**Distribution Agreement**

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ __04/18/2023_____

HORIJA JOOF

# Assessment of Healthcare Information Systems in Sierra Leone and Liberia, 2023

By

Horija Joof

MPH

Hubert Department of Global Health

Scott JN McNabb, PhD, MS

Committee Chair

# Assessment of Healthcare Information Systems in Sierra Leone and Liberia, 2023

By

Horija Joof

Bachelor of Science in Biological Science

Atlanta Metropolitan State College

2020

Thesis Committee Chair: Scott JN McNabb, PhD, MS

An abstract of

A thesis submitted to the faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health

in Global Health

2023

## ABSTRACT

**Background**: Public health surveillance (PHS) is incredibly significant to monitor diseases, outbreaks, and response. Healthcare information systems (HIS) are also incredibly significant to manage healthcare services and PHS. Sierra Leone – a member of the West Africa Health Organization (WAHO) is situated on the West coast of Africa with a population of approximately eight million. In Sierra Leone there are five administrative regions subdivided into sixteen districts. Liberia – also situated in West Coast of Africa with a population of five million – is divided into 15 regions and subdivided into 90 districts and clans. The 2014 – 2016 Ebola pandemic caused devastation in Guinea, Sierra Leone, and Liberia; there is still much support needed. Healthcare in Sierra Leone and Liberia is concentrated on family planning, antenatal and delivery care, and disease prevention through immunizations. They have HIS that are extremely weak in infrastructure; limitations include lack of servers and computers, poor internet connection, and power supply. HIS personnel lack skills for proper maintenance and development of national HIS, with a general lack of qualified IT personnel.

**Methods**: A systemic literature review was employed to assess the state of HIS in Sierra Leone and Liberia using relevant literature and documents available from primary and secondary sources.

**Results**: The current status of HIS in Sierra Leone and Liberia (post-civil war and post Ebola outbreak) shows that technical infrastructure is unevenly distributed between rural and urban areas. This poses a challenge for designing solutions that will make interoperability possible within both countries. Nonetheless, efforts have been made to build a more resilient HIS with a manageable and sustainable system. The information gathered by this analysis maybe limited in some areas, but it still details the need for investment in HIS to help build a better more resilient health system and make response to disease outbreaks or public health emergencies easier for Sierra Leone and Liberia with limited resources. There is also a need for capacity building, trained human resources, and government backed policy for creation and implementation of HIS.

# Assessment of Healthcare Information Systems in Sierra Leone and Liberia, 2023

by

Horija Joof

Bachelor of Science in Biological Science

Atlanta Metropolitan State College

2020

Thesis Advisor: Scott JN McNabb, PhD, MS

A thesis submitted to the faculty of

the Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health

in the Hubert Department of Global Health 2023

**Acknowledgments**

A great thank you to my terrific advisor, Dr. Scott McNabb, for his genuine interest in mentoring me through this project. His always amazing advice, patience in helping me synthesize and refine this topic. His dedication to public health and mentoring Rollins students, I look forward to gaining more knowledge from you throughout my career in public health. You are a true gem to the Rollins and the public health community.

Thank you to, Amanda Prophett my ADAP for answering all my questions and always helping me, Shenita Peterson, and Mia White for assisting and helping me narrow my topic and developing search terms that made my literature review a reasonable undertaking.

Finally, I would like to thank my family and friends, especially my lovely sister Isatou for always encouraging me and pushing me to always be a better version of myself. My Mother for always making me see the positive side of everything even when things are hard.

**Table of Contents**

## Chapter 1: Introduction

African and international health agencies understand the requirements for modern, efficient, and effective health information systems (HIS). An integrated, interoperable HIS within a national framework where data, information, and messages are available when and where needed should be a common goal to tackle the complex issues affecting global health security.

Outbreaks, developmental challenges, and conflicts pose serious threats to fragile health systems. In Dec 2013, an Ebola outbreak began in Guinea and spread to Liberia and Sierra Leone in 2014. The epidemic has claimed an estimated 11,310 lives in the West Africa Health Organization (WAHO) region. [1] The rapid spread and high mortality prompted the World Health Organization (WHO) to officially declare a public health emergency of international concern (PHEIC). [2]

The HIS present in these countries lacked the infrastructure and preparedness to respond quickly to the outbreak. Sierra Leone and Liberia are among countries with the lowest level of public investment in healthcare; histories of civil conflict and unrest in both countries have caused great suffering and poverty which has burdened a HIS already fragmented and weakened.

However, Sierra Leone and Liberia have invested heavily in HIS for better service delivery, PHS, and reporting after the devasting Ebola outbreak of 2014. This systemic review assessed HIS in Sierra Leone and Liberia, taking a close look at existing data and analyses on HIS systems and PHS before, during and after the 2014 Ebola pandemic.

### 1.1 Background

Sierra Leone and Liberia are small West African countries situated on the Atlantic coast. Sierra Leone is situated on the West coast of Africa with a population of approximately eight million people. There are five administrative regions subdivided into sixteen districts. Sierra Leone had the greatest number of Ebola cases during the outbreak. The public health system including PHS broke down because of the being overwhelmed. [3] The Ebola outbreak proved devasting to vulnerable populations. [1] HIS infrastructure was extremely weak with poor conditions for IT equipment such as humidity and dust. Power outages also presented dangers to equipment, and poor communication create challenges for data collection and reporting. [4]

Liberia is situated on the West Coast of Africa with a population of five million divided into 15 counties and further subdivided into 90 districts and clans. Health-related activities were concentrated on family planning, antenatal and delivery care, and disease prevention through immunization. [5] The Ebola outbreak proved devasting to the population causing considerable mortality and morbidity for the communities affected. HIS in Liberia are extremely weak in infrastructure. Limitations in IT infrastructure include lack of servers and computers, poor internet connection, and power supply. HIS personnel lacked advanced skills for proper maintenance and development of national HIS with a general lack of qualified IT personnel.

### 1.2 Statement of Purpose

The functionality and quality of HIS came into question during the Ebola epidemic in West Africa. PHS was not acceptable, leading to many infections and deaths. There are many challenges and factors responsible for the lack of effectiveness of HIS for PHS and healthcare services. The purpose of this review was to assess the state of HIS in Sierra Leone and Liberia using existing data and analyses before, during, and after the Ebola epidemic of 2014.

## Chapter 2: Methods

A systemic literature review of articles and reports that assessed the state of HIS in Sierra Leone and Liberia was performed making use of primary and secondary sources. This review included articles from West Africa with a concentration on Sierra Leone and Liberia regarding PHS, HIS, and disease outbreak responses during the 2014 – 2015 Ebola epidemic.

All searches included ("Sierra Leone" OR "Liberia") and combinations of search terms related to PHS ("Public Health," "Surveillance data," "surveillance"), HIS ("information systems"," Health Information Systems") and infectious disease outbreak response ("infectious," "disease," "infectious disease," "outbreak," "response"). Citations from all collected articles and reports were exported to Endnote™. A systematic literature review was performed for all relevant articles and evaluated for inclusion. Inclusion criteria used for the review included studies …

- conducted in West Africa (Sierra Leone and Liberia).
- including urban and rural areas.
- assessing PHS and HIS in West Africa.
- on PHS and response.
- on the 2014 – 2015 Ebola outbreak in West Africa.

