking about having a curriculum development program you can also use the Integrated Health Service training modules. So that is now open in the WHO. Then you can also task the professional bodies to look at it.

The Ministry of Health and non-government multilateral partners sponsored training programs that would most significantly enhance the system's preparedness and response capacity, including IPC. A respondent from the NPHIL explained that "our strategy is working towards how can we train short term, intermediate and long term. […] but the long term we usually collaborate with other universities and send these people to go out and train through PhD and then come back and serve the country in that capacity."

Finally, this study finds that continuing medical education and professional development were crucial elements in ensuring the new cadres of health workers could remain abreast of the nature and influence of the public health emergencies. Participants consistently pointed to the importance of close collaboration in defining training priorities and securing professional development opportunities. When speaking on this, a respondent from the WHO pointed out:

> One of the things we also discovered during the project's situation analysis was the need for continuing professional development and continuing medical education, which is very important. Also, develop continuing education program or CPD.

A participant from NPHIL elaborated on the training programs collaboratively implemented for the Liberian health workforce:

> That's what we're doing now, the training of the frontier program. We have IPC fellows, public health, emergency management fellows who were trained also with the help of CDC in Atlanta, Georgia in the US so we have them here. So, as I speak to you next week, we'll be rolling out the first term training program.

> So again, with the help of other programs like the medical school, we now have one medical school in Liberia. Doctors are being trained. And then when they are trained, we also offer because they are trained to treat patients, sometimes they are not trained to provide this public health care, so we also incorporate some of them.

4.1.5. Health Service Delivery

Given the fragmented nature of the Liberian health system at the time of the EVD outbreak, health service delivery was initially characterised by insufficient coordination, limited scopes, and lack of guidelines and procedures to support service delivery. In consequence, there was widespread duplication of efforts with inefficient output, as well as negative feedback loops where the toll of the EVD outbreak led to reduced utilisation of health services due to mistrust, in turn leading to facility closures, which then drove up out of pocket expenditures.

Considering these challenges, respondents frequently referred to strategies to improve service delivery capacity during the EVD outbreak, captured under the category of mitigating barriers to service delivery. According to a respondent from an international NGO working in service delivery, these strategies were not effective during the early stages of the EVD outbreak: “Attempts were made to increase availability, but it was not, it did not happen in my experience until we were at the point where there was a significant decline in the transmission of the virus.”

Another idea identified by respondents in this category was the need for service continuity during the public health emergencies, as noted by a respondent from the WHO:

> We continue to emphasize the need for having surge capacity, health service continuity planning guidelines, developments and also it's already developed, but making sure that people actually appreciate it and how to really put it into use during outbreaks, so that phase needs to be really supported.

Results show that the bedrock for improvement in service delivery was determining essential services to be prioritised. In this sense, the Liberian Ministry of Health defined an

Essential Package of Health Services (EPHS) centred around primary care to provide a minimum standard of care for facilities to implement.[100] Beyond routine services, respondents also noted maternal and newborn care and malaria treatment as areas that had to be prioritised, as identified in the literature during the EVD outbreak[101] and noted by a participant from an international service delivery NGO:

> During the outbreak, maternal and child health was considered as essential. Malaria care is also essential in Liberia because malaria is another major cause of mobility and mortality so care for people who had diagnosis and treatment of malaria was an essential component.

Data from a respondent from the WHO adds to this characterisation:

> During outbreak routine healthcare services like for example vaccination, maternal HR, healthcare, and all of those, even like NCD, ones you know. So, some of those services will easily collapse because all of the partners' focus was on the outbreak preparedness.

A key finding contained in the category of a comprehensive health service quality strategy is that service continuity planning embedded into the regular operations of government stakeholders and effectively communicated to service delivery partners was the fundamental enabler for preserving the identified essential services. A respondent from the WHO stressed that: "We are actively involved in health care service continuity planning and making [stakeholders] appreciate the role of continuity in health care quality."

This study finds evidence of this health service continuity planning in Liberia after the EVD outbreak in how the Liberian Ministry of Health instituted a Healthcare Quality Management Unit tasked with establishing guidelines and procedures for continuity planning and surge capacity, as well as disseminating these across the system. A respondent from the WHO summarised this institutional transformation:

> In 2016, the ministry established what they called Healthcare Quality Management Unit considering that quality is a rudiment of healthcare. So have your Quality Management Unit and the project was to work along with that unit to see that they are actively involved in health services continuity planning and making them appreciate the rules of quality.

Another category that stands out from the results is targeted strategies for enhancing the service delivery mechanisms. Findings reveal that the Liberian health system developed standard triage procedures and referral pathways to ensure the integration of new or enhanced services into the existing structures. As noted by a respondent from a national healthcare delivery organisation:

> We were able to develop technical guidelines, we train our healthcare workers, you know, and then we also secure some emergency treasure items like drugs, PPE, and preposition them in counties. Now, vulnerability mapping strategy of these priority diseases, where they are mostly endemic, we preposition those emergency treasure item drops or commodities or PPE to those areas.

Further, this study's results support the finding that these service enhancement strategies implemented after the EVD outbreak increased the Liberian health system's preparedness for and responsiveness to the COVID-19 outbreak. The same respondent cited above highlights this finding in the following way:

> So like for COVID was a bit different. So with those trainings that we provided and with the experience we were able to avoid completely shutting down our routine care because our healthcare workers were trained especially when we started to see the pandemic was in other countries. For our preparedness, we started to train people in case management, risk communication and IPC for COVID in the length and breadth of Liberia.

4.1.6. Health Infrastructure

Like with other elements of the health system, infrastructure was in a very fragile state in Liberia when the EVD outbreak erupted. Not only was facility density low, but essential facility features like water, power and sanitation, waste disposal and management structures, triage

spaces, and isolation units were not available or not properly functional. As a result, initial response efforts required a strong focus on capital assets, which delayed other operations.

This study identifies a category of preserving and adding necessary facilities as the first emerging finding in this category. As mentioned previously on this paper and highlighted by respondents, during the EVD outbreak, the Liberian health system repurposed existing facilities for triage and isolation, and eventually established ETUs to consolidate the clinical activities for public health emergency management. A respondent from an international NGO with local presence noted: "Temporary service centres were established so that people had some place to go, and also in addition to that we were able to have for example isolation units."

Participants' responses also elucidated that the Liberian health system gained the situational awareness to repurpose existing infrastructure and create ad-hoc facilities by leveraging the decentralised command structure of the EVD response to obtain and distribute information. As noted by a participant from an international health service delivery NGO:

> The national health system tried to establish a national network and distribute public messages using the radio, and also through the district health workforce they will inform the communities of where services were available. That's when the community health volunteers really came in handy because they were closer to the communities and they could take the information as to where those services were available and encourage people to take advantage of those facilities.

Further categories identified in this component are detailed later in this section when presenting the findings from the key documents review.

4.1.7. Health Information Systems

Data analysis in this category promptly yielded the category of integrated disease surveillance and reporting, which is reflective of the strategic activities undertaken as one of the pillars of the Liberian health system's public health emergency response. In this area, respondents first

referred to capacity building in the Government of Liberia by developing disease surveillance and reporting standards with assistance from non-governmental stakeholders.

When asked about capacity-building activities implemented to this end, a respondent from an international NGO with local presence in health service delivery explained that: “There were international epidemiologists who came in to assist. So, they worked with the Liberians to develop their capacity by developing standard operating procedures for the various activities that needed to be done.”

Findings highlight that the introduction of standard operating procedures (SOPs) enabled the Liberian Ministry of Health to operationalise the IDSR strategy that was developed after the EVD outbreak for determination of target pathogens for epidemiological surveillance, standard case definitions and reporting guidelines. A respondent from NPHIL explains the developments in this area:

> As a country we've all already catalogued some priority diseases of public health importance, so they have simplified case definitions to be able to detect those public health threats and report it to the next level. Like I said, we already backed them up, so our community healthcare workers do that on a routine basis. So information is well disseminated from the community level to the district, to the county, up to the national level.

Data analysis also shows that the Liberian health system implemented initiatives to enhance the laboratory capacity to accurately identify cases of infectious diseases, captured under the category of increasing capacity for outbreak detention. As noted by participants, before the EVD outbreak, Liberia was naïve to the virus, which coupled with the unspecific symptoms of EVD’s prodromic stage that mimic illnesses like malaria, created a lag between the onset and the detection of the outbreak.

A respondent from an international NGO delivering services on the ground in Liberia highlighted this critical lag:

> And you never knew because also the symptoms of Ebola that start at the beginning of the illness, the symptoms were very similar to malaria. So you never knew if somebody had malaria and they say I had malaria when it wasn't really malaria and they were exhibiting symptoms of Ebola.

As shown by the interview results, in the recovery stages after the EVD outbreak, Liberia implemented a strategy to decentralise the public health laboratory capacity to counties and districts where feasible and establish specimen transportation pipelines for facilities that could not have access to public health laboratories. This was coupled with case detection and reporting protocols for health workers at the national, county, district, and community levels.

By the time of the COVID-19 outbreak, Liberia had implemented several improvements based on the EVD outbreak experiences. The decentralization of laboratory capacities to counties and districts and the establishment of specimen transportation pipelines became critical components of the health system's response. Evidence for this can be seen noted by a respondent from NPHIL: "That's what we are doing right now. So we have these disease leads that keep watch from the national level, straight down to the sub national level and they provide information on these diseases."

A major example of transformative change identified in these findings is the implementation of the "7-1-7" framework, developed during the recovery phase post-EVD by the NPHIL, which enabled the system to quickly detect, confirm, and respond to potential infectious diseases within 72 hours. This framework was instrumental in managing COVID-19, as it streamlined outbreak detection and response processes, as stressed by the participant from NPHIL:

> As I tell you that we are able within 72 hours to detect and respond to an outbreak, we have the capacity and that is backed by also the national reference lab where we have the national director who is in control of the investigation of any detectable or susceptible outbreak. When we get that result, then we can also use the bad directional flow of information to tell

> our country health serving officers that a suspected case was confirmed to be positive and then they can be able to mount a robust response strategy.

A bidirectional flow of information was found to be an enabling factor for the effectiveness of health information systems in Liberia during both outbreaks. The category of information sharing incorporates this notion and captures functions of knowledge dissemination and stakeholder communication identified in the data.

In this regard, respondents observed that this capacity did not exist before the EVD outbreak and became fully realised and implemented during the COVID-19 response. One participant from an international service delivery NGO reflected on this development during their involvement with the EVD outbreak response:

> But with the time as time went on, that capacity was built and there were reports generated data generated from the community to the health facility that was then delivered to the to the Ministry of Health in real time. So that every day we had an update of what had happened the previous 24 hours.

The reports mentioned above are identified in this study's findings as part of a twofold category of information dissemination products that the Liberian health system implemented: a public facing list of messages and epidemiological updates and a set of update reports with a different scope and focus that was disseminated to stakeholders involved in the response. A participant from NPHIL elaborates on this finding by explaining the types of products used:

> We prepare situational reports to disseminate to the wider public. We also provide because we are obliged by the International Health Regulations to provide, based on the IDSR, the Integral disease surveillance and response strategy that all countries in Africa have adopted we provide the WHO the necessary information on a monthly basis. So internally we have our internal mechanism and externally we also provide this information externally to our partners.
>
> And then we also have a weekly bulletin review meeting that we have every Friday we'll have stakeholders coming. So all of the stakeholders in the health sector as it relates to epidemic prone diseases. We have that bulletin review meeting where we present

> epidemiological projecting on all of the prior diseases that we're keeping surveillance on in the country. We used these to disseminate this information to stakeholders.

A prominent category found in the data, but that was interestingly not as widely discussed in the published literature, was using research to inform decision-making. Respondents noted that aside from ensuring updated clinical guidelines and best practices, locally driven research can play a role in identifying unique opportunities for policy development and system innovation. As expressed by a respondent from a national healthcare service delivery organisation:

> It's critical because there are a lot of lessons that this country has a lot of rich data, but can only be gathered through research. I know you say that it is a part of the health information system, yes. But I think it's a critical component that needs to be reflected in the system model.

Fostering a robust national research infrastructure requires innovations in the governance and regulations of research activities, along with access to adequate funding streams. This study finds that in the post-EVD period, the NPHIL established a national research agenda and a registry to track its research affiliates, introduced SOPs for research protocol development and implementation, and established a mechanism for tracking health research funding allocation and expenditures to cohesively promote research efforts.

However, the data suggest that further investments are still needed to ensure research is locally owned and the lessons obtained are provided back to the system to inform policymaking and intervention design, benefitting the local context where the research is produced. This was stressed by a respondent from a national healthcare service delivery organisation:

> There's not a lot of investment into research in most of our information generated. Currently key people are not really investing into communicating results, even if the

> research is done. For example, if you go on the Ministry of Health website, you won't see anything. You go into most of our websites, you won't see anything.

4.1.8. Medical Products and Technologies

The capacity to sustainably acquire, store, and manage crucial resources to carry out the health system's activities is as much a function of the system as the resources themselves are its assets. During public health emergencies, resource availability in low-and-middle income countries is typically jeopardised, as evidenced during the COVID-19 pandemic.[102] Accordingly, the findings reveal a category of institutional standards and processes for supply chain management through legislation, policy, and regulation.

The results suggest that the complex and disorganised supply chain management processes that were in effect during the EVD outbreak encouraged agents of the health system to develop and implement their own processes. A respondent from the WHO detailed how they supported local health facilities in assessing their supply chain capacities and logistics management during the EVD outbreak to improve their responsiveness to the surge in health needs:

> The level to which we took resilience to make it more practical, we at a facility level, if you have your stock, is your inventory management system really working? Are you conducting inventory on a routine basis because you already have the structure and telling you at the facility level you have hospital pharmacies adequately stocked?

Data analysis shows that one of the most salient consequences of the lack of standardised supply chain management processes, especially in the early stages of the EVD outbreak, was disorganised resource distribution. A respondent from an international NGO with local presence recalled the challenges faced when trying to manage resources:

> So getting the drugs and supplies to the health facilities took a while. It depended on the information they had, the data that they had on hand, the data in terms of number of patients, number of contacts and the stages of the contacts.

This relates to an additional observation made by study participants that, when managing what resources were available, the enabler to ensure effectiveness in distribution was conducting needs-based resource allocation to guarantee supplies were being used where they could have the most significant positive impact. A respondent from a national healthcare service delivery organisation described how they strategically determined supply distribution: "Now, vulnerability mapping strategy of these priority diseases, where they are mostly endemic, we preposition those emergency treasure item drops or commodities or PPE to those areas."

4.1.9. Community Trust and Ownership

The initiatives led by the Liberian health system to increase community member buy-in and rebuild trust in the system's institutions and services are arguably the most highlighted element in the country's response to the EVD outbreak in the published literature, and also one of the most innovative developments from a systems thinking perspective.

The cumulative effect of the health system's weaknesses leading up to the EVD outbreak was the loss of community and individual trust. Patients refused to seek health care services due to mistrust in the system's capacity to adequately respond, the safety of health facilities and workers, and disinformation on the authorities' agency and motivations regarding the outbreak response. As a result, patients moved away from the health system and into alternative forms of treatment, which drove up out-of-pocket health expenditure, further undermined the health care institutions' capacities and resources, and weakened service oversight for safety and efficiency.

The first category that emerged from the data in this category is strategic communication to empower communities, which encompasses the Liberian health system actors' efforts to mobilise key messages to convince communities of the safety, quality, appropriateness, and equity of health services and facilities, as well as building trust in the health interventions being deployed as part of the response to both outbreaks, but particularly EVD when misinformation and mistrust ran rampant. A respondent from NPHIL spoke about the communication strategy that was designed during and after the EVD outbreak:

> We have to engage our communication strategy where we are our risk communicators are going into the community, we use the community structure where in the leadership, in the community local leadership, the imams, the religious leaders, the youth groups, the women groups. You know, and the other stakeholders, we brought them on the table, we were able to at least create the risk communication messages.

This shows that along with designing key messages to address the identified issue of mistrust, the Liberian health system also disseminated these messages through structures and hierarchies that were meaningful to the target community rather than implementing central information channels on a one-size-fits-all basis.

Participants also noted that success in strategic communication was driven in part by delivering the messages in culturally appropriate and significant ways that considered the communities' value systems and appealed to the relevant issues for their context.

Messages were designed in English as well as relevant local languages and were graded for education level and literacy. They were incorporated into a variety of communication products including posters, oral announcements, drama, door-to-door information sessions, jingles, advertisements, as well as technical briefs like epidemiological bulletins, situational reports, public statements and recommendations from government and non-government stakeholders.

A respondent from an international NGO providing education initiatives noted that:

> So there were messages within the local languages. Messages at the more higher level for the more educated. So there were people who were in the position or who were there working in that area of the community and could spread messages on infection control trying to interrupt the transmission.

Another respondent from a national healthcare service delivery organisation explained the vehicles chosen to disseminate the messages and the intended impact:

> They also made sure that messaging was critical, so as part of what we call SBCC, social behaviour change communication. So those messages were communicated in, in local languages, in vernaculars, on posters, through drama. So those messages were continuously communicated so that they resonated with everyone in a form part of people's daily lives.

This study finds that the Liberian health system used the decentralised structure of the EOCs for risk communication and community engagement at the national and county levels and enlisted the help of CHWs in an approach summarised by a participant from a national service delivery organisation: “So every community has a committee called the Community Health Development Committee that is led by the town. So, at the health facility, we have the Health Facility Development Council [which] is made out of all the Health Community Committee leaders, so information is discussed, and feedback is given to the community.”

Along with strategic communication, the findings identify a category of strategically locating public health interventions in the community. Results show that the Liberian health system empowered the CHWs, who worked and lived in the communities, to identify community health needs, engage in social and behaviour change communication, implement direct public health interventions and increase access to facility-based care.

A respondent from a health service delivery organisation reflected on this: “Especially for interventions like community-based event surveillance, the communities and individuals

would not accept the guidelines that were coming from the government… so we worked with the [CHWs] to help reduce the curve."

This was further stressed by the same organisation when describing how they worked with CHWs to increase uptake of public health interventions and clinical services during the COVID-19 outbreak with lessons learnt from the EVD period:

> So [organisation] through community health workers in communities where people trusted them, worked with these community health workers to help and reduce the curve. So those systems were already in place. [Organisation] already had community health systems in place for disease surveillance but most importantly, we have citizens who already knew about the impact of the Ebola virus disease and what it caused to them. So that once they heard that [COVID-19] is a disease that killed people, they're ready to help the national government to respond.

Another crucial finding for the sustainability of these interventions is captured in the category of creating ownership in communities. This study finds this was achieved by identifying key community leaders with traditional legitimacy such as religious leaders, town chiefs, matriarchs, local celebrities, or influential individuals such as athletes, community members with specialised knowledge,[103] and other individuals who could marshal the attention of their neighbourhoods and communities.

A respondent from a national healthcare delivery organisation discussed this observation:

> We recognized that religious groups were very important and we started going to these groups and these leaders and engaging with religious community. This was critical because our society is purely religious.
>
> The second group of people, the community pillars started to utilize was influencers. So you have these musicians, you had these movie stars, you have these football players so we started to work with influencers and these influencers made a lot of impact.
>
> The third group of people we started work with was the marketeers. So how these market associations and majority of the women who are associated with market like particulars.

> So once we started to work with these youth groups, market women and these subgroups in the communities, that also was very, very effective.

The crucial benefit of this approach to create local ownership of the messaging and interventions was further elaborated by a participant from NPHIL who explained:

> So we use these loops to communicate these messages rather than we communicating because if [the government] is communicating the message people reject it, but if it's coming from one of their own, from the priest, from the imam, when it's coming from a football player that you play with, or is coming from a musician that is in the community, or it's coming from a community health worker that lives and works with you, then you believe it.

This approach proved transformative for the system, as these structures were maintained and further developed after the EVD outbreak and included into the system's formal planning, which allowed health authorities to leverage the existing structures during the COVID-19 outbreak to guarantee the uptake of interventions such as physical distancing and hand washing and immunisation and identify disproportionately affected sectors.

4.1.10. Interinstitutional Collaboration

Given the interconnected nature of global health issues, and especially considering the complex structure of the Liberian health system, ensuring strong interinstitutional collaboration is paramount to initiating and sustaining transformative change.[104] This cuts across the national and subnational governments including the ministries, and all 15 county authorities. Additionally, bilateral collaboration with agencies from other governments was, and continues to be, a crucial enabler for the Liberian health system's operations.

The study results highlight a category of ensuring adequate stakeholder representation in decision-making tables. Data from the participants' responses indicate that the Liberian

health system succeeded in incorporating such a wide range of stakeholders by using the governance structures of the IMS to map and involve stakeholders in decision-making tables.

A respondent from a national healthcare service delivery organisation described this complex structure by summarising the executive spaces in which discussion happened during the EVD and COVID-19 outbreak responses:

> So we have that at both levels national subnational levels. At the national level we have a lot of coordination meetings that happen. And these meetings are intended to bring together stakeholders to review and discuss issues affecting the sector. And also share lesson learned from what they are doing across the country. We also have quarterly review meetings and annual review meetings. These meetings are intended to be used as a platform where data is being shared and then people review the data and have conversations on what are the reasons behind the numbers.

Further, the same participant described how this stakeholder integration strategy impacted decision-making for the various institutions represented in the technical meetings in the IMS during the COVID-19 outbreak response:

> So we have technical working group meetings, we have coordination meetings, we have capacity building meetings, we have technical review meetings. So there are a lot of meetings that have been held. There are a lot of areas where data have been shared and decisions have been made. All key action points are derived and actual decisions are taken so that people make follow-up decisions on how to address them.

Finally, the second critical category identified in this component is facilitating shared agency and collaboration. This was noted by study participants as the solution for aligning the various actors' mandates and objectives and ensuring compatibility amongst their leadership structures and their participation in the IMS. A respondent from an international NGO offering health programming during the EVD outbreak noted the need for this approach:

> But we know that health is not just confined into the Ministry of Health. So there were efforts made to bring together the various sectors and partners. We are related institutions,

> the NGOs where they had NGOs basically come under the umbrella of the Minister of Health. So there is already that relationship and collaboration. There was effort made through the Minister. The president was very involved. She was very engaged in the whole process. She really led the process of the interruption of the Ebola transmission fight.

This finding shows that providing unified leadership allowed the Liberian government to harmonise the stakeholders' agendas and coordinate discussions, decisions, and feedback during the EVD response. As the structures matured, Liberia's government institutionalised stakeholder integration by formally incorporating the IMS into NPHIL, an approach which, as evidenced during the response to the COVID-19 outbreak, has been sustainably embedded into the health system's institutions and processes.

4.2. Key Document Reviews

Two program documents related to the Liberian Ministry of Health's policies and strategies for health system resilience were selected for thematic analysis, the Investment Plan for Building a Resilient Health System in Liberia (the "Investment Plan"), and the National Public Health Institute of Liberia 2023-2028 Strategic Plan (the "NPHIL Strategic Plan").

Thematic analysis was conducted through a first round of deductive coding that used the same coding structure established for the analysis of the key informant interviews, to allow for direct comparisons of the data in terms of what new ideas they added to the existing results.

After an initial round of coding, the data were organised into the 29 categories outlined in section 4.1 above, and then deductively coded once again with structural codes that matched the case study's research questions to determine how the data as a whole provided answers to the inquiries and fulfilled the study's objectives.

The results from key document reviews are discussed below detailing what new ideas were gleaned from these data and how they added to the study's theory and propositions.

4.2.1. Leadership and Governance

Results from analysis of the Investment Plan show that, after the EVD outbreak, the Liberian government made strategic decisions to maintain the decentralised governance structure applied in the IMS and EOCs during the outbreak aligned with the category of an integrated, plural and responsive governance structure, as evidenced by the following key objective outlined in the document: "Make operational the governance and monitoring systems and structures at community, health facility, district, county and national levels that ensure citizen participation and involvement in health."

This strategic direction was further elaborated in the Investment Plan through the following objective to guarantee the sustainability of the transformative change in the disaster response governance structure: "Establish and ensure functionality of sector coordination mechanisms at community, health facility, district and county levels, in line with the experiences from the HSCC."

4.2.2. Health Financing

Regarding domestic funding, institutionalising planning and budgeting through yearly reviews emerged as an enabler to forecast and advocate for funding ahead of appropriation cycles. In turn, having an actionable financial plan and budget allowed the Liberian health system to reallocate funds from other pools into the public health emergency during the EVD outbreak to fund initial response tasks. The Investment Plan refers to this strategic direction:

> Strengthen systems and capacities for planning and budgeting as well as financial accountability, to ensure that the resources made available are used for their intended purposes, as and when needed. This would involve need based recruitment to strengthen and improve the skills of financial management teams at national, county, district and hospital levels.

In both outbreaks, ensuring the sustainability of donor funding was critical for transformative institutional change. In this sense, the system built continued donor interest by creating shared accountability from the national, county, district, and health facility levels to their funding partners. The Investment Plan notes that "many partners now supporting the response are also able and willing to stay longer to support transition, recovery and rebuilding."

4.2.3. Health Workforce

Results from these data stressed that it is necessary to improve the health system's capacity for workforce planning through the design of accreditation standards and scope of practice definitions. In Liberia, this change was introduced in the system by decentralising the regulatory functions to professional bodies and reducing the dependency on the Ministry of Health. The Investment Plan highlighted this objective: "Constructing a regulatory campus (one-time capital investment with sustainable revenue-generation potential) for all regulatory bodies to strengthen and decentralize regulatory systems, reduce dependency on government transfers, reduce long-term rental costs to improve quality, ethics and safety of healthcare."

In addition to regulation, the findings show that planning and tracking was also a strategic objective for innovation after the EVD outbreak, as detailed in the Investment Plan: "Strengthening and reforming the [Ministry of Health] Human Resources for Health structure and health worker information system. Institutionalizing capacity for evidence-driven health workforce planning and establish a national health workforce account."

4.2.4. Health Service Delivery

Results indicate that institutional changes in the Liberian health system after EVD was marked by policy instruments to bolster triage and referral procedures at the national and subnational levels, including by transitioning response-related resources (paramedicine, safe disposal,

dedicated laboratory capacity, psychosocial services, and clinical monitoring) into the system with support from health service delivery partners.

The Investment Plan provides direction on this: "In the transition phase, the sector focus shall shift towards ensuring effectiveness of care and patient-centeredness of services, in line with the EPHS, to rebuild the trust with communities." This included transition of emergency response services, laboratory capacity, safe burial services and psychosocial supports from ad-hoc service delivery points to sustainable institutions in the health system.

Study findings in this component indicate that the institutional changes in service delivery were made sustainable when supported with overarching policies that account for ordinary and extraordinary mechanism to ensure health service continuity, which spans funding, logistics, resource reallocation and reduction of administrative barriers. This study finds evidence of this transformative change in Liberia with the design of multi-hazard contingency plans under a One Health Emergency Preparedness and Response Technical Working Group with the scope to strengthen EOC capacities and procedures at the national, county, district, and health facility levels.