Full text of selected articles that met the inclusion criteria were obtained, as well as reference sections scanned to identify additional articles of interest. Relevant data were extracted from articles, and abstracted information included reference, region and country study was conducted, study design, population studied, key findings and results.

## Chapter 3: Results

The database search identified 18 published articles that included the search terms and met the inclusion criteria. Full text was obtained for all published articles and studies; 15 included analyses and assessment data on HIS systems, PHS, and response. The remaining four gave analyses of HIS and the state of healthcare in Sierra Leone and Liberia. Other data sources from the World Health Organization (WHO) regarding HIS were obtained. Study findings concentrated on research articles and materials obtained for the systemic literature review.

### 3.1 Health Information Systems (HIS)

A good HIS at all levels is particularly important for healthcare. HIS has multiple goals (e.g., improving health and health equity). To achieve them, all healthcare systems must carry out basic functions. These functions can be carried out through six building blocks: good health services; well-performing workforce; good health financing; leadership and governance; a well-functioning health system; and HIS. [6] A well-functioning HIS is one that ensures the production, analysis, dissemination, and use of reliable and timely information on health determinants, health system performance, and health status. [6]

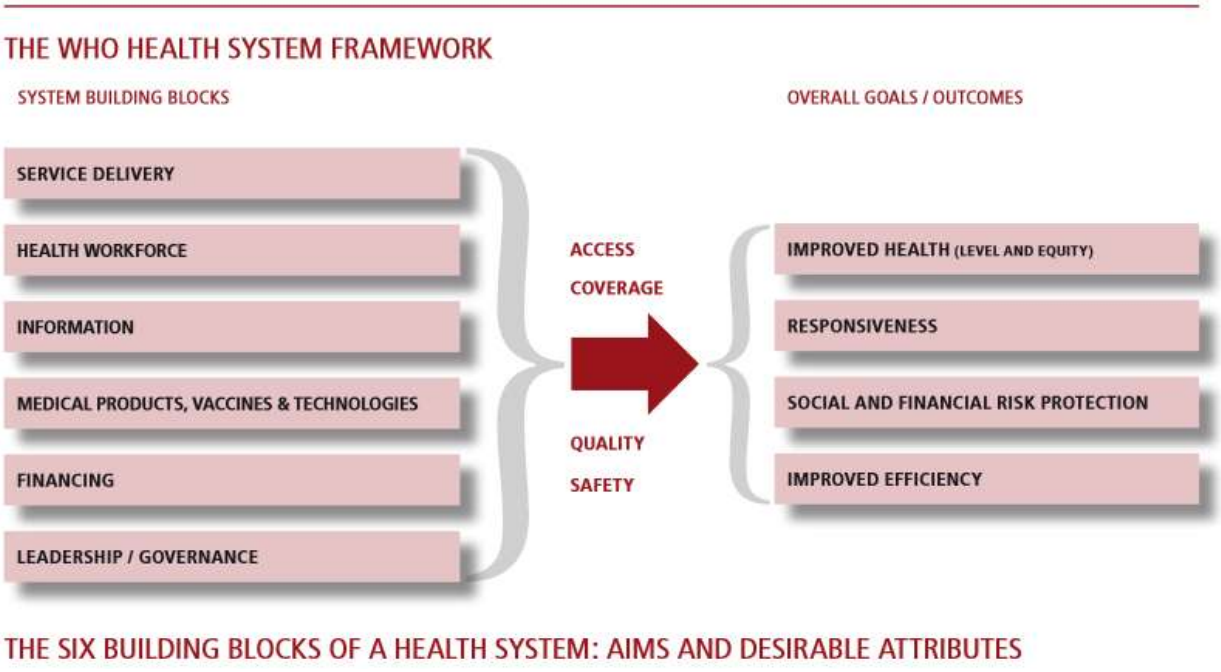



**Figure 1**: The World Health Organization Health System Framework. **Source.** World Health Organization, Geneva, Switzerland [6].

In 2005 the Health Metrics Network (HMN) launched to provide global leadership as well as consensus for the over-all strategy for the development of HIS in low- and middle-income countries (LMIC). [7] The rationale and justification for strengthening HIS is that health information matters, measurement in health in conceptually and technically complex systems are fragmented leading to poor performance, and recognition of weakness in systems will be particularly important drivers for change. [7] HMN framework provides an overview, context, and tangible goals for national HIS development and provide guidelines for how LMIC African countries can achieve the goals set by the framework. [7] HMN can provide the guidelines for how HIS systems could be built in Sierra Leone and Liberia.

Given the current status of HIS in Sierra Leone and Liberia, technical infrastructure is unevenly distributed between rural and urban areas posing a challenge for designing solutions that will make interoperability possible within a country. The HMN technical framework advises countries to implement a central data repository receiving data electronically from subsystems purposing uniform access to a wide area network like the internet. With many data sources being paper-based, new ICT solutions need to be established to mitigate fragmentation and create an interoperable system. (Figure 2)

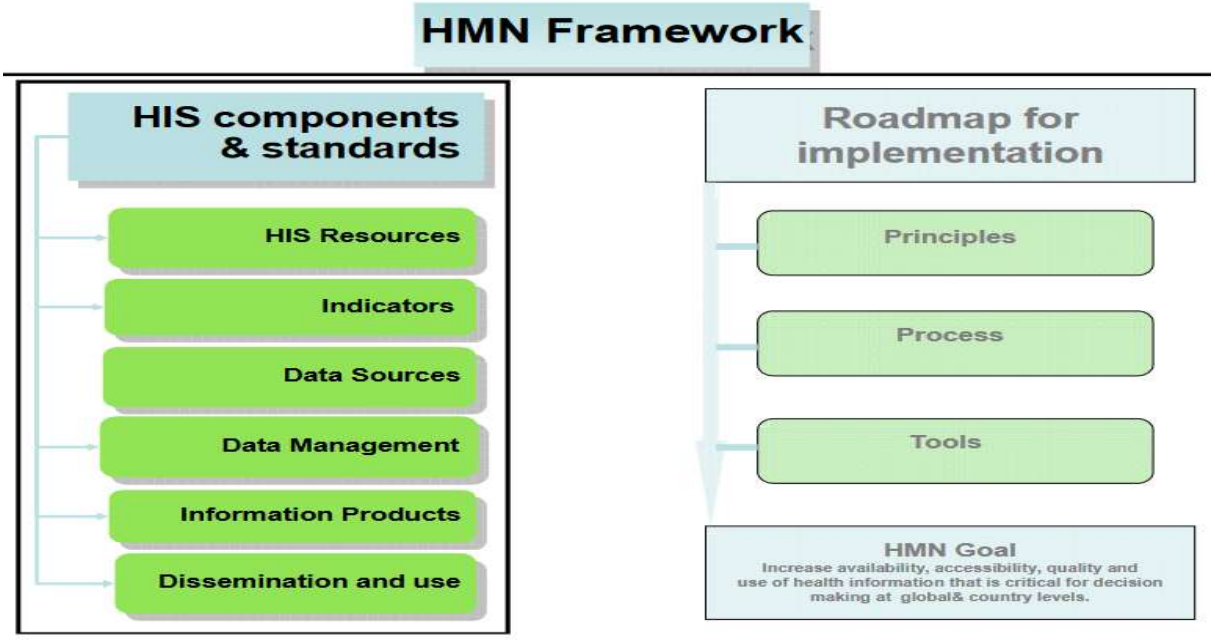



**Figure 2**. HMN Framework components and standards **Source**. WHO framework and standards for country HIS development [7]