The NPHIL Strategic Plan described this strategic direction and the institutional innovations that were enabled by this capacity after the COVID-19 outbreak:

> With a robust surge capacity now existing, the plan is to upgrade this to a multi-hazard national public health emergency preparedness and response teams around the country to respond to all epidemic-prone diseases (e.g., dengue fever). A multi-hazard contingency plan is available, the One Health emergency preparedness and response technical working group is functional, and the One Health Rapid Response Team (RRT) training package developed and validated.

4.2.5. Health Infrastructure

Within the identified category of processes and protocols to increase facility effectiveness In Liberia, the process of operationalising resilience in the health infrastructure involved an

arduous post-EVD recovery stage before enhancement could take place, which was underpinned by the implementation of IPC policies and triage standards at health facilities to ensure the safety of staff and patients, as outlined in the Investment Plan:

> In the health system restoration and recovery period, the overall focus shall be to restore and enhance service delivery systems to ensure quality of care for clients and a safe working environment for health staff. We will undertake a comprehensive initiative to improve quality of care in all its six dimensions (safety, effectiveness, timeliness, efficiency, equity and patient-centeredness).

Analysis of the Investment Plan reveals that this strategic direction prioritised the functions of IPC standard setting, triage protocols design, implementation of initiatives for facility hygiene and sanitation, and quality assurance and improvement.

The Investment Plan prioritised the remodelling of existing facilities to ensure compliance with the standards and regulations. To operationalise this, a quality assurance and improvement framework for health facilities was implemented to highlight deficiencies and make targeted investments for improvement in water and sanitation, isolation spaces, and triage units.

Results indicate that the Liberian government undertook initiatives to sustainably expand service offering, captured in the category of enhancing infrastructure and capital resources. Data analysis highlights the function of incorporating new facilities or the procedures to activate the renovation of existing facilities, into the system's routine functioning.

This study finds evidence of this approach in Liberia when ad-hoc units were integrated into health facilities after ETUs were shut down, and this capacity was leveraged to establish triage and isolation units during the COVID-19 outbreak. The Investment Plan for a Resilient Health System outlined this: "The infrastructure priorities will focus on updating the norms for

infrastructure, equipment and transport… decommissioning the ETUs and [Community Care Centres] and repositioning the existing WASH and other resources into health facilities."

A category that emerged in this component exclusively from the key document reviews was processes and protocols to improve facility effectiveness. This study finds that the Investment Plan established facility enhancement, both in infrastructure and processes, as a priority for developing resilience. This is evidenced in the following strategic directions contained in the Investment Plan:

> Improve the functionality in all existing facilities by remodelling them to ensure they have the required infrastructure to ensure better functionality and compliance with government standards and norms.
>
> Improve the readiness of existing facilities to provide services, by ensuring adequate, safe and sustainable water and backup power supplies exist.
>
> Put in place robust management and maintenance systems for facilities, fleet and equipment and strengthen referral/transport network.
>
> Strengthen QA system to support and monitor adherence to clinical protocols for priority health conditions (e.g. malaria, pneumonia, labour and delivery management, care of the sick newborn, etc.).

The results also indicate that the Liberian government developed sustainability of these infrastructure enhancements by introducing policy instruments that incorporated these transformative changes into facility standards. The Investment Plan details this when discussing future steps after the EVD outbreak:

> Revision and implementation of infrastructure policy and standards including triage and isolation units.
>
> Reopen all closed health facilities by redeployment of existing staff and ensure adherence to IPC standards and triage protocols.
>
> Build capacity for districts and counties in management of corpses; this includes improving availability and quality of morgue services (public and private), strengthened surveillance

for causes of death, and strengthening the regulatory framework around corpse management.

4.2.6. Health Information Systems

This study finds that after the EVD outbreak, the NPHIL was mandated to incorporate the IDSR strategy into executive agencies to roll out comprehensive surveillance planning and activities at the national, county, district, and health facility levels. Additionally, the system developed an Early Warning and Alert Network to implement SOPs on epidemiologic notification.

This was initially supported by international partners and later institutionalised by bringing those functions into the NPHIL, which created policies to enact comprehensive data reporting, preparedness, and action frameworks at the national and subnational levels. The NPHIL highlights this collaborative, decentralised approach when discussing previous policy:

> Liberia and its partners have made significant investments to build a decentralized public health surveillance system to robustly detect, diagnose, and report on any human disease or public health threat. On the policy side, several guidelines and standard operating procedures were updated or developed, including the third edition of the IDSR Technical Guidelines, the CEBS Guide, SOPs for monkeypox, meningitis, measles, AFP, human rabies, and contingency plans for Lassa, Cholera, EVD, etc.

However, this study also finds that important deficiencies in the implementation of critical transformative changes remains an obstacle to sustained resilience when it comes to comprehensive public health surveillance. As noted in the NPHIL Strategic Plan:

> The goal of strengthening the national surveillance system to predict, prevent, and detect events of public health security is far-fetched. Inadequate funding to conduct quarterly supportive supervision, conduct quarterly data harmonization across the 15 counties, and incentivize health care workers involved with surveillance activities, especially at the point of entry, are challenges to address.

4.2.7. Medical Products and Technologies

As noted in the Investment Plan for a Resilient Health System, in the post-EVD period the Ministry of Health sought to "coordinate and harmonize all different supplies systems in order to build adequate capacity for management of required medicines and supplies at all levels."

This study finds that with an enabling institutional framework after the EVD outbreak, the health system undertook the task of ensuring decentralised stocks, enhanced warehousing capacities and cold chain management. Where building the capacity on site was not feasible, road infrastructure and transport vehicles were outsourced and made available to facilitate resource distribution.

The Investment Plan detailed the objectives of this initiative which were used as a road map to develop the supply chain management strategy that was in effect in Liberia during the COVID-19 outbreak:

> Restoring, or constructing where there is none, county depots to improve storage capacity at county level (considering storage of cold chain items). Develop HR capacities to enable proper functioning of supply management system, ensure last mile distribution from county depots to facilities through the availability of enough and particularly assigned vehicles for emergency supply distribution.
>
> Establishing and supporting overall distribution system; consideration will be given to the possibility of outsourcing distribution system throughout the entire supply chain but with the aim of building capacity to be handed over by the government before the end of this plan.

Another key finding from this analysis is that the Investment Plan prioritised institutional transformations to enable the Liberian health system to manage its own supply chain, which was a significant innovation between the EVD and COVID-19 outbreaks. The results indicate that targeted institutional capacity building enabled the sustainable implementation of supply chain management innovations into the system, as noted in the Investment Plan:

> Strengthening of the National Drug Service to fulfil the role of an independent, integrated Logistic Service Provider (LSP) for the public sector in Liberia through defining its legal status (government autonomous agency), improving functionality, centralizing/integrating parallel supply chains, developing HR capacities, improving storage capacity, ensuring proper functioning of supply management system and assuring good distribution practices from central to county depots.

4.2.8. Interinstitutional Collaboration

One emerging finding that was not previously identified in the literature or through key informant interviews in this component was the extensive integration efforts between the Liberian government and the governments of Guinea and Sierra Leone to expand the monitoring capacities across the countries' borders.

This study finds that the impact of human motility on public health was a key consideration for Liberian authorities when determining the policy priorities for post-EVD recovery. The Investment Plan notes:

> The government recognizes the need for very close cross border collaboration with neighbouring countries, for real system resilience in the face of similar health threats. It is therefore also prioritising sustained and comprehensive cross-border collaborations within the context of the Mano River Union.

The results indicate that this collaboration extended to the areas of workforce through the capacity building for surge capacity mobilised during the EVD outbreak that could be redeployed to cross-border operations, the surveillance strategy and capacity developed to increase outbreak detection and reporting functions, and the IPC standards that were put in place in health facilities to mitigate infectious disease spread and increase the safety of health facilities for patients and health workers.

The NPHIL Strategic Plan reflects on the positive impact of the policies implemented as a result of the Investment Plan:

> Surveillance is now strengthened at sea, air, and ground crossing points, as evidenced by the institution of SOPs, the development of a public health emergency contingency plan, the establishment of three regional isolation units across the country, the creation of triage at international border crossing points, and testing for COVID-19 at Liberia`s international airport.

This supports the finding that interinstitutional collaboration extended to integration of international stakeholders to increase the Liberian health system's resilience to the COVID-19 outbreak by improving the disease surveillance and outbreak detection capacities as well as enabling early planning for disaster response ahead of the public health crisis.

5. Discussion

This study has highlighted some of the institutional processes that underpinned the Liberian health system's response to the EVD and COVID-19 outbreaks under the lens of transformative resilience. By identifying functions that drove the development of resilience and organsing these into a framework, the study presents a systemic theory of how health systems resilience was operationalised in the Liberian context responding to infectious disease outbreaks.

During the EVD outbreak, the Liberian government designed and implemented EOCs as complex and decentralised structures to function as coordination authorities stratified at the national and subnational level. The central EOC was replicated in Liberia's 15 counties through the County Health Teams under the supervision of a County Health Officers, and further division into 98 Health Districts with the corresponding Health District Teams and Health District Officers. This delegated governance structure supported local implementation of national strategies for transformative resilience while ensuring accountability and, at the same time, increasing institutional legitimacy by preserving closer connections to communities.

The finding of this command structure agrees with Meyer *et al.*'s findings highlighting the need for central coordination,[52] but contrasts against the previous authors in the function of

decentralisation through subnational structures, which is compatible with the conclusions reached by Chamberland-Rower *et al.* regarding the study of a leadership model for health systems resilience.[55]

What resulted from this multi-tiered governance is an authority and accountability structure that creates checkpoints for decisions when they move down the health system and provides space for discussion and coordination to happen at the national, county, and district levels. Given the heterogenous nature of population health needs in Liberia during both outbreaks, this organisation was crucial to making national policymaking responsive to local contexts, which was highlighted by Forsgren *et al.* as a necessary function for innovation.[87]

This level of institutional transformation was supported by several transformative changes, including legislated additions to the health system institutions such as the NPHIL, policy instruments to guide the implementation of IDSR, manuals for community event-based surveillance (CEBS), SOPs for priority infectious diseases with the potential to trigger future outbreaks, national technical guidelines for routine services such as occupational health, water sanitation and hygiene, safe disposal of bodies, and research policy, all with the aims of establishing a robust preparedness and response regulatory framework.

There were also wider determinants to the effectiveness of the response which were not necessarily under the Liberian health system's control but influenced the initial lag in response efforts followed by increased impetus (perhaps late, as noted by some participants). An example of these "distal" determinants of resilience is international interest in providing aid.

The sense of urgency created by public health emergencies of international concern is a strong driver for donor support, and this was particularly true during the EVD outbreak due to the catastrophic nature of the disease. However, this alone is not sufficient to secure timely funding, and the study suggests that the more proximal the public health emergency feels to the donor, the more readily available the contributions will be. This was observed during the

EVD outbreak as international support exponentially increased after a case of EVD was identified in the United States on a person traveling from West Africa, and corroborates Bertone *et al.*'s findings of donor dynamics being influenced by power structures.[65]

The comparative analysis of donor engagement during EVD and COVID-19 highlights a key difference: the sense of urgency during EVD motivated vigorous donor support, whereas COVID-19 required more strategic engagement due to the broader impact on global funding. In both cases, involving donors in coordination meetings and decision-making processes was crucial for ensuring efficient allocation and avoiding duplication of efforts.

The EVD response highlighted the importance of a flexible and scalable command structure. A robust central command with defined roles for subnational entities proved effective and accountable. These structures were crucial in responding to the diverse health needs across Liberia, especially in light of the considerable challenges facing the system at the time of the EVD outbreak, allowing national policymaking to be more responsive to local contexts.

Despite these successes, while the command structure was effective, the monitoring processes at the national, county, and district levels were not fully realised as described in the policy and strategic documents. This ultimately signals an opportunity for improvement in ensuring accountability and fulsomely demonstrating the impact of governance interventions in service delivery and disaster response which can be capitalised by the Liberian health system when considering future innovations to the EOC and IMS structures, such as those proposed by Olu for monitoring during the response phase and continuous response plan reviews during the post-recovery phase.[22]

During the COVID-19 response, Liberia built upon the lessons learnt from the EVD outbreak. The command structure established in 2014 proved beneficial, although the COVID-19 experience revealed areas needing improvement, such as more agile response mechanisms and better integration of international partners. Nevertheless, this case highlights a success

story of creating a comprehensive public health emergency response management structure to improve health system resilience and shows that leadership and governance of such structures must be collaborative and decentralised in order to remain sustainable.

Another key lesson for transformative resilience in the Liberian case is the implementation of decentralised management of health worker cadres to support accountability and effective service delivery. The Liberian health system's ability to transform its workforce management strategy and policy to prioritise these goals showcases the system's resilience in a new health emergency context, which is aligned with the gaps identified by Petherick[1] and opens up an opportunity is the realisation of the Liberian government's Investment Plan for a Resilient Health System.

Naturally, workforce capacity building goes beyond production pipelines, and the Liberian case illustrates that a resilience plan must create the institutional change to establish support networks for health workers where peers and supervisors receive guidelines to provide orientation and advice., especially during public health emergencies. The Liberian health system achieved this by implementing formal and informal monitoring programs to understand the health status of healthcare workers with continuous risk assessment. This level of psychosocial support directly addresses the gaps identified by Meyer *et al.*[8]

This decentralised approach to increasing both the numbers and capacity of the workforce is not only a central function, but a shared function of all sectors of the system, as shown by the evidenced close collaboration with funding partners, technical advisors, and educational institutions. In Liberia, these efforts resulted in facilitated recruitment, retention, and integration, and in ensuring health workers are empowered to practice at their full scope and in alignment with national and subnational priorities.