### 3.2 Sierra Leone Digital Health Landscape

The Sierra Leone's government and partners have invested heavily in HIS for-service delivery, PHS, monitoring, and reporting. In 2018 Sierra Leone's government launched its first digital health strategy; in 2019 a broader national innovation and digital strategy was launched. [8] The aim was to launch the health pillar in the direction of using big data and artificial intelligence (AI) to improve healthcare in general and maternal and child health in Sierra Leone. [8]

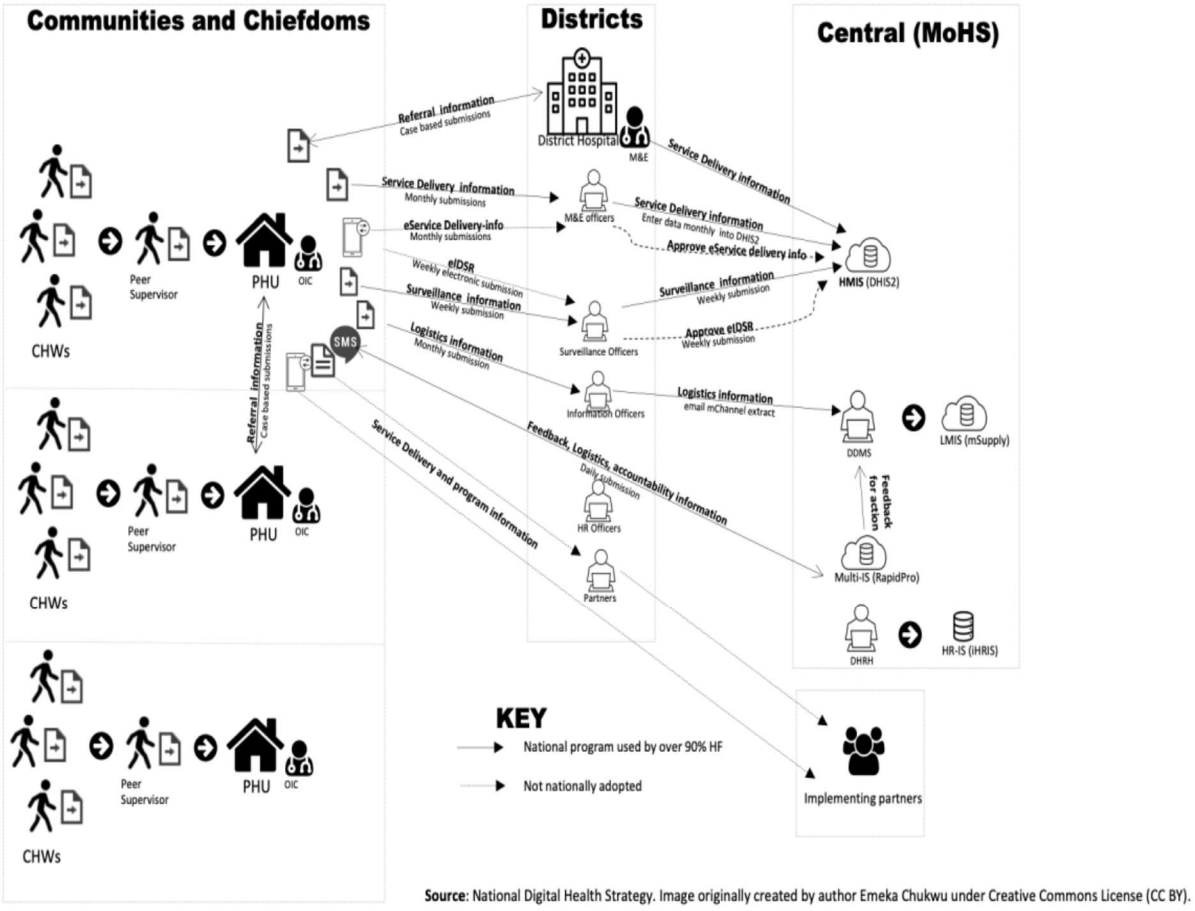
In 2017, the Ministry of Health and Sanitation (MoHS) inaugurated an eHealth coordination hub to facilitate the systemic application of digital health solutions for health systems improvement through data. [8] The 2019 broader national innovation and digital strategy set out three strategic health pillars for 2019 – 2029:

1. Application of data science methods such as AI, diagnostics imaging, genomics, environmental, and other data analytical methods for automated disease diagnostics, predicting disease outbreaks, disease prevention, and identifying high-risk groups for planning and resource allocation.
2. Use of AI to support junior-level and expert-level healthcare practitioners to make better healthcare decisions related to treatments and referrals in quicker time and for more people; and
3. Use of an integrated community and technology approach to significantly reduce maternal and child mortality.

There are 1,284 health facilities in Sierra Leone, including 24 district hospitals and the remaining are primary healthcare units. [8] Sierra Leone has been a "first wave" country for implementing the HMN model since 2007, including initial HIS assessment, development of strategic plan, and development of national HIS as according to the HMN Framework. [8] National data sets and reporting tools in Sierra Leone have been harmonized using the District Health Information System (DHIS-2). DHIS-2 data repository software application has been implemented at the district and national level in Sierra Leone between 2008 and 2009 as a pilot program. The country was selected as one of the HMN for Health Information Systems Strengthening (HISS) in West African

countries and initiated a project to use DHIS-2 as a national data warehouse for integrating various structures of data reporting at district levels. [7]

DHIS is a generic tool for collecting, managing, and presenting aggregated data and indicators. It is a free, open source, web-based health HIS that has been deployed in numerus countries in Africa and Asia through the HISP Network. As of 2018, DHIS-2 was implemented in 46 countries across four continents and at different health systems. [7] Sierra Leone has been using the DHIS-2 web-based system to develop and generate a general maturity model for scalable and comprehensive solutions and strategies for national HIS development. DHIS is used for the delivery of PHS unit reports to the MoHS at the central level. The health facility's aggregate service delivery report submission rate was at 98.6% and 91.4% submitting rate. [8] (Figure 3)




**Source**: National Digital Health Strategy. Image originally created by author Emeka Chukwu under Creative Commons License (CC BY).

**Figure 3**: DHIS health information flow in Sierra Leone [8]

In 2022, the Directorate of Planning, Policy, and Information at the Sierra Leone MoHS and the Directorate of eGovernment, Ministry of Information and Communication collaborated with the Monitoring and Evaluation Unit, Health, and Nutrition UNICEF to do a landscape analysis of the digital health solutions and the interoperability of the system. A stratified sample of 72 health facilities was selected out of the 1,284 facilities nationwide. District health medical officers (DMOs) where targeted for this study as they were the health care policy implementers in their respective district and oversee the district health programs. [8]

The digital health mapping was done using questionnaires sent to DMOs and digital health implementing organizations were also visited, and questionnaires distributed for surveys. Data collection and analyses were done at the national level and then at the district level. Interviews were carried out using the CommCare mobile app which facilitated automatic data transmission to the cloud for easy access. The data were aggregated and analyzed using “pandas” and “matplotlib” libraries of Python. [8] The results of the digital health landscape are grouped into data sharing practices and current data use.

DHMT survey findings show that Kailahun, Kenema, Karane, Pujehun, Moyamba, Freetown-Western-Rural, and Freetown-Western-Urban districts reported having four or more digital health services and applications. Bo and Kono districts had three, and the remaining districts had two or fewer health services and applications. Among the digital health solutions, every district used the national District Health Information Software (DHIS-2). [8] Health facility survey findings showed that three health facilities had four or more digital health services and applications, and the majority of them use DHIS for aggregate reporting. Some health facilities reported using SMS reporting through RapidPro and the NHMIS-paper-form HF1_HF9 reporting tool. (Figure 4)

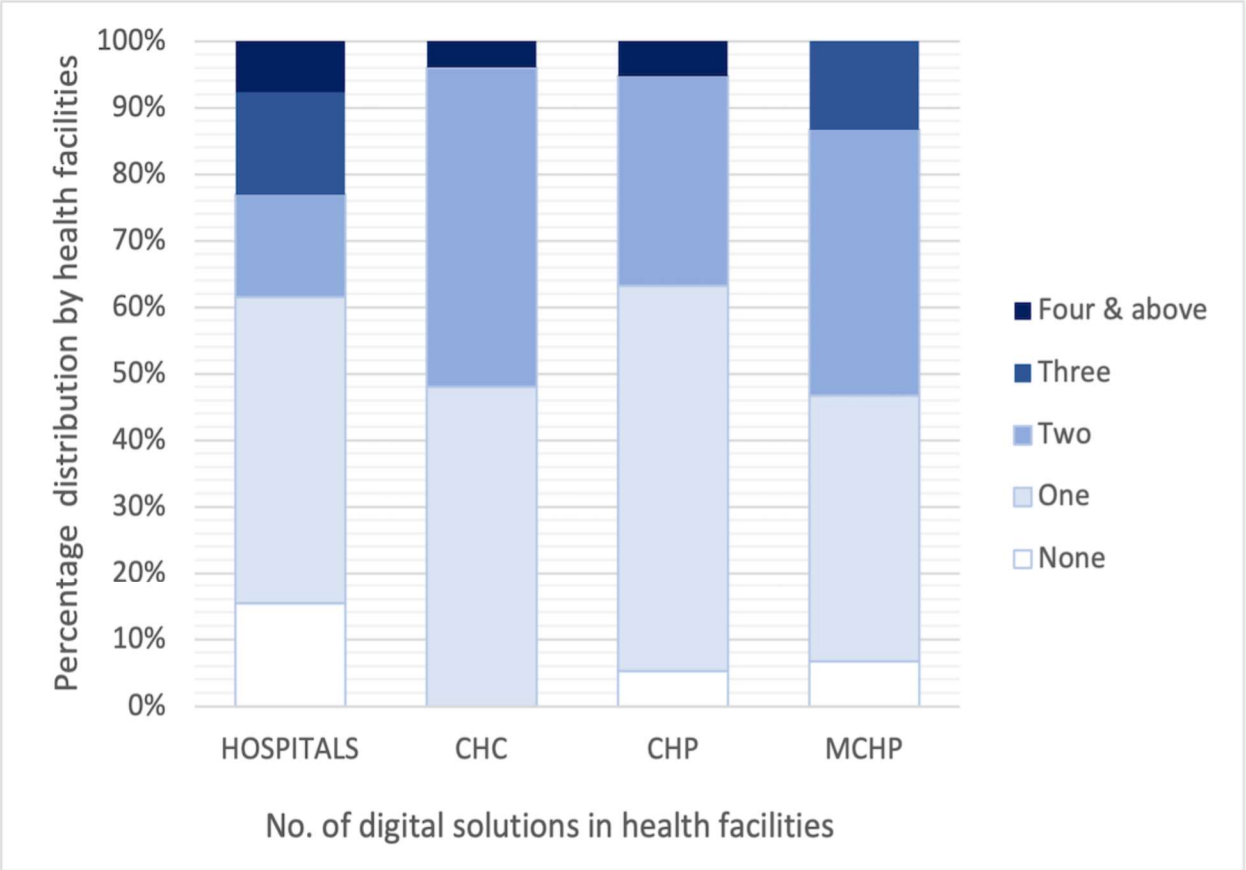



**Figure 4.** Health facilities by the number of digital health activities (health facility survey). CHC: community health center; CHP: community health post; MCHP: maternal and child health post; No: number [8]

Findings from this study show that the majority of implementing partners used DHIS, noting that the status of their digital health is active and working. Information sharing shows that all but one of the districts shares information with the MoHS, NGOs or other implementing partners. [8] Some districts shared information vis email, printed format and others reported sharing information through SMS. All districts were, however, required to submit data through the NHMIS web portal monthly in the required format. Majority of implementing partners reported having written standard operating procedures for the facilitation of data exchange. [8] Most data shared was in the government approved format in addition to other formats. Although data were being shared among district implementers and stakeholders, there was no interoperability in how data was formatted and shared. Mapping, however, showed that there were many digital health solutions in operation at health facilities in Sierra Leone.

Addressing the problem of how to integrate HIS systems in low-income countries with varying technical infrastructure and human resources is an important part in addressing PHS issues in these low resource settings. In 2010, following the establishment of a DHIS system by HMN, a collaborative effort was made with the Open Architecture, Software and Information Systems for Africa (OASIS), the Ministry of Health in Sierra Leone, HMN and other stakeholders to create an integrated eHealth system. [9] A pilot was created to convince various stakeholders to standardize and share their health information and all of them would benefit by using the following approaches:

1. Acknowledge the existence of the various overlapping data collection tools by providing a data entry for each one of them in the DHIS system.
2. Harmonize all the data elements being collected inside the database.