The experience during COVID-19 further highlighted the importance of timely and accurate health intelligence from robust health information systems. The capacity for outbreak

detention alongside comprehensive routine public health surveillance must be prioritised and, in alignment with Takian and Raoofi's call,[19] data must be reported to and utilised by health authorities to assess the impact of potential outbreaks, determine the appropriateness and potential effectiveness of public health interventions, make informed policy decisions, and ultimately reinforce the health system's capacity for resilience.

This capacity for resilience is the cornerstone of this study's findings on the approach undertaken by the Liberian Ministry of Health, Montserrado County authorities, local health service delivery organisations, and national and international NGOs to transform the health system's capabilities and make them more resilient to infectious disease outbreaks.

This study's framework summarises how the different actors in the Liberian health system operationalised the objectives of building resilience through a holistic view that shows resilience planning should not be focused on outcomes or indicators, but rather on the effectiveness of processes and the performance of institutions, identifying systemic drivers of resilience and, when necessary, implementing changes to the health system itself to "learn" from the impact of public health emergencies to maintain the quality and safety of the services provided while remaining sensitive to shifting population health needs.

This transformative approach to developing resilience is seen in the Liberian case when considering how institutions were modified or, in some cases, created, to direct and implement the activities in the responses to the public health emergencies that guaranteed proactive action. Completely new institutions like the IMS and EOCs, the NPHIL, County, District, and Community Health Teams, and the Technical Working Groups under the One Health Platform illustrate how the Liberian health system added necessary capacity through innovation.

Special attention must be given to transformative changes in community engagement and its influences across the entire system,[105] as these represent arguably the most impactful innovation between the EVD and COVID-19 outbreak, not just through leadership structures

like the Community Health Teams and procedures like engagement strategies and risk communication plans, but also through promotion of community-led initiatives like CEBS and the Community-Led Total Sanitation program. These transformative interventions exemplify how the health system in Liberia evolved to address public health needs more effectively.

By obtaining health intelligence on community health needs, Liberian authorities and implementing partners were able to adjust their service offerings to be patient-centred in terms of timeliness, location, safety, and equity. This was aligned with the essential package of health services to reassure communities of the robustness of the health system's planning and, at the same time, build the logistic and managerial capacities of CHWs to deliver local services, a finding that supports the WHO's assessment of Liberia's community based structures.[76]

Operationalising transformative resilience can also mean introducing key changes to existing institutions, as showcased in Liberia with the enhancement of the National Drug Service to consolidate the logistic services management, the decommissioning of ETUs and incorporation into regular healthcare institutions, the enhancement of triage units, and the expansion of surveillance offices' capacities through renewed SOPs and increased infrastructure.

As we can see in the Liberian case, uncoordinated allocation of resources that isn't backed by health service planning runs the risk of not reaching the intended population or being unable to deliver services according to the actual constraints on the ground, especially if such interventions are dependent on donor funding and cannot be deployed early in the response. This is evidenced by the initial low coverage of many ETUs due to untimely deployment and the lack of a plan to deliver services that were responsive to population health needs and expectations in the context of low community engagement and mistrust, as also signalled by Arwady *et al*.[27]

As learnt from the initial challenges with ETUs in Liberia, system level planning for service delivery is one side of the equation which cannot be isolated from patient-centredness to guarantee access and interest in health services, as well as uptake of new service offering. This is institutionalised by designing patient-centred services linked to tangible goals and outcomes. In Liberia, this was reflected in the design of policies for the Ministry of Health to ensure patient responsiveness and routine delivery of psychosocial services after the EVD outbreak, which became fully realised ahead of the COVID-19 outbreak.

In practice, this means health facilities must be adequately equipped with the physical space to deploy public health emergency response interventions, but also plans and procedures to incorporate the new services without disrupting the already existing ones or reorganising their service offering to guarantee the delivery of essential services.

In many cases, this is achieved by establishing dedicated spaces for activities related to the public health emergency such as diagnosis, isolation, monitoring, and treatment. These dedicated spaces can be standalone temporary facilities, such as Liberia's ETUs, or be incorporated into general facilities with distinct wards or service areas.

One of the most complex tasks undertaken by the Liberian health system was facilitating interinstitutional collaboration by integrating the mandates, procedures, and scopes of the various stakeholders involved into the Ministry of Health's own mandate and scope. In this regard, structural alignment is necessary to ensure the transferability of information and decisions, as well as to foster a clear sense of each stakeholder's roles and limitations. This conceptualisation of the cross-cutting nature of health system planning is compatible with the approach presented by Sagan *et al.* in their study of development of effective governance for health systems resilience after the COVID-19 pandemic.[60]

The approach to collaboration with government and non-government partners considered not just domestic operations but cross-border initiatives as well. After the EVD

outbreak, it was recognised that synchronisation of resources and information was vital to effectively managing public health emergency responses in cross-border communities and, consequently, the rest of the national territory as well. In this regard, Liberia prioritised strong collaboration with the governments of Guinea and Sierra Leone to align protocols on disease surveillance, early alert and warning, and IPC protocols.

Other innovations were identified but not fully implemented due to systematic barriers. These include strengthening the financial accountability strategy through routine fiscal reporting at the national, county, district, and health facility levels, improving the funding allocation mechanisms by developing needs-based allocation formulas, and establishing equity funds to mitigate the impact of funding shortfalls.

The lessons obtained in this study through the systematic exploration of transformative resilience in the Liberian health system show that the experience gained from both outbreaks fostered a culture of preparedness and responsiveness, ensuring that health services remained accessible and community focused. This approach not only strengthened the system during crises but also built a foundation for future resilience.

Limitations to the scope and reach of this study are framed by the comparably low number of participants for the key informant interviews and the fact that all respondents were in leadership or management positions in their respective institutions. This means that the breadth of views captured by this study's data collection may not be reflective of implementation-level officers or community members to offer grassroots perspectives. Further development of this study's findings should focus on increasing the range of participants to include technical officers and implementing partners as well as community members to capture views representative of all levels of the health system's actors and beneficiaries.

Going forward, research on health systems resilience should set objectives to explore some of the operational items identified in this study in more depth to identify the processes,

institutional enablers, and determinants of transformative change. Further research can build on this study's findings to examine each component of the health system and the actions that lead to the development of transformative resilience found here.

After refining the case study's theory through the findings, supported by categories oriented by the research questions, the study's operational framework underwent modifications to incorporate emerging ideas not previously considered, as well as improve the original components to reflect functional links discovered through data analysis, illustrated below.

Figure 4: Revised Operational Framework for Development of Transformative Health System Resilience

With the modifications to the operational framework, the study's propositions themselves were also modified in response to the findings and the theory developed, as well as situating the One Health approach at the centre of the health system's organisation to align with Liberia's strategic direction after the COVID-19 outbreak response. A revised list of propositions organised through the study's operational framework is presented below.

Table 3: Revised summary of operational components, functions, and change tasks for transformative health system resilience.

Component	Function	Transformative change tasks
Leadership and Governance	Sustainable Command Structure	Establishing a central command structure aligned with a PHEOC.
		Consolidating local facilities into the response efforts.
		Developing and disseminating a national plan or strategy to develop resilience.
		Supporting PHEOC through appropriate legislation, regulations, and policy.
		Building institutional legitimacy through stakeholder and public engagement.
Health Financing	Sustainable Funding	Revising the system's revenue streams and allocation policies, including accountability, to build resilience to funding pressures.
		Conducting situational assessments to understand funding pressures.
		Triaging funding needs.
		Ensuring equitable funding distribution.
	Allocation and Planning	Developing awareness of what services are essential and where financial supports could provide immediate relief and achievement of long-term goals.
		Disseminating resilience financing plans to funders and implementing partners.
		Producing a national plan to prioritise revenue streams and secure additional sources of funding where necessary.
		Reallocating existent funding to better serve priority initiatives.
		Securing sustainable funding agreements with clear expectations and goals which are reflective of transformative change initiatives.

Table 3: Revised summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Health Workforce	Health Workforce Planning	Establishing a national workforce strategy that enables a strong situational awareness of national and local provider availability.
		Establishing strategic partnerships with relevant institutions to train health workers on both a routine and extraordinary basis.
		Supporting recruitment and reassignment when service delivery needs change.
		Facilitating training and deployment of community health workers.
		Providing regular training and continuing education for health workers to guarantee appropriate infectious disease management and IPC guidelines are in place.
Health Service Delivery	Access to Health Services	Developing a defined minimum basket of services that directly tie into the system's goals and objectives.
		Typifying priority health services grounded on primary health care.
		Ongoing assessment of emergent health needs.
		Developing situational awareness of the location and distribution of health facilities and services.
		Implementing national and local service continuity strategies.
		Establishing service continuity plans.
Health Infrastructure	Facility Availability	Establishing temporary health facilities for response services
		Securing triage and isolation units at health facilities
		Ensuring appropriate referral pathways and protocols
	Facility Readiness	Implementing quality assurance and improvement standards
		Establishing IPC protocols for health facilities
		Guaranteeing adequate utilities and services

Table 3: Revised summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Health Information Systems	Public Health Surveillance	Developing robust epidemiological surveillance and case reporting guidelines.
		Building community capacity for case identification and referral to health facilities.
		Providing comprehensive epidemiological training for healthcare providers.
		Tracking nosocomial infections
		Mapping and appraisal of health facilities and service delivery centres.
	Information Dissemination	Developing a strong communication strategy and reliable channels to disseminate information to all elements of the health system, relevant external stakeholders, and the general public.
		Implementing consistent procedures to deliver regular reports to healthcare providers on epidemiological updates, preventive measures, and clinical guidelines.
		Supporting health facilities to communicate with each other and with health authorities to facilitate assessments of capacity, burden, available services, and opportunities for immediate intervention.
	Research	Enhancing research governance through policies and standard operating procedures to regulate and support research conduct.
Medical Products & Technologies	Procurement	Implementing resource and supply chain tracking to understand resource availability and gaps
		Establishing purchasing agreements through public-private partnerships, donor assistance, and participation in purchasing coalitions.
	Supply Chain Management	Managing supply chain disruptions including access and distribution of essential supplies

Table 3: Revised summary of operational components, functions, and change tasks for transformative health system resilience (continued).

Community Trust & Ownership	Strategic Communication	Deploying risk communication and engagement strategies to reassure the public about the safety and appropriateness of health facilities and interventions, maintain communities informed of service availability, and provide regular situational updates.
		Considering and choosing the proper risk communication strategy, which is culturally relevant, appropriate, and sensitive to the social context and community issues
	Community Empowerment	Conducting assessments at the national and local levels to identify subsectors of society who are particularly vulnerable and at risk of being disproportionately impacted by the public health emergency.
		Establishing relationships with community social brokers.
		Engaging social brokers as disseminators of public-facing key messages and to enable community feedback for health authorities to inform intervention design, implementation, and monitoring.
	Trust Building	Deploying public health interventions with community health workers to improve legitimacy.
		Involving the community in local decision-making tables at health facilities and local government bodies.
Interinstitutional Collaboration	Collaboration, Coordination & Partnership	Engaging the appropriate stakeholders at the right time
		Setting up agreements ahead of public health emergencies, to facilitate technical cooperation and, in the case of funding partners, secure sustained investments
		Establishing a stakeholder engagement plan that foresees the shift in relationships during shocks
		Including the various actors with influence on the response, both bilateral and multilateral, in planning and decision-making tables.

6. Conclusion

In conclusion, this case study has explored multiple dimensions of transformative health system resilience in Liberia, revealing both the strides made and the ongoing challenges faced. The analysis underscores that while Liberia has demonstrated significant evolution in the institutions that make up its health system from the time of the EVD outbreak, and that this progress enabled a more effective response to the recent COVID-19 pandemic, the path to sustainable transformative resilience remains complex and requires continuous adaptation.

Key findings indicate that transformative resilience is rooted in the integration of strong and inclusive leadership, sustainable financing strategies, a diverse and engaged workforce, comprehensive health information systems, high-quality and safe health services, robust health infrastructure, sustainable supply chain management, community-based approaches, and multi-sectoral integration. The evidence highlights that fostering local ownership and ensuring equitable resource distribution are pivotal for resilience, as is the need for adaptive strategies that respond to both anticipated and unforeseen health threats.The transformative changes observed in Liberia offer valuable insights into how health systems in fragile contexts can evolve. However, the journey is far from complete. Future efforts should focus on enhancing data-driven decision-making, investing in health workforce development, and strengthening interinstitutional collaboration. Additionally, sustained international support and policy coherence are crucial to maintaining momentum and addressing systemic vulnerabilities.

In sum, Liberia's experience provides a compelling case for how health system resilience can be built through a combination of innovative strategies and steadfast commitment. As Liberia continues to navigate its path toward a more resilient health system, these lessons can inform similar efforts in other contexts facing comparable challenges, enhancing our knowledge of resilience, and contributing to a more robust global health framework.

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Appendix A: Data extraction table of reports included in scoping review.