These approaches ensured that data from all stakeholders and partners were integrated into one database. The pilot was regarded as a success after initial integration of data helped the Ministry of Health with comprehensive analysis of all public health data collected in the country. [9] The main goal was to create a comprehensive and scalable HIS applicable in Sierra Leone. The DHIS and OpenMRS systems implemented nationwide is interoperable; this will have created a system that is scalable as patient records expand to new groups. [9] The main aim of integration was to ensure that OpenMRS will aggregate data and automatically report it to DHIS, and facilities using mobile data entry will be able to aggregate data and have it entered into DHIS monthly. [9]

To achieve this flexibility in design, several factors will need to be considered. The maturity of the model is a significant factor as the solutions need to grow over time from one level to the next to be more comprehensive. The maturity model represents the practical way in which to implement the HMN framework with the national data repository representing an integrated framework in which medical records system can be scalable. [9]

Another factor required for successful implementation is reuse of information; reuse of information collected for another purpose or in another context. [9] Clear definitions should be given to define the data fields for use by different systems; this will make

rolling up information from district level to national level easier. Addressing these challenges will require establishing an institutional base capacity building and collaborations with international stakeholders at the educational and academic level. [9] Results from this pilot and implementation show that the approaches presented emphasize flexibility, architecture, and collaboration. [9] (Figure 5)

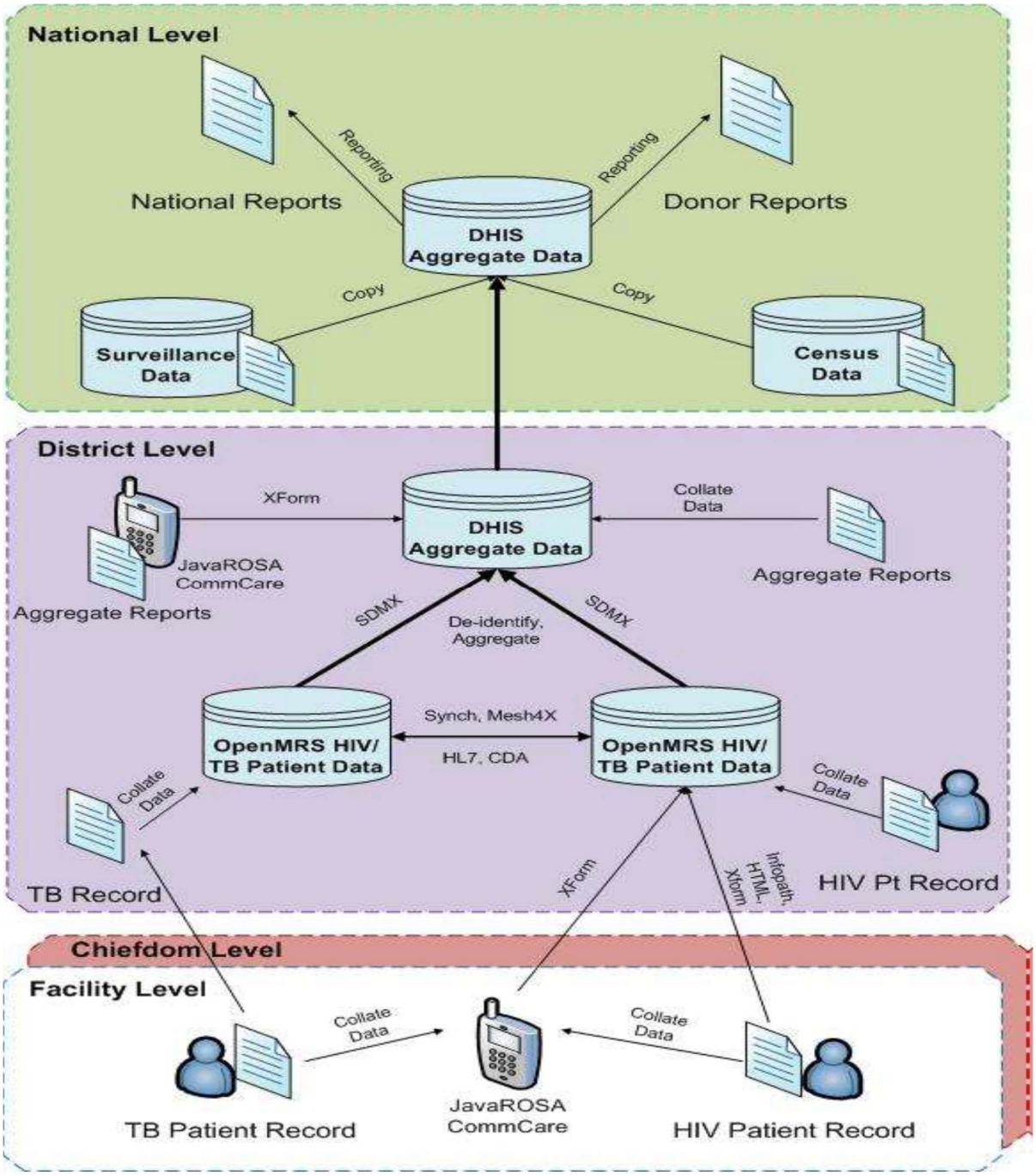



**Figure 5**: Proposed OASIS-DHIS eHealth enterprise architecture for Sierra Leone [9]

The next steps are to build off of the existing deployment of OpenMRS and DHIS, deploying OpenMRS and mobile solutions where appropriate, and helping to build capacity where necessary. [9] This can be achieved through establishment of simple systems and the gradual introduction and spread of more tools over time.

The Ebola outbreak in Sierra Leone proved devasting to the population. This led to a breakdown in trust in the healthcare system which was unprepared. A study was conducted to look at the impact of Ebola on the health systems and population health in Sierra Leone. Field work for the assessments was undertaken in Moyamba district which has a population of 373,000 in the Southern Region and in Koinadugu district with a population of 398,000 in the Northern Region during the months of February and May 2015, respectively. [1]

Mixed qualitative and quantitative methods were employed, with interviews conducted across both districts with the participation of local stakeholders such as District Health Management Teams (DHMT). A representative sample was collected from each district looking at geography, health facility type, and condition and resources of the facility. [1] Ebola response data were obtained and assessed and paired t-tests were performed to compare the mean difference in monthly and period attendance counts between years. [1] Findings showed a loss of trust in the health system which led to reduced utilization of services, highly avoidable all-cause mortality, adverse impacts on the health workforce and health system leadership and governance, and disruption of essential health programs and systems. [1] These have consequences on population health and the healthcare system.

Ebola impacted the healthcare system; there were direct losses as healthcare workers were infected with Ebola and many lost their lives. [1] This led to understaffed health facilities and over worked health staff. Health system resources and other healthcare resources were diverted to the Ebola response leading to the disruption of vertical healthcare programs such as HIV, malaria, and nutrition programs. [1] Findings showed a current public health emergency as a result of the Ebola outbreak.

A compromised health system had been impacted; vertical health programs and activities and essential systems were disrupted.

There were limitations to the study, as it was conducted in two districts considered representative of the country outside of the western region. [1] However, the Ebola outbreak did not affect every district health system in the same way. Other districts were affected more than others, but overall findings described the wider impact of the Ebola epidemic on the health systems of Sierra Leone. [1]

During the Ebola outbreak in West Africa, the U.S. Centers for Disease Control and Prevention (CDC) initiated multiple activities in Sierra Leone under the Global Health Security Agenda (GHSA) whose purpose is to prevent, detect, and respond to infectious disease threats through core capacities required by International Health Regulations (IHR). [10]

Since 2015, the CDC worked with stakeholders and partners in Sierra Leone to assist the Ministry of Health (MoHS) in developing Integrated Disease Surveillance and Response (IDSR). [10] A study was conducted to look at the implementation of the nationwide facility based electronic PHS in Sierra Leone and the lessons learned. System development and implementation, and system assessment and data analysis were the methods applied to assess the facility based electronic PHS being implemented nationwide. [10] IDSR had been implemented in health facilities across Sierra Leone, where a health facility focal person completed a weekly paper reporting form comprised of a total of 26 priority diseases or conditions. [10]

Systems development and implementation was divided into two phases where Phase 1 was system development and Phase 2 was IDSR implementation. In Phase 1, data entry staff, computers, and internet were placed at District Health Management Teams (DHMTs). A national web-based PHS database was developed using DHIS-2, and data entry staff were trained on how to enter data into the new system weekly. DHMTs were the only one using the eIDSR during phase 1, while health facility focal persons continued to use paper forms.