Numerical reference	Authors	Title of Study	Year of Study	Type of Report	Study Setting	Aims	Methodology	Important Findings	Quality
6	Abimbola, S., & Topp, S. M.	Adaptation with robustness: The case for clarity on the use of “resilience” in health systems and global health.	2018	Editorial	N/A	Providing clarity on the definition and use of the term "resilience in health systems".	N/A	For a health system to be resilient, it must be robust at baseline. "Over-optimisation" of deficient areas of the health system can be a consequence of health system strengthening without critical assessment.	N/A
54	Ako-Egbe, L., Seifeldin, R., Saikat, S., Wesseh, S. C., Bolongei, M. B., Ngormbu, B. J., George, R., Ocan, C., & Lasuba, C. L. P.	Liberia health system’s journey to long-term recovery and resilience post-Ebola: a case study of an exemplary multi-year collaboration.	2023	Qualitative Study	Liberia	Review the Liberia Health Service Resilience Project and propose recommendations for next steps.	Case Study - Key Informant Interviews	The project has demonstrated that health system resilience could be operationalised by applying a catchment and integrated approach and encouraging multi-sectoral collaboration, partnership, local ownership, and promoting the primary health care approach.	Good

82	Alonge, O., Sonkarlay, S., Gwaikolo, W., Fahim, C., Cooper, J. L., & Peters, D. H.	Understanding the role of community resilience in addressing the Ebola virus disease epidemic in Liberia: a qualitative study (community resilience in Liberia).	2019	Qualitative Study	Communities in Liberia	Studying the role of community resilience in the overall response to the EVD outbreak.	Key Informant Interviews	Highlighting the role of community leadership and social capital in building resilience in communities as part of the response to the EVD outbreak in Liberia. Underfunding of community resilience building compared to emergency and facility-based services.	Good
90	Ammar, W., Kdouh, O., Hammoud, R., Hamadeh, R., Harb, H., Ammar, Z., Atun, R., Christiani, D., & Zalloua, P. A.	Health system resilience: Lebanon and the Syrian refugee crisis.	2016	Qualitative Study	Lebanon	Assessing health system resilience in Lebanon due to the increased influx of asylum seekers from Syria between 2011 and 2013.	Case Study with input-process-output-outcome model.	Evidence of health system resilience was found in the areas of networking with stakeholders, health system diversification, health infrastructure, human resources, communicable disease response, integration of refugees.	Moderate
27	Arwady, M. A., Bawo, L., Hunter, J. C., Massaquoi, M., Matanock, A., Dahn, B., Ayscue, P., Nyenswah, T., Forrester, J. D., Hensley, L. E., Monroe, B., Schoepp, R. J., Chen, T. H., Schaecher, K. E., George, T., Rouse, E., Schafer, I. J.,	Evolution of ebola virus disease from exotic infection to global health priority, Liberia, mid-2014.	2015	Review	Liberia	Provide a summary and case study of the evolution of the 2014 EVD outbreak in Liberia	Literature Review and Key Document Review	Between 2014-2015, the EVD outbreak overwhelmed the Liberian health system through disproportionate impact on health workers and ETUs having low coverage. Priorities included enhanced surveillance, infection prevention and control, and health	Good

	Pillai, S. K., & De Cock, K. M.							service continuity planning.	
66	Barasa, E., Mbau, R., & Gilson, L.	What Is Resilience and How Can It Be Nurtured? A Systematic Review of Empirical Literature on Organizational Resilience. International journal of health policy and management.	2018	Review	N/A	Conceptualise health system resilience and identify systemic enablers.	Systematic Review	Health system resilience is both planned and in response to emerging crises (adaptive resilience). The types of shocks that can trigger the need for resilience include acute stressors and chronic deficiencies (everyday resilience).	Good
23	Barker, K. M., Ling, E. J., Fallah, M., Vandebogert, B., Kodl, Y., Macauley, R. J., Viswanath, K., & Kruk, M. E.	Community engagement for health system resilience: Evidence from Liberia's Ebola epidemic.	2020	Qualitative Study	Liberia	Explore community engagement as a function of health system resilience in Liberia after the 2014 EVD outbreak.	Key Informant Interviews and Focus Group Discussions	Community engagement was a crucial part of developing resilience during and after the EVD outbreak, particularly through active interventions like community-based surveillance. Positive community engagement led to increased trust in the health system.	Good
65	Bertone, M. P., Jowett, M., Dale, E., & Witter, S.	Health financing in fragile and conflict-affected settings: What do we know, seven years on?	2019	Qualitative Study	N/A	Examine the knowledge on health financing in fragile and conflict-affected countries and discuss ongoing challenges.	Literature Review	Health financing in fragile and conflict-affected countries is still largely driven by countries with high donor presences, and the field is skewed in favour of larger projects and reforms compared to local and	Good

								community-based initiatives. There is a dearth of evidence in terms of health financing goals and objectives for universal health care.	
83	Bhandari, S., & Alonge, O.	Measuring the resilience of health systems in low- and middle-income countries: A focus on community resilience.	2020	Mixed Methods	N/A	Developing a quantitative model for measuring community resilience in health systems.	Scoping Review and Quantitative Model Building.	Community resilience can be measured as a function of 20 indicators.	Good
37	Biddle, L., Wahedi, K., & Bozorgmehr, K.	Health system resilience: A literature review of empirical research.	2020	Quantitative Study	N/A	Provide a quantitative analysis of the body of literature on health systems resilience.	Literature Review and Quantitative Descriptive Analysis	The majority of the studies analysed focused on health system resilience in health service delivery. Most papers addressed absorptive and adaptive capacities of resilience, with institutional legitimacy and transformative resilience addressed less often.	Good
56	Blanchet, K., Diaconu, K., Witter, S. Understanding the resilience of health systems. In: Bozorgmehr, K., Roberts, B., Razum, O., & Biddle, L.	Health policy and systems responses to forced migration.	2020	Book	N/A	Analyse the challenges presented by forced migration through a systems thinking approach.	Varied, reviews and qualitative analysis, quantitative analysis.	Chapter 6 - The capacity to manage resilience is determined by four factors: knowledge, uncertainties, interdependence, and legitimacy.	N/A

10	Blanchet, K., Nam, S. L., Ramalingam, B., & Pozo-Martin, F.	Governance and Capacity to Manage Resilience of Health Systems: Towards a New Conceptual Framework.	2017	Qualitative Study	N/A	Develop a conceptual framework to describe the dimensions of health system resilience.	Literature Review	Health system resilience can be understood on a continuum of three dimensions or capacities: absorptive, adaptive, and transformative.	Good
15	Borghi, J., & Brown, G. W.	Taking systems thinking to the global level: using the WHO building blocks to describe and appraise the global health system in relation to COVID-19.	2022	Qualitative Study	N/A	Use the WHO Building Block's framework to conduct an assessment of global health institutions in the context of the COVID-19 pandemic.	Case Study	Global health performance was found to be deficient in the areas of fragmented and voluntary funding, non-transparent pricing of medicines and supplies, poor quality standards, inequities in procurement and distribution, and weak leadership and governance.	Good
102	Boro, E., & Stoll, B.	Barriers to COVID-19 health products in Low-and Middle-Income Countries during the COVID-19 Pandemic: A rapid Systematic review and evidence Synthesis.	2022	Qualitative Study	N/A	Identify the factors leading to medicine and supply shortages in LMICs during the COVID-19 pandemic.	Systematic Review	Medical products and technologies shortages were found to be driven mainly by market forces, unavailability, inaccessibility and unaffordability. In developing countries, the impact of colonialism was often cited as an underlying cause for the systemic weaknesses.	Good

29	Centers for Disease Control and Prevention	2014-2016 Ebola Outbreak in West Africa | History | Ebola (Ebola Virus Disease) | CDC	2020	Situational Report	West Africa	Provide an overview of epidemiological data and history on EVD outbreaks in West Africa.	N/A	The 2014 West Africa EVD outbreak is the largest in history. Poor surveillance, fragile health systems, and inadequate IPC, led to high disease burden and mortality.	N/A
30	Centers for Disease Control and Prevention	Ebola Epidemic — Liberia, March–October 2014.	2014	Situational Report	Liberia	Provide a summary of the history and evolution of the 2014 EVD outbreak in Liberia.	N/A	At the time, the coverage of the ETUs was insufficient and it was found that an appropriate response would necessitate enhancements in service delivery, diagnostic capacity, and surveillance.	N/A
55	Chamberland-Rowe, C., Chiocchio, F., & Bourgeault, I. L.	Harnessing instability as an opportunity for health system strengthening: A review of health system resilience.	2019	Qualitative Study	N/A	Design an operational model to explain development of resilience.	Systematic Review	The development of resilience can be studied in an operational model that engages functions of leadership to harness instability for health systems strengthening.	Good
86	Christensen, D., Dube, O., Haushofer, J., Siddiqi, B., & Voors, M.	Building Resilient Health Systems: Experimental Evidence from Sierra Leone and the 2014 Ebola Outbreak.	2020	Quantitative Study	Sierra Leone	Test the impact of two interventions on EVD reporting and Ebola-related mortality.	Interrupted Time Series	During the EVD outbreak, both interventions tested increased EVD reporting by 62% and the community monitoring intervention significantly reduced Ebola-related deaths.	Good

72	Dreisbach, T., & Gbanya, M. Z.	Building a More Resilient Health System after Ebola in Liberia.	2019	Qualitative Study	Liberia	Review the implementation of the Investment Plan for a Resilient Health System 2015-2021 in Liberia.	Case Study	The investment plan succeeded in achieving key outcomes like the creation of a new cadre of community health workers, the founding of a new public health institute, and infrastructure advancements including improved laboratory facilities, triages, and isolation units.	Good
3	Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J.	Resilience Thinking: integrating resilience, adaptability and transformability.	2010	Qualitative Study	N/A	Review the dimensions of resilience in social ecological systems.	Social ecological model building.	Resilience in social ecological models involves the interconnected dimensions of adaptability and transformability. Transformational change at smaller scales enables resilience at larger scales.	N/A
78	Foroughi, Z., Ebrahimi, P., Aryankhesal, A., Maleki, M., & Yazdani, S.	Toward a theory-led meta-framework for implementing health system resilience analysis studies: a systematic review and critical interpretive synthesis.	2022	Qualitative Study	N/A	To design a framework to guide the study and analysis of health system resilience based on previous frameworks.	Systematic Review	The framework defines 5 phases of health system resilience, 6 attributes, 6 tools, and 3 main strategies that can guide the implementation of analytical studies on health system resilience. Highlights the importance of coordination of actors	Good

								and stakeholders, informing the present case study's findings on interinstitutional collaboration.	
87	Forsgren, L., Tediosi, F., Blanchet, K., & Saulnier, D. D.	Health systems resilience in practice: a scoping review to identify strategies for building resilience.	2022	Qualitative Study	N/A	Explore and typify strategies to build health systems resilience.	Scoping Review	Identified 9 areas where strategies to build health systems resilience can be classified: use of community resources, governance and financing, leadership, surveillance, human resources, communication and collaboration, preparedness, organisational capacity and learning, health system strengthening.	Good
73	Fridell, M., Edwin, S., Schreeb, J. von, & Saulnier, D. D.	Health system resilience: what are we talking about? A scoping review mapping characteristics and keywords.	2020	Qualitative Study	N/A	Summarise the descriptions of health systems resilience to improve understanding of the concept.	Scoping Review	There is considerable variability in the conceptual approaches to health systems resilience, but most consider just acute shocks.	Good
51	Gebremeskel, A. T., Otu, A., Abimbola, S., & Yaya, S.	Building resilient health systems in Africa beyond the COVID-19 pandemic response.	2021	Editorial	Africa	Elaborate on the understanding of health systems resilience in the context of COVID-19 responses in Africa.	N/A	Four main challenges to health systems resilience in Africa were identified: community and community worker engagement, medical and diagnostic supplies, data	N/A

								governance and stewardship, and health infrastructure development.	
91	Gooding, K., Bertone, M. P., Loffreda, G., & Witter, S.	How can we strengthen partnership and coordination for health system emergency preparedness and response? Findings from a synthesis of experience across countries facing shocks.	2022	Qualitative Study	Sub-Saharan Africa and South Asia	Identify enablers for partnership and collaboration in health systems for disaster preparedness and response.	Scoping Review	Partnership and collaboration in health systems for disaster preparedness and response are driven by four main factors: inclusiveness, robust structures, capacity, political leadership.	Moderate
48	Grimm, P. Y., Oliver, S., Merten, S., Han, W. W., & Wyss, K.	Enhancing the Understanding of Resilience in Health Systems of Low-and Middle-Income Countries: A Qualitative Evidence Synthesis.	2022	Qualitative Study	N/A	Improve the understanding of dimensions, uses and implications of health systems resilience in the context of major shocks.	Systematic Review	Five themes were found to be essential for achieving resilience to major shocks: realigned relationships, foresight, motivation, emergency preparedness, and change management.	Moderate
71	Haldane, V., & Morgan, G. T.	From resilient to transilient health systems: The deep transformation of health systems in response to the COVID-19 pandemic	2021	Editorial	N/A	Discuss the intersection between the concept or health system resilience and transilience.	N/A	Incorporating transilience into the concept of health system resilience is necessary to ensure that responses to major health system shocks do not worsen pre-existing social inequalities in the	N/A

								health journey and outcomes.	
21	Haldane, V., de Foo, C., Abdalla, S. M., Jung, A. S., Tan, M., Wu, S., Chua, A., Verma, M., Shrestha, P., Singh, S., Perez, T., Tan, S. M., Bartos, M., Mabuchi, S., Bonk, M., McNab, C., Werner, G. K., Panjabi, R., Nordström, A., & Legido-Quigley, H.	Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries.	2021	Qualitative Study	28 countries	Test a conceptual framework for health system resilience.	Comparative Case Study - Systematic Review, Document Review, Key Informant Interviews.	Four elements were identified as determinants of resilience: activate comprehensive responses, adapt health system capacity, preserve health system functions and resources, reduce vulnerability.	Good
67	Hanefeld, J., Mayhew, S., Legido-Quigley, H., Martineau, F., Karanikolos, M., Blanchet, K., Liverani, M., Yei Mokuwa, E., McKay, G., & Balabanova, Di.	Towards an understanding of resilience: responding to health systems shocks.	2018	Qualitative Study	Europe and West Africa	Study health system behaviours to four different shocks.	Systematic Review	Five dimensions were identified as relevant to responding to acute shocks: health information systems, funding/financing mechanisms, health workforce, governance, and "values".	Moderate
53	Hart, L., Street, D., & Kulatilaka, H.	Building Capacity for Resilient Health Systems Lessons Learned from Sierra Leone, Guinea, and Liberia	2017	Qualitative Study	Guinea, Sierra Leone and Liberia	Explore strategies for capacity building for resilience implemented in	Comparative Case Study - Key Informant Interviews, Key	Capacity building for health system resilience was found to be determined by four priorities: assessing and planning,	Moderate

		in the Time of Ebola				the three chosen countries.	Document Review	stakeholder engagement, transition planning from implementing partner to Ministry of Health, establishing realistic scopes of work.	
11	HBS Online	Types of organizational change & How to manage them	2020	Report	N/A	Describe the types of organisational change and how to initiate them.	N/A	The spectrum of organisational change ranges from adaptive change to transformational change.	N/A
12	Healthcare Improvement Scotland	Transformational Change Summary. Healthcare Improvement Scotland IHub.	2019	Qualitative Study	N/A	Describe transformational change in healthcare organisations.	Rapid Review	Transformational change in healthcare organisations is achieved through 5 core principles: communicating a vision of change, distributing leadership, learning and capability, emerging changes in behaviours and processes, and service user and community engagement.	Moderate
46	Juárez-Ramírez, C., Reyes-Morales, H., Gutiérrez-Alba, G., Reartes-Peñafiel, D. L., Flores-Hernández, S., Muños-Hernández, J. A., Escalante-	Local health systems resilience in managing the COVID-19 pandemic: lessons from Mexico.	2022	Qualitative Study	Mexico	Describe the experiences of primary health care workers in managing service delivery the COVID-19 pandemic in Mexico.	Case Study - Key Informant Interviews	Transformative capacity for health systems resilience in the studied population was driven by three strategies: preparation, adaptation, and learning.	Good

	Castañón, A., & Malo, M.								
47	Karamagi, H. C., Titi-Ofei, R., Kipruto, H. K., Seydi, A. B. W., Droti, B., Talisuna, A., Tsofa, B., Saikat, S., Schmets, G., Barasa, E., Tumusiime, P., Makubalo, L., Cabore, J. W., & Moeti, M.	On the resilience of health systems: A methodological exploration across countries in the WHO African Region.	2022	Quantitative Study	WHO Africa Region	Assess the resilience of 47 countries in the region through a computed index of characteristics associated with two types of resilience.	Cross-sectional Study	Overall resilience was 48.4 out of 100 on the 47 countries studied. Of the two types of resilience considered (emergency preparedness and response and inherent system resilience), inherent system resilience scored the lowest and the main areas of weakness in this type of resilience were transformation capacity, mobilisation of resources, awareness of own capacities, self-regulation, and diversity of services.	Good
26	Kittelsen, S. K., & Keating, V. C.	Rational trust in resilient health systems. Health	2019	Qualitative Study	N/A	Develop a theoretical model to explain the determinants individuals' trust in the health system during times of crisis.	Systematic Review	The rational model of trust posits that trust is determined by three assumptions: similar benefits and losses, generalised trust, and clear attributions of success. Discussing trust as a driver of community	Good

								engagement supports the addition of this function to the present case study's framework.	
92	Koeva, S., & Rohova, M.	Health system resilience: concept development.	2020	Qualitative Study	N/A	Explore the roots and development of the concept of health systems resilience.	Scoping Review	Beyond healthcare, resilience in systems science has been widely used for social-ecological models, climate change and disasters, and organisational theory, which impacted the concept development of resilience for health systems.	Moderate
13	Kruk, M. E., Ling, E. J., Bitton, A., Cammett, M., Cavanaugh, K., Chopra, M., El-Jardali, F., Macauley, R. J., Muraguri, M. K., Konuma, S., Marten, R., Martineau, F., Myers, M., Rasanathan, K., Ruelas, E., Soucat, A., Sugihantono, A., & Warnken, H.	Building resilient health systems: A proposal for a resilience index.	2017	Qualitative Study	Liberia, Lebanon and Indonesia	Develop a suite of measures to be used as an evaluation tool for health system resilience.	Case Study	25 measures were developed across five health system characteristics for resilience: aware, diverse, self-regulating, integrated, adaptive. This study highlights community involvement as a critical driver of success in developing resilience in Liberia.	Good
4	Kruk, M. E., Myers, M., Varpilah, S. T., & Dahn, B. T.	What is a resilient health system? Lessons from Ebola.	2015	Qualitative Study	West Africa EVD outbreak	Develop a definition and conceptual framework for	Case Study	Health systems resilience was defined as "the capacity of health actors,	Good

						health systems resilience.		institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learned during the crisis, reorganise if conditions require it", and the conceptual framework identifies five characteristics of a resilient health system, stating that they need to be aware, diverse, self-regulating, integrated, and adaptive.	
93	Langeland, K. S., Manheim, D., McLeod, G., & Nacouzi, G.	How civil institutions build resilience: Organizational Practices Derived from Academic Literature and Case Studies.	2016	Book	N/A	Review and typify the approaches and strategies through which organisations build resilience.	Literature Review and Critical Analysis	General approaches for building organisational resilience are identified as: impact avoidance, adaptation and flexibility, recovery and restoration.	Good
64	Ling, E. J., Larson, E., MacAuley, R. J., Kodl, Y., Vandebogert, B., Baawo, S., & Kruk, M. E.	Beyond the crisis: Did the Ebola epidemic improve resilience of Liberia's health system?	2017	Qualitative Study	Liberia	Explore the functions of resilience and how they improved during and immediately after the EVD outbreak.	Case Study – Key Informant Interviews	The functions and priorities for resilience that received the most investment and showed the most improvement were those identified by international and national stakeholders compared to district,	Good

								county and community stakeholders.	
103	MacCormack, C. P.	Health care and the concept of legitimacy. Social Science & Medicine.	1981	Qualitative Study	N/A	Explore the concept of legitimacy in healthcare planning institutions and propose means for integration.	Literature Review	The study considers three types of legitimacy: rational-legal, traditional, and charismatic. Healthcare planning institutions rely on rational-legal legitimacy, but may benefit from integration with community-based planned to increase traditional and charismatic legitimacy, especially in rural and remote communities.	Moderate
20	MacKenzie, A., Abdulwahab, A., Sokpo, E., & Mecaskey, J. W.	Building a resilient health system lessons from Northern Nigeria.	2015	Qualitative Study	Northern Nigeria	Study the insights gained from building health systems resilience in Northern Nigeria to derive practical learnings on how resilience can be operationalised in health systems.	Case Study	The changes implemented to develop resilience in the Nigerian Health system can be summarised in an adapted version of the WHO Building Blocks framework including: service delivery; health workforce; information; medical products, vaccines and technology; health	Good

								financing; leadership and governance; and the additional element of community engagement which informs the framework development for the present case study.	
16	Manyazewal, T.	Using the World Health Organization health system building blocks through survey of healthcare professionals to determine the performance of public healthcare facilities.	2017	Quantitative Study	Ethiopia	Assess the performance of the health system through survey of healthcare workers based on the WHO Building Blocks framework.	Cross-sectional Study	Overall performance in the surveyed public hospitals was 60% with the lowest performing building blocks being health information and health workforce.	Good
69	Marsh, R. H., Plyler, C., Miller, M., Klar, R., Adeiza, M., Wachekwa, I., Koomson, F., Garlo, J. L., Kruah, K., Lake, S. C., Matte, R., Cook, R., Maweu, D., Kerr, L., Ogbuagu, O., Talbert-Slagle, K., & Dahn, B.	Facing COVID-19 in Liberia: Adaptations of the resilient and responsive health systems initiative.	2021	Qualitative Study	Liberia	Explore the challenges presented by the COVID-19 pandemic to the RRHS initiative to improve HIV-related health outcomes in Liberia.	Case Study	Direct challenges were found to be decreased patient participation and understaffing. The program was found to implement adaptive capacity through development of training and safety protocols, provision of telehealth services, and community health worker involvement.	Good

88	Martineau, F. P.	People-centred health systems: building more resilient health systems in the wake of the Ebola crisis.	2016	Editorial	N/A	Provide support for the argument of refocusing the conceptual approach to health systems resilience to prioritise local, relational and practice-oriented policy thinking.	N/A	Taking a local and community focus to health system resilience requires shifting the planning priorities to understanding and reducing local power disparities, building the trustworthiness of health actors and institutions, developing mechanisms for reconciling rather than eclipsing different actors' priorities and addressing them meaningfully in operational decisions both between and during crises.	N/A
104	Martineau, T., McPake, B., Theobald, S., Raven, J., Ensor, T., Fustukian, S., Ssengooba, F., Chirwa, Y., Vong, S., Wurie, H., Hooton, N., & Witter, S.	Leaving no one behind: Lessons on rebuilding health systems in conflict- and crisis-affected states.	2017	Qualitative Study	Sierra Leone, Zimbabwe, northern Uganda, and Cambodia.	Contribute to the evidence base on program planning for health systems resilience.	Comparative Case Study	Three cross-cutting themes were identified for resilience in the four health systems analysed: communities, human resources for health, and institutions.	N/A

49	McDarby, G., Seifeldin, R., Zhang, Y., Mustafa, S., Petrova, M., Schmets, G., Porignon, D., Dalil, S., & Saikat, S.	A synthesis of concepts of resilience to inform operationalization of health systems resilience in recovery from disruptive public health events including COVID-19.	2023	Qualitative Study	N/A	Develop an operational definition of health systems resilience.	Systematic Review	Identified 3 key areas to foster health systems resilience: embedding consideration of resilience within health system strengthening efforts; ensuring the systematic capture of learning within health systems and the translation of that learning into practice; and ensuring health systems have a public health orientation, and provides an operational definition for health systems resilience.	Good
52	Meyer, D., Bishai, D., Ravi, S. J., Rashid, H., Mahmood, S. S., Toner, E., & Nuzzo, J. B.	A checklist to improve health system resilience to infectious disease outbreaks and natural hazards.	2020	Qualitative Study	N/A	Develop a checklist for measuring the resilience of health systems to infectious disease outbreaks.	Scoping Review and Focus Group Discussions	90 items were developed for the checklist, classified in 10 categories: Core health system capacities and capabilities; critical infrastructure and transportation; financing; barriers to accessing health services; communication, collaboration, coordination and partnerships; leadership and command structure;	Good

								surge capacity; risk communication; workforce; infection control. The discussion on stakeholder coordination informs the present case study's addition of interinstitutional collaboration as a component.	
8	Meyer, D., Kirk Sell, T., Schoch-Spana, M., Shearer, M. P., Chandler, H., Thomas, E., Rose, D. A., Carbone, E. G., & Toner, E.	Lessons from the domestic Ebola response: Improving health care system resilience to high consequence infectious diseases.	2018	Qualitative Study	West Africa EVD outbreak	Integrate perspectives from expert interviews to develop a checklist to foster health systems resilience to high-consequence infectious diseases.	Case Study - Key Informant Interviews	Themes identified included health care facility issues like identifying assessment and treatment hospitals, isolation and treatment unit layout, waste management, community relations, patient identification, patient isolation, limitations on treatment, laboratories, and research considerations-and health care workforce issues like psychosocial impact, unit staffing, staff training, and proper personal protective equipment	Good

80	Miller, N. P., Milsom, P., Johnson, G., Bedford, J., Kapeu, A. S., Diallo, A. O., Hassen, K., Rafique, N., Islam, K., Camara, R., Kandeh, J., Wesseh, C. S., Rasanathan, K., Zambruni, J. P., & Papowitz, H.	Community health workers during the Ebola outbreak in Guinea, Liberia, and Sierra Leone.	2018	Mixed Methods	Guinea, Sierra Leone and Liberia	Study the impact of CHWs on maternal, newborn and child health services during the EVD outbreak and draw lessons for promoting resilience.	Key Informant Interviews and Focus Group Discussions (Qualitative) and Descriptive Cross-sectional Analysis (Quantitative)	Despite the fact that the involvement of CHWs improved service continuity in MNCH services, health systems were slow to bring community actors into the response, signalling a priority for future action plans.	Good
17	Mounier-Jack, S., Griffiths, U. K., Closser, S., Burchett, H., & Marchal, B.	Measuring the health systems impact of disease control programmes: A critical reflection on the WHO building blocks framework.	2014	Qualitative Study	N/A	Exploring the strengths and limitations of using the WHO Building Blocks framework as a research tool for immunisation programs.	Systematic Review	The WHO Building Blocks framework is not suitable to study dynamic systems due to the siloed nature of its components which does not enable exploration of the interrelations between the different elements it considers.	Good
70	Mustafa, S., Zhang, Y., Zibwowa, Z., Seifeldin, R., Ako-Egbe, L., McDarby, G., Kelley, E., & Saikat, S.	COVID-19 Preparedness and Response Plans from 106 countries: a review from a health systems resilience perspective.	2021	Qualitative Study	N/A	Assess COVID-19 preparedness and response plans from 106 countries to determine the integration of essential service continuity with emergency response activities.	Key Document Review	Ongoing and future emergency planning should include strengthening plans for local health services, community engagement in planning, service continuity, IPC, and monitoring capacity.	Good