Phase 2 was the eIDSR implementation at the health facility level with the use of android tablets for data entry with district level review of submissions. Health facility-based IDSR is the first at-scale use of mobile systems for healthcare (mHealth) in Sierra

Leone. Mobile eIDSR app was developed to help facilitate the data entry directly from the health facility to the national database. [10]

System assessment and data analyses were done with a mixed-methods approach employed to assess the system's performance. Continuous feedback monitoring during and throughout development was essential in providing feedback on operational issues, permitting iterative improvements. [10] Continuous feedback, usability, user acceptance assessment, data quality, and system performance were used. This continuous feedback method identified multiple issues with the health facility based eIDSR application as initially implemented. [10]

Lessons learned are that Sierra Leone's health facility-based eIDSR system depends on financial requirements from partners, and sustainability and long-term ownership in a low resource setting depend on the reconciliation of many priorities competing for limited funds. [10] There was success in the use of eIDSR in Sierra Leone, this demonstrates the feasibility of national scale, facility-based mHealth PHS in limited resource settings. [10] Sierra Leone's efforts may be considered by other countries in enhancing their PHS and reporting for global health security purposes for low-income countries.

A systemic review was conducted to look at the link between the West Africa Ebola outbreak and health systems in Guinea, Sierra Leone, and Liberia. The systemic review was conducted following the PRISMA guidelines, with relevant literature search from databases including Medline™, Embase™, Global Health™, and Cochrane library™. [2] Google scholar™ and Scopus™ were searched for grey literature; article was chosen based on an inclusion and exclusion criteria.

The collected data were then extracted into a spreadsheet and analyzed, and critically appraised using the Crowe Critical Appraisal Tool. [2] Expert interviews where participants were identified from reference lists and using the snowball method were conducted. [2] The search strategy yielded a total of 969 articles out of which 13 were selected for data extraction. [2] Articles analyzed looked at healthcare workforce, health financing, information and research, medical products and technologies, service delivery, leadership, and governance. [2] The review and the expert interview explored

the nature of the link between the West African Ebola outbreak and health systems in Guinea, Sierra Leone, and Liberia.

Results from the study suggest that healthcare work force had a major effect on the control of the outbreak. These countries lacked the experience and resources to respond promptly and appropriately because of the shortage of healthcare workers. [2] Lack of trained health workforce for PHS and investigation of cases and lack of diagnostic facilities also made an impact on the outbreak.

The lack of policies and IPC strategies in place before the Ebola outbreak meant that there was a gap in investment in infrastructure, training of health staff, and availability of needed supplies and medication. [2] Problems in service delivery as a result of resources being diverted to the Ebola outbreak, causing interruption to health programs such vaccination programs, HIV programs, maternal and child health programs, and nutrition programs. [2]

There were limitations to the study as the number of articles selected was limited due to the selection criteria scores. Expert interviews also created limitations due to the ways they were identified and invited for interviews. However, there are lessons learned from this study. The study offered several implications for practice and research such as the importance of training healthcare workforce, government and stakeholders investing in health infrastructure, and capacity building to revive the weakened health systems to better prepare for disease outbreaks.

Further study was done to assess the institutionalized data quality to improve the accuracy of IDSR in Sierra Leone. The methodology applied for this analysis was random selection of healthcare facilities and interviews with district health management teams (DHMT) and health facility staff. Four retrospective assessments were conducted in the selected health facilities and districts, and IDSR data were collected. [3] The DHMT would list all health facilities included in the IDSR reporting system, stratifying them by service level and ownership. For each type of facility, selection would be done using randomly generated computer numbers. [3] Data accuracy was validated by calculating a verification factor (VF) that was the ratio of the verified value. [3] Interviews were conducted with DHMT who gave an overview of the DQA process, how IDSR data

were being processed and stored from the district level to the national DHIS-2 health data system. [3]

Results of this assessment showed that four data quality assessments were conducted in 444 health facilities. Weekly IDSR reports were reviewed for data collection, collation, analysis, and reporting. [3] Results show that the IDSR reporting tools were available in lower-level health facilities but were less available in hospitals and laboratories. The proportion of accurate reports was consistent across all healthcare facilities. Healthcare facilities owned by not-for-profit organizations over reported data in the IDSR system, and under reporting was done in the community health posts and the maternal and child health post facilities.

Overall, the accuracy of data reporting improved as the assessments were conducted. Discrepancies in data were as a result of the compilation of data generated monthly and data in the DHIS-2 system. Other discrepancies were a result of missing registers, failure of submission of health facility IDSR weekly reports, and failure to enter data into the DHIS-2 system. [3] This assessment implies that regular data quality assessments can contribute positively to data quality and accuracy.

Ravaged by the prolonged civil war, Sierra Leone's healthcare system suffered from a huge loss of both personnel and infrastructure. Rebuilding and providing the capacity to improve services has been supported by the government and the international community through many agencies (e.g., UNAIDS, WHO, UNICEF). [11] The rapid growth of various health initiatives and the need to achieve the millennium development goals has created a situation of fragmented health information systems. To counter this fragmentation, health information systems need to be integrated and strengthened. [11] HMN started an initiative in 2007 to integrate the HIS system in Sierra Leone at the district and the national level by employing novel approaches such as solar-powered low energy computers, running Linux programs and countering problems of electricity supply breakdowns and computer viruses. [11]

The research along the lines of Action Research (AR) which is a form of participative research where the researcher takes part in the change processes in an organization. [11] There are critiques often raised against using AR in the field of IS research, but it

has over the last two decades increasingly become accepted as a way to generate very relevant research findings on technology in its human context. [11]

The writers of this paper are also the researchers who are actively involved in the project to integrate the HIS system in Sierra Leone. Based on these strengths and weaknesses, solutions were proposed to provide meaningful and relevant information for decision making and to diminish the workload of staff who is collecting and reporting the data. [11] (Table 1)

| Strengths | Weakness |
|---|---|
| • **Clear and understood reporting procedure.**<br>• **CRIS used in all districts.**<br>• **Computers in all districts**<br>• **Information awareness and computer usage very good in one of the districts visited; multiple spreadsheets designed and used for particular program activities displayed on the wall.** | • **Poor IT skills of data management teams at all levels**<br>• **Lack of power supply**<br>• **Lack of resource to fuel regularly the generators.**<br>• **Lack of IT support and recurrent viruses' problems**<br>• **Multiple and not well coordinated tools and formats for data reporting from facility to district, with overlaps and gaps, are in use;**<br>• **Multiple computer based tools in use, also with overlaps (same data captured in different systems), and they are not linked**<br>• **Data analysis and local reporting carried out in districts by re-capturing data in excel spreadsheet.**<br>• **Data aggregated to district totals before reporting to national; making quality check of data difficult.**<br>• **No feedback on reports from national districts**<br>• **Reporting from hospitals very poor (e.g., incomplete, poor coverage); morbidity and admissions/discharges reported, but not time spent by patients in hospital (laying days/bed-days), resources utilization therefore not possible to deduct.**<br>• **Anti RetroViral therapy (ARV) patients managed by not-optimal paper record system; very difficult to provide outcome and cohort indicator reports based on current system** |