85	Nagai, M., Abraham, S., Okamoto, M., Kita, E., & Aoyama, A.	Reconstruction of health service systems in the post-conflict Northern Province in Sri Lanka.	2007	Mixed Methods	Sri Lanka	Identify unmet health service needs and make recommendations for post-armed conflict health system reconstruction.	Retrospective analysis, Surveys (Quantitative) and Key Informant Interviews (Qualitative)	Identified deficiencies were maternal mortality, staffing, water and sanitation, public awareness of service availability, access, and mental health. Community empowerment through health awareness programs and comprehensive mental health strategy were recommended as potential solutions.	Good
57	Nuzzo, J. B., Meyer, D., Snyder, M., Ravi, S. J., Lapascu, A., Souleles, J., Andrada, C. I., & Bishai, D. (	What makes health systems resilient against infectious disease outbreaks and natural hazards? Results from a scoping review.	2019	Qualitative Study	N/A	Identify capabilities that health systems need to develop and maintain to achieve resilience.	Scoping Review	No frameworks were identified that listed specific capacities that health systems can employ to develop resilience. The most salient themes identified in the literature were the need to develop plans for altered standards of care during emergencies, the need to develop plans for post-event recovery, and a commitment to quality improvement.	Good

28	Nyenswah, T. G., Kateh, F., Bawo, L., Massaquoi, M., Gbanyan, M., Fallah, M., Nagbe, T. K., Karsor, K. K., Wesseh, C. S., Sieh, S., Gasasira, A., Graaff, P., Hensley, L., Rosling, H., Lo, T., Pillai, S. K., Gupta, N., Montgomery, J. M., Ransom, R. L., … De Cock, K. M.	Ebola and its control in Liberia, 2014-2015.	2016	Qualitative Study	Liberia	Provide an account of the evolution and public health measures to respond to the EVD outbreak in Liberia between 2014-2015.	Case Study	The study of the response identified the following essential components: government leadership and sense of urgency, coordinated international assistance, sound technical work, flexibility guided by epidemiologic data, transparency and effective communication, and efforts by communities themselves, a critical finding to support adding community engagement to the present case study's theory development.	Good
9	Odhiambo, J., Jeffery, C., Lako, R., Devkota, B., & Valadez, J. J.	Measuring health system resilience in a highly fragile nation during protracted conflict: South Sudan 2011-15.	2020	Quantitative Study	Sudan	To develop an index for health system resilience based on data from MNCH programs compared against three conceptual approaches.	Vulnerability testing.	Through the developed resilience index, defining resilience as improving function had the most variability. Health system resilience and health system stress are not consistently negatively associated.	Good

63	OECD	Ready for the Next Crisis? Investing in Health System Resilience	2023	Report	N/A	To make policy recommendations for investment to promote health systems resilience after the COVID-19 pandemic.	Systematic Review, Critical Analysis	Issued recommendations for investment in four priority areas: prepare, absorb, recover, adapt.	N/A
22	Olu, O.	Resilient Health System As Conceptual Framework for Strengthening Public Health Disaster Risk Management: An African Viewpoint.	2017	Qualitative Study	Africa	To create a health system framework for Disaster Risk Management	Systematic Review	A framework for Disaster Risk Management to improve health systems resilience considered the following areas: health disaster risk reduction, health disaster preparedness, emergency health response, health system recovery. Within these areas, the framework identifies the functions of leadership/governance; health financing; medicines, vaccines and technologies; health information; health workforce; and health service delivery.	Good

74	Ozawa, S., Paina, L., & Qiu, M.	Exploring pathways for building trust in vaccination and strengthening health system resilience.	2016	Qualitative Study	Northern Nigeria	Examine the factors that undermine trust in immunisation programs and propose strategies to build trust and increase health system resilience.	Systematic Review and Secondary Data Analysis	The model for trust in vaccination programs indicates that trust originates from the intersection of positive interactions with the health system, communication, and social capital. This adds to the theory of trust for community engagement in this case study's findings.	Good
18	Palagyi, A., Marais, B. J., Abimbola, S., Topp, S. M., McBryde, E. S., & Negin, J.	Health system preparedness for emerging infectious diseases: A synthesis of the literature.	2019	Qualitative Study	LMICs	Develop a conceptual framework to describe how health systems LMICs respond to emerging infectious diseases.	Narrative Synthesis	The framework identifies six core constructs: surveillance, infrastructure and medical supplies, workforce, communication mechanisms, governance, and trust.	Good
50	Paschoalotto, M. A. C., Lazzari, E. A., Rocha, R., Massuda, A., & Castro, M. C.	Health systems resilience: is it time to revisit resilience after COVID-19?	2023	Qualitative Study	N/A	To reassess the concept of health systems resilience after the COVID-19 pandemic through a comparative approach of HICs vs LMICs.	Scoping Review and Key Informant Interviews	The previously established model used in this study to consider resilience of preparedness, onset and alert, responsiveness and impact, recovery and learning, can be improved by considering this an iterative process and the interconnectedness of these functions. A refined framework based on previous	Good.

								works considers the following elements for a resilient health system: financing; human resources; physical resources; medicines; services provision; governance; leadership and regulation; all framed around technology and information, and decision-makers.	
1	Petherick, A.	Ebola in west Africa: Learning the lessons.	2015	Editorial	West Africa EVD outbreak	Reviewing the lessons learnt from the management of the EVD outbreak in Guinea, Sierra Leone, and Liberia.	N/A	The two largest gaps identified in the response efforts in all three countries related to the timeliness of international support and workforce training and deployment.	N/A
75	ReBUILD Consortium	*ReBUILD for Resilience Resilience Framework*.		Qualitative Study	N/A	Develop a framework to analyse the capacities which underlie resilience and how these can be built.	Systematic Review, Case Study	The framework presents a series of feedback loops that explain the capacities that underlie health systems resilience and provides a view to the relationships between these capacities.	Good

84	Rippon, S., Bagnall, A. M., Gamsu, M., South, J., Trigwell, J., Southby, K., Warwick-Booth, L., Coan, S., & Woodward, J.	Towards transformative resilience: community, neighbourhood and system responses during the COVID-19 pandemic.	2021	Qualitative Study	N/A	Study how communities have responded to the COVID-19 pandemic through a resilience lens.	Rapid Review, Critical Analysis	Identifies three levels of resilience: individual, community, and system. Introducing transformative resilience at the community level requires addressing the interrelationship between the causes of disadvantage, employ a health assets approach, and create opportunities that enable communities to co-design resources.	Moderate
60	Sagan, A., Webb, E., Rajan, D., Karanikolos, M., & Greer, S. L.	Health system resilience during the pandemic: it's mostly about governance	2021	Qualitative Study	N/A	Identify strategies for building effective governance for health systems resilience to the COVID-19 pandemic.	Case Study	Developing effective governance for health systems resilience involves 7 distinct functions of governance.	Good
7	Saulnier, D. D., Blanchet, K., Canila, C., Cobos Muñoz, D., Dal Zennaro, L., de Savigny, D., Durski, K. N., Garcia, F., Grimm, P. Y., Kwamie, A., Maceira, D., Marten, R., Peytremann-Bridevaux, I.,	A health systems resilience research agenda: moving from concept to practice.	2021	Qualitative Study	N/A	Discuss and identify priorities for health systems resilience research and implementation based on lessons from the COVID-19 pandemic and other public	Case Study	Five research priority areas were identified: measuring and managing systems dynamic performance, the linkages between societal resilience and health system resilience, the effect of governance on the capacity for resilience, creating legitimacy, and the influence of	Good

	Poroes, C., Ridde, V., Seematter, L., Stern, B., Suarez, P., Teddy, G., … Tediosi, F					health emergencies.		the private sector on health system resilience.	
38	Saulnier, D. D., Duchenko, A., Ottilie-Kovelman, S., Tediosi, F., & Blanchet, K.	Re-evaluating Our Knowledge of Health System Resilience During COVID-19: Lessons From the First Two Years of the Pandemic.	2023	Qualitative Study	N/A	Understand what aspects of resilience remain uncertain based on the literature and propose ways to address these gaps.	Narrative Literature Review	There is further understanding needed on decision-making, localised trust, influences on interdependence, and transformation. Aspects that are still not discussed in the research are monitoring risks beyond the health system, and consequences of changes in the system.	Good
24	Siekmans, K., Sohani, S., Tamba, B., 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.	2017	Mixed Methods	Liberia	Examine the value of a community-based health system in ensuring continued treatment of child illnesses during the EVD outbreak in Liberia.	Surveys, Focus Group Discussions	In the project areas, service continuity for community-based treatment of child diarrhoea and pneumonia was achieved. CHWs were an essential resource in improving trust and increasing health seeking behaviours in their communities.	Good

81	Simen-Kapeu, A., Lewycka, S., Ibe, O., Yeakpalah, A., Horace, J. M., Ehounou, G., Boima, T., & Wesseh, C. S.	Strengthening the community health program in Liberia: Lessons learned from a health system approach to inform program design and better prepare for future shocks.	2021	Mixed Methods	Liberia	Examine the community health policy development process in Liberia after the EVD outbreak.	Program Evaluation, Key Informant Interviews, Focus Group Discussions	Implementation of the community health program in Liberia must include: establishing a coordination mechanism and leveraging partner support, using a systems approach to better inform policy shifts, strengthening community engagement, and conducting evidence-based planning to inform policy-makers.	Good
101	Sochas, L., Channon, A. A., & Nam, S.	Counting indirect crisis-related deaths in the context of a low-resilience health system: The case of maternal and neonatal health during the Ebola epidemic in Sierra Leone.	2017	Quantitative Study	Sierra Leone	Quantify indirect deaths in Sierra Leone as a result of decreased maternal and neonatal health service utilisation during the EVD outbreak.	Interrupted Time Series	The most conservative model calculates 3,600 additional deaths attributable to decreased service coverage during the outbreak.	Good
19	Takian, A., & Raoofi, A.	We must redesign the WHO's building blocks to create more resilient health systems for the future.	2021	Editorial	N/A	Reflect on the need to further develop the WHO Building Blocks framework to assess health systems after the COVID-19 pandemic.	N/A	Two additional components are proposed for the WHO Building Blocks framework: Inter-sectoral collaboration, and global health surveillance. These findings offer crucial support to adding the component of interinstitutional	N/A

								collaboration to the present case study's framework.	
105	Thu, K. M., Bernays, S., & Abimbola, S.	A literature review exploring how health systems respond to acute shocks in fragile and conflict-affected countries.	2022	Qualitative Study	N/A	Examine the mechanisms by which health systems in fragile and conflict-affected countries respond to health crises for resilience.	Literature Review	Findings support the model proposed by Blanchet et al. (2017) and identify the cross-cutting role of community involvement, frontline workers, and leadership capacity.	Moderate
89	Turenne, C. P., Gautier, L., Degroote, S., Guillard, E., Chabrol, F., & Ridde, V.	Conceptual analysis of health systems resilience: A scoping review.	2019	Qualitative Study	N/A	Evaluate the clarity in use of the concept of health system resilience using a concept analysis model.	Scoping Review	There is a lack of clarity in how the concept of health system resilience is used across the literature, potentially hindering cohesive research and knowledge translation.	Good
68	Varpilah, S. T., Safer, M., Frenkel, E., Baba, D., Massaquoi, M., & Barrow, G.	Rebuilding human resources for health: A case study from Liberia.	2011	Qualitative Study	Liberia	Examine the policy decisions implemented to rebuild the workforce focused on nursing professionals.	Case Study	Through the development and implementation of an Emergency HR Plan, the Government of Liberia was able to significantly increase the number of nurses by increasing and standardising salaries, mobilising donor funding to improve management capacity	Good

								and fund incentive packages, reopening training institutions, and providing scholarships.	
2	Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. P.	Resilience, adaptability and transformability in social-ecological systems.	2004	Qualitative Study	N/A	Discuss the components and dimensions of resilience in social ecological systems and provide a conceptual approach.	Social ecological model building.	Resilience has four components: latitude, resistance, precariousness, and panarchy. Highlights a need to shift the focus of sustainability science from seeking optimal states to resilience analysis, resource management, and adaptive governance.	N/A
5	Witter, S., Thomas, S., Topp, S. M., Barasa, E., Chopra, M., Cobos, D., Blanchet, K., Teddy, G., Atun, R., & Ager, A.	Health system resilience: a critical review and reconceptualisation.	2023	Editorial	N/A	Review the concept of health systems resilience, highlight problems, and provide a new conceptual approach.	N/A	Assessing resilience through the use of quantitative measures is not reflective of the capacity-oriented nature of health systems resilience as a process rather than an outcome. Shocks that trigger the need for resilience are typified as: short, long, short repeated, chronic health system stressors, and chronic health system dysfunction.	Good