**Table 1**: Strengths and Weakness of HIS system in Sierra Leone [11]

A consortium consisting of the MoH of Sierra Leone and health programs, HMN, ICT Development Center-IDC Sarl and Inveneo which are both IT companies who bring diversity and synergy to the project. [11] Infrastructure, was also another challenging factor, and the decision to use trained and qualified IT companies such as Inveneo to setup low power hardware operating systems was significant in helping health officers

access DHIS systems. [11] Software development and capacity development was incorporated into the project to address the problems of previous HIS systems.

DHIS data systems were assessed for system problems and the results show that data was duplicated from health facilities as a result of collection in multiple forms. [11] Capacity building was done through a three-module training course centering on computer usage to get the most of the DHIS training, DHIS operation including regular tasks and basic database maintenance, HIS and data use, to create understanding and motivation and using data from DHIS and analytical and presentation tools taught in the first week. [11]

Earlier approaches to develop HIS systems in Sierra Leone focused on partial solutions for organizations, health programs, or in some occasions to implement new reporting formats including several of the health programs. [11] A major problem to HIS has been fragmentation, which has rather increased than decrease. Results show that the approach chosen by the project in Sierra Leone has been different from earlier attempts in that it is trying to incorporate all the various requirements for reporting and use of data in a step-wise approach. [11] Findings also show that a principal difference between the chosen approach and the previous approach is the allowed and promoted flexibility to change the system as users and involved health programs learn about current shortcomings and potentials for improvement. [11]

Concluding findings show that introducing the radically new technical infrastructure and type of computers such as the Inveneo technology represent a considerable capacity development challenge, and the best way to approach this is to make the technical part of the HIS integral to the training. [11] This can be done through contextualizing the training by basing it on problems in the district, including hardware parts is the best way to approach sustainability challenges. [11]

### 3.3 Liberia Digital Health Landscape

Liberia has emerged from 14 years of civil war causing the deaths of tens of thousands, destroyed livelihood, and destroyed healthcare system. [12] Eighty percent of health clinics and hospitals across the country were shuttered during the war due to flight of health personnel, looting, and destruction. [12] The country is divided into 15 counties,

further divided into 90 districts; due to its population size, Montserrado county is divided into 22 health zones. [13]

The government today is supported by the United States and other foreign donors to rebuild the healthcare system. The USD 52 million Rebuilding Basic Health Services (RBHS) program aims to reconstruct and equip 100 of the 330 clinics in the country, as well as provide the needed skills training for the nurses and clinic managers. [12] The focus is to develop the healthcare systems in rural Liberia where access to healthcare is poorest after the civil war.

In spite of the resources and efforts committed by the Liberian Ministry of Health and foreign donors across the country, quality HIS and data management remain a challenge. [14] Plans were made to adapt IDSR in 2004, but IDSR was not implemented until 2015 after the Ebola outbreak. [13]

IDSR in Liberia is being used as a platform for the implementation of International Health Regulations (IHR). Healthcare-related activities are concentrated on areas of family planning, antenatal and delivery care, immunization, health workforce, and infrastructure. [5] Mortality and morbidity are high as a result of combination of poor living conditions, lack of quality healthcare, and infectious diseases (e.g., malaria, pneumonia, diarrhea). [12] The 2014 Ebola outbreak caused devastation to the healthcare system which had not fully recovered from the civil war. [15]

In 2015 the Liberian government moved to set the scene for health systems recovery and resilience through a comprehensive seven-year investment plan (2015 – 2021). [15] This comes in the wake of the Ebola outbreak which highlighted the weaknesses of PHS and response in Liberia.

In 2018, a study was done to look at the healthcare services status in the 15 counties of Liberia reviewing the differences among counties. A narrative review was employed making use of recent international and national documents and relevant literature and available information from primary and secondary resources and databases. [5]

A total of 701 health facilities were assessed during this review and the following primary and secondary resources and databases were used to gather information and literature needed for the study.

- Published Liberian documents were included including policies, strategies, plans, programs and reviews of the Ministry of Health and Government of Liberia.
- The most recent situation analysis is presented in the Liberia Service Availability and Readiness Assessment and Quality of Care report (SARA and QOC).
- The most recent documents covering MNH policy implementation are the "Joint Annual Health Sector Review Report 2016 "and the "Consolidated Operational Plan (FY 2016/17)".
- Publications in the area of routine health statistics were included like population census and household surveys developed by the Liberia Institute of Statistics and Geo-Information Services with partners (2008 Population and Housing Census, Liberia Demographic and Health Survey 2000, 2007, 2013).
- National e-databases were included with administrative data of Liberia Health Information Management System (DHIS-2) and international e-databases (WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division, UN Inter-agency Group for Child Mortality Estimation) for purpose of comparison.
- Published reviews, scientific and professional articles on Liberian maternal and new-born health in international journals, national surveys, and project reports of international organizations (WHO, EU, World Bank, UNICEF, UNFPA) we included that deal with issues of women's and new-born health in Liberia.

Results from this study showed resilience can be built after a healthcare crisis like a pandemic. However, the purpose of the Liberian governments actions in the field of

health was to monitor progress throughout the implementation period of the Health Investment Plan. [5]

The main purpose of the health investment plan was to improve access to safe and quality health services, health emergency risk management, and enabling environment and restoring trust. In 2016, a WHO SARA report on general availability and readiness to provide services and essential medicines show that services in 701 health facilities was 59%, basic equipment 77%, basic amenities 57%, standards precautions for prevention of infections 73%. [5] The 15 counties differed significantly in their capacity to deliver basic health services. The UHC approach embraced four core groups of indicators (i.e., reproductive and newborn health, child immunization, infectious disease, and major social determinants). [5]

Reproductive and newborn health in Liberia indicators included family planning, four or more antenatal visits, skilled birth attendance, and coverage of pregnant women with IPT. Family planning services are offered by 88% of facilities in all 15 counties, this service is more available in 97% of rural area health facilities and only 70% of urban area health facilities. [5] Family planning services where more available in government/public facilities in comparison to private, NGO and faith-based facilities. Trained family planning services counselor was extremely low with only 14% of facilities indicating that they had at least one trained staff in the past two years. [5] Antenatal care services was available in 90% of all the facilities in all 15 counties with only six counties reporting that they had some but not all of the resources needed for this service. [5]

The seven-year investment plan placed health workforce as the first investment area, but despite this it was hit hard by the Ebola crisis. There is a national deficit in physicians, nurses, certified midwifes, and nurse-midwifes. [5] Health infrastructure is significant for a resilient health system; Liberia needs more health facilities in addition to the 701 that have been used in this assessment. There is a projected addition of 543 facilities, but still a comprehensive plan for facilities and equipment are still missing. [5] Coverage of health services to the entire population is the responsibility of the Ministry of Health, and one key instrument is the transparent, accurate and timely reporting of

disease surveillance. [5] In spite of the deficits, the position of Liberia's healthcare system is fairly acceptable for a country that is emerging from 14 years of civil war.