14	World Health Organisation	Monitoring the building blocks of health systems: A Handbook of Indicators and Their Measurement Strategies.	2010	Report	N/A	Develop a framework to define the components and objectives of a health system along with proposed measures.	Literature Review and Critical Analysis	Health system components are typified as: leadership and governance, health financing, health workforce, health service delivery, health information systems, and medical products and technologies.	Good
25	World Health Organisation	Framework on integrated, people-centred health services.	2016	Report	N/A	Provide policy options in a framework for people-centred health services to support States in the achievement of the universal health coverage goal.	N/A	Strategies to develop people-centred health services are classified as: empowering and engaging people and communities, strengthening governance and accountability, reorienting the model of care, coordinating services within and across sectors, creating an enabling environment.	N/A
34	World Health Organisation	Liberia takes bold step to integrate COVID-19 vaccines into routine immunization	2023	Editorial	Liberia	Review the policy strategies implemented by the Government of Liberia to deliver a COVID-19 immunisation program an integrate it into the system's regular operations.	N/A	Liberia made significant progress to comprehensive uptake of COVID-19 immunisation programs through robust planned and enhanced implementation, integration of COVID-19 vaccines into routine immunisation,	N/A

								and expanded support for integration efforts.	
35	World Health Organisation	Liberia: WHO coronavirus Disease (COVID-19) dashboard with vaccination data.		Report	Liberia	Provide a summary of COVID-19 epidemiological data for Liberia.	Longitudinal Analysis	Morbimortality for COVID-19 peaked in Liberia in June 2021 with another spike in January 2022, with stable behaviour since. Vaccine coverage reached 74% of the eligible population.	N/A
61	World Health Organisation	Building health systems resilience for universal health coverage and health security during the COVID-19 pandemic and beyond: WHO position paper.	2021	Editorial	N/A	Provide policy recommendations for socioeconomic recovery and institutional transformation for resilient health systems to achieve universal health coverage after the COVID-19 pandemic.	N/A	Policy recommendations hinge on four main areas to leverage the COVID-19 response to strengthen both pandemic preparedness and health systems.	N/A

59	World Health Organisation	Fostering resilience through integrated health system strengthening: technical meeting report.	2021	Report	N/A	Summarise key learnings from a high level stakeholders meeting co-chaired by WHO and USAID discussing technical updates and next steps on implementation of health systems resilience activities.	N/A	Actionable next steps identified through the analysis included: strengthen or establish regional hubs or centres of excellence for health systems strengthening, enhance academic partnerships between countries through connecting schools of public health, support ministries of health to strengthen stewardship of national public health institutes.	N/A
76	World Health Organisation	Liberia: How reinforced community health structures and capitalizing on lessons learned from the Ebola virus epidemic of 2014–16 helped the country respond to the challenge of its second major disease outbreak in five years.	2021	Report	Liberia	Review the impact of community health programs designed after the EVD outbreak in improving the response to the COVID-19 outbreak.	N/A	CHWs were essential to avoid the breakdown of essential services. CHW training on outbreak preparedness, surveillance and management enabled access to COVID-19 and non-COVID-19 services to be resumed rapidly after initial disruption.	N/A
79	Zhang, Y., McDarby, G., Seifeldin, R., Mustafa, S., Dalil, S., Schmets, G., Azzopardi-Muscat, N., Fitzgerald, J.,	Towards applying the essential public health functions for building health systems resilience: A renewed list and key enablers for operationalization.	2023	Qualitative Study	N/A	Review the essential public health functions and how these are operationalised through key enablers.	Literature Review and Critical Analysis	A renewed list of 12 essential public health functions was produced and three key enablers were identified: high-level political commitment to public health,	Good

	Mataria, A., Bascolo, E., & Saikat, S.	multisectoral accountability mechanisms for delivering essential public health functions, and assessment of essential public health functions provision.

Appendix B: Master interview guide for data collection

Note: Lettered bullets under each question represent points for probing and guiding the conversation related to the study's propositions.

Section 1: Laying the foundation.

Before we begin, I would like to thank you for agreeing to participate in this interview and taking the time to meet with me today. Your valuable insights will be a tremendous contribution to my study on how transformative health system resilience was developed in Liberia in the context of the EVD and COVID-19 outbreaks and will provide impactful learnings on how the concept was operationalised and embedded into the system.

1) Could you describe your area of work and your functions during the EVD and COVID-19 outbreaks?

Probe for background, expertise, responsibilities, people in charge, authority, mandate.

2) How would you describe, from that portfolio, your placement within/relationship with the Liberian national health system?

Probe for stakeholder relations, shared goals, expectations and outcomes, shared/dependent functions like funding, stewardship, oversight, implementation.

3) *Using a visual of the conceptual model for this study as a prompt.* Would you consider the structure/functions of the Liberian national health system are well captured in this representation? What would you change? What's missing?
4) How would you describe the response of the Liberian national health system to the EVD and COVID-19 outbreaks? (Ask as two separate questions).

Probe for dimensions of resilience (absorptive, adaptive, and transformative) – use Blanchet et al *as a visual aid.*

5) Do you consider your involvement in the response contributed to the development of resilience in the Liberian health system? If so, how?

Probe for dimensions of resilience and specific elements/actions/interventions that led to developing resilience.

Section 2: Operationalising resilience.

6) When you think of a resilient health system, what are the features that make the system resilient?

The following series of questions will concern the characteristics and capacities of the Liberian national health system during and after its response to the EVD and COVID-19 outbreaks.

Always probe for existing capacities and those that were developed during/after the response. For the latter, gather details on how they were developed.

First, let's talk about **leadership and governance** in healthcare and health management/policy – including public health, as it relates to the responses to the previously mentioned outbreaks.

7) In your experience, was the national government leadership effective in setting up a clearly defined and cohesive command structure with clearly defined roles and responsibilities?

Probe for elements or organisational efficiency such as role clarity, knowledge sharing, and supportive learning.

a) In your experience, were there defined emergency operation centres (EOCs) as part of the response? How were these structured?

Define EOCs together with the participant, establish a common term and use that term going forward to replace the generic "EOC".

Probe for involvement of various sectors of government, service providers, relevant private sector partners and relevant international partners.

b) In your experience, were the EOCs effective in incorporating the local health facilities into their command structure to ensure reciprocal impact from service provides and decisionmakers?

Probe for development of capacity to incorporate health facilities into EOCs after EVD and during COVID-19, and support by regulatory frameworks..

8) Were the executive functions of leadership supported by national infection prevention and control guidelines grounded on legislation and regulations?

Probe for institutional enablers and barriers to designing, disseminating, and enforcing the guidelines. Make sure these include waste handling and caring for high-consequence infectious disease patients. Also probe for measurement and evaluation.

a) Was performance measurement, monitoring, and evaluation a component during and/or after the responses? Did the national leadership structure develop a plan to study health system strengthening from the emergencies?

Probe for resources allocated, stakeholder engaged, scope of evaluation, and objectives/outcomes.

Now let's address **health financing**. We can stipulate that, of course, health financing as a function is tied to most, if not all, other functions of the health system as one of the most essential resources.

However, let's focus on the individual role of financing to improve health system resilience during health emergencies, and how the actors within the system can use financing to build resilience.

Probe for public vs private, government vs NGO, admin vs service delivery, local vs international.

9) To your knowledge, how was the national response to EVD and COVID-19 funded? How was your involvement in the response funded?
   a) What is your understanding of how the Liberian national health system is financed?
   b) How did the EVD and COVID-19 public health emergencies impact health financing? What funding pressures were introduced?

   Probe for pressures within and outside health.

   c) From your experience, did the national response to the public health emergencies include mechanisms to ensure financing stability for essential services? If yes, what were the mechanisms? If no, what were the barriers to financing stability?
   d) For the responses to the outbreaks, are you aware of mechanisms that allowed the national system to access additional/targeted sources of funding and allow for the

reallocation of ordinary funding to support the response efforts? If so, what were these mechanisms?

Probe for sources of funding, type of funding (cash, capitals, loans, etc), allocation methods, fiscal accountability, timeliness of access.

Now that we've talked about the money part of the equation, let's cover the people component **(health workforce)**, arguably at the centre of the health system and which has certainly been brough to the limelight in recent years.

10) In your experience, as part of the response, did the national health system develop/implement a workforce strategy that allowed for enhanced routine and just-in-time tracking, training, deployment, and redeployment of health workers during the emergencies?

Probe specifically for the role of community health workers and the strategies for maintaining/enhancing the workforce supply, as well as the challenges to workforce supply.

a) In terms of workforce management, to your knowledge, did the Liberian national health system maintain the capacity to track healthcare workers to understand availability during emergencies and the ability to identify additional resources as needed?

Probe for strategies to identify and manage workforce attrition and maintain chains of command with appropriate leadership and technical expertise.

b) Were there efforts to promote continuing medical/public health education, either originated from within the national health system or supported by international initiatives, to help build capacity and strengthen the health workforce regarding the public health emergencies?

Probe for topics prioritised, key messages supported, the role of evidence, and emphasis on behaviour change.

From health workforce we can move on to talk about **health service delivery** as the direct output of the health workers.

For the purposes of this study and in the context of both public health emergencies, we will use the term "health services" broadly to cover not only direct healthcare (i.e. diagnosis and treatment), but also additional services like contact tracing, case confirmation, case management, immunisations, and safe disposal of bodies.

11) Besides the critical services related to the outbreak responses, what health services were considered essential?

Probe for other priority health problems that demanded attention along with the outbreaks.

12) Did the national response strategy include establishing temporary centres for essential service delivery or the reallocation of existing spaces to prioritise essential services?

a) Did the national health system engage support situational awareness of the availability/location of appropriate facilities? If so, was this information communicated to all relevant components of the system?

Probe for sources of intelligence and channels of communication.

13) How did the national response strategy include plans to develop surge capacity for healthcare surges during/due to the public health emergencies?

Probe for emergency services, primary care, specialised treatment, non-emergency surgical care.

We can now move on to discuss **health information systems** as a component *and* a function of the health system as a whole. Of course, we have touched on several of the outputs of health information systems in the other elements of health system resilience, but now we will focus on the specific ways in which health information systems contribute to developing resilience. As we know, one of the principal enablers of a response to an infectious disease outbreak is the system's ability to become aware of the disease as it emerges in the local environment.

14) In your experience, ahead of the EVD and COVID-19 outbreaks, did the Liberian national health system have the capacity to document which diseases should be under surveillance, implement processes for reporting and analysis (including expected frequency), and facilitate dissemination of epidemiological information to the rest of the health system? How did this capacity evolve over time during and after the outbreaks?

Probe for specific developments in the reporting mechanisms, analytical epidemiology, and establishment of standardised guidelines.

a) In your experience, was there a national strategy in place to keep facilities and health service providers apprised of the situation and facilitate information sharing, including providing updated guidelines on outbreak management?
b) In response to the EVD and COVID-19 outbreaks, was the national surveillance system capable of ongoing case detection and report analysis to inform decision-making?

Probe for tracking nosocomial infections.

In outbreak situations, the response may very well hinge on access to diagnostic technology, therapeutic products, immunisations, and personal protective equipment, making **medical products and technologies** a crucial enabler to outbreak management.

15) As part of the response, did the national Liberian health system have a strategy to review resources shortages, access additional resources and maintain supply chains? If not, was there space to develop such a strategy?

Probe for logistic corridors, supplier relationships, access to bilateral/international resources, enablers and barriers, and performance.

a) In your experience, how did the national system handle PPE, directed at service providers and the general public?

Regarding **trust in the health system**, we will focus on public efforts to include the community in the responses as stakeholders. This includes, of course, risk communication and information sharing, but we will also consider delegation of authority, involvement in decision-making, establishment of trust, and legitimacy building.

16) In your experience, how was the community (as a whole and by priority sectors) involved in the response including decision-making, advocacy, oversight, and health promotion?
a) In your experience, as part of its response to the public health emergency, did the Liberian national health system put in place strategies to identify sector of the population that were at risk of being disproportionately impacted by the crises?

Probe for issues of equity, social determinants of health and multisectoral considerations.

b) Similarly, in your experience, did the national response involve the identification of community leaders/representatives (e.g., religious leaders, traditional village leaders or chiefs, etc.) to act as main points of contact and response ambassadors?

c) In your experience, how did the national government and key partners handle communications with the population? How comprehensive and accurate was the public messaging?

Probe for key messages targeting priority community sectors, messaging delivered in culturally appropriate and accessible formats (including language), risk communication specific enough to enable community situational awareness?

Probe for providing accurate and reliable information on health facilities and services (including where and how to access), and safety and appropriateness of health facilities.

Finally, let's talk about **interinstitutional collaboration** with both regional and global partners and how this may have been harnessed to contribute to developing resilience in the Liberian context.

Cooperation with other countries and international organisations is, of course, an integral component of Liberia's national health system and is well embedded into the system's regular functioning, so we will focus primarily on how cooperation was leveraged during the public health emergencies to aid in the response, and ultimately contribute to the development of resilience.

17) What is your perception of Liberia's relationships with its partner organisations in the health system? How were these relationships influenced by the EVD and COVID-19 outbreaks?

Probe for specific organisations and stakeholder dynamics.

a) In your experience, during the outbreaks, how did the Liberian national health system engage its stakeholders to facilitate change and adaptation to the public health emergencies?

Section 3: Integrating concepts.

18) From your perspective, what actors in the Liberian health system oversaw the decisions interventions that shaped the response? How did the national government integrate input from non-governmental partners into their approach to the public health emergencies? Is this reflective of the general dynamics in the Liberian health system?

19) In your opinion, to what extent has the Liberian national health system transformed its processes, policies, and institutions, or become better able to continue to perform at least relatively well in the face of significant shocks?

20) What evidence of evolution or "learning" in the system have you seen?

21) Is there anything else you would like to add before we end this interview?

I want to extend my sincere gratitude for taking the time to participate in this interview, for your rich insights, and for the invaluable contribution that the data from our conversation represents for my study on health system resilience in Liberia. I look forward to continuing our communication to share the results of my study, and hopefully continue collaborating on this fascinating and challenging field.