In 2017, following the Ebola outbreak in West Africa the West African Health Organization (WAHO) did a situation assessment of HIS. A comparative study of HIS in selected seven countries, Liberia was one of the selected countries for the study. [4] The main focus of the assessment was to look at integration presented in four sections:

1. Overall, the findings are based on primary observations and the use of assessment tools.
2. HIS narrative focuses on the context and the history of HIS in each country.
3. HIS status reports for the 15 ECOWAS countries
4. Methodology and tools, this section provides the details of the countries, personnel and facilities visited, and descriptions of the tools used for the assessment.

Liberia is the only one of the seven countries selected that implemented HIS to a large degree. There was a compilation of agreed data collection tools from scratch as a collaborative effort of all health programs and partners. [4] A compilation of 20 forms for data collection were consolidated into a book of forms. [4] Results showed some of the countries studied, especially at the local level found a positive environment towards integration.

Three facilities were assessed in Liberia with the results showing that one was very good, one was medium with some problems, and one was poor. [4] The TALI tool was used to assess all the facilities in the seven countries, but it is impossible to say that facilities in a country had a particular level according to this tool Liberia's internet limitations were found to be restricting for the use of DHIS-2 in a server-based mode, but there was an institutional will to integrate systems. [4] There was a brief presentation of the challenge of integration in the countries studied including Liberia. All countries, apart from Liberia, have very fragmented and not well functioning HIS systems.

Using the 3-level HIS integration model, results show some facilities in Liberia are very good in data management. [4] Subnational and national levels of HIS in Liberia showed

many problems in some counties, but data was well organized in the country data warehouse in sets that have been integrated. But there was still need for dissemination and use of data. [4]

There was poor power supply which prompted the need for cloud hosting for easy storage and access of data; considerations should be made for mobile internet and mobile phones for transmission of data from remote areas where connection is not possible. [4] Lack of basic infrastructure and technical support presented as a strong obstacle to the flow and integration of data. Staff at facilities in Liberia to be meticulous and competent in managing their registers and carrying out paper-based reporting. Staff in facilities in Liberia lack exposure to computers and manually made charts and graphs, there was a strong need for training at the national level. [4]

Since 2007, Liberia has made significant strides in strengthening its HIS systems. There is progress towards integration based on the WAHO assessment, but there are challenges with respect to integration.

In conclusion, we can say that there is a potential for an integrated model, in the coming years there will be a need to support the conversion to pull scale application. [4]

Quantifying the influence of healthcare system attributes, especially the quality of care on preferences for healthcare clinics in Liberia insights to the health system is a significant factor. Understanding this newly rebuilt health system and population health services requires having a comprehensive knowledge of healthcare utilization and preferences. Healthcare services research was conducted to look at population preferences for health care in Liberia. [12] Liberia is a country with a high burden of disease that is rebuilding its health system after 14 years of civil war.

A discreet choice experiment (DCE) was designed to assess preferences for structure and process of care at healthcare clinics, this was fielded in rural northern Liberia in 2008 as part of a population-based survey on health care utilization. [12] Survey response rate was 98%, with the mixed logit model used to estimate the influence of attributes on choice of hypothetical clinics for a future illness. [12] Improvement of population health can be done with the usage of new health services. Previous work

done in healthcare utilization in Liberia suggests that rural Liberia is disproportionately use informal or traditional sources of care compared to modern healthcare services. [12]

In Liberia, there is the concern that after a long war the population may not have confidence in the healthcare system. The reason for this lack of confidence is largely due to the fact that the health system is being run by stakeholders who are mostly from foreign non-governmental organizations. [12] There is also the assumption that given the fact that there is widespread poverty, affordability would be the determinant of heath service utilization. For this study, the Ministry of Health and Social Welfare and the Institutional Review Board at the University of Michigan provided ethical approval for the study, and all respondents provided written consent. [12] The survey was administered through interviews and statistical analysis was done using Stata v.11, with several sensitivity and validity tests also performed. [12]

Results showed that among 1,464 eligible respondents recruited for household data collection, 1,434 completed the questionnaire. Fewer than half of the respondents were women. [12] Findings show that participants choice of clinic was mostly influenced by provision of thorough physical exam and consistent availability of medicines. Respectful treatment and government vs non-government management marginally increased utility and waiting time was not significant. [12] Liberians value technical quality of care over convenience, courtesy, and public management in selecting clinics for curative care. This suggests that investments in improved competence of providers and availability of medicines may increase population utilization of essential services as well as promote better clinical outcomes. [12]

Qualified healthcare providers within an effective health system are critical to achieving and promoting greater health outcomes such as those in the Millennium Development Goals. [16] In 2015, following the Ebola epidemic a paper was written to review the historical context for the human resources for health crisis in Liberia. The paper examined two context-specific health policy options to address the crisis and recommends reverse brain drain as a policy option to address the immediate and critical crisis facing the health care sector in Liberia. [16]

In examining the problem the effects of the long war which ended in 2003, the paper utilized a policy triangle as a framework to rigorously analyze the two policy options and recommend a coherent policy option with the most feasible components to implement in Liberia. [16] The first policy option of addressing the crisis is the reverse brain drain policy which analyzes the issue of brain drain and the implementation of the policy.

*Brain drain* is not a new phenomenon, but over the years many countries have implemented two approaches to reverse *brain drain*. First is seeing that the *brain drain* as a loss, second is also seeing it as a gain. [16] The first approach is implementing policies such as making migration difficult, offering incentives to would be migrants and compensatory policies asking for incentives from receiving countries. [16] However the case for Liberia is different as stopping people from leaving would be difficult since freedom of movement is a constitutional right, and the country is still recovering from civil war. [16] Using the second approach, the Liberian government can initiate networks for Liberian medical professionals across the world encouraging them to work together to share ideas and knowledge amongst themselves. [16] However, there are disadvantages to using this approach as this can be time consuming. Comprehension of materials shared maybe difficult for some professionals; the Liberians are unwelcoming because they may view diaspora Liberians as threatening their job security.

Scholarship schemes can be another option for students in the medical and healthcare field. But this, however, can be tricky as many students may abscond after completing their programs. The policy option recommendation is the reverse brain drain or diaspora option. It is the most feasible option as it involves multi-stakeholders support and gives the Liberian government more control over the actors, contents, and processes. [16]

Cost is an important issue to consider for policy recommendation and the diaspora approach is a more cost effective and sustainable policy for the Liberian government. [16] The diaspora option is a short-term fix, but it is what Liberia needs right now as its health system is in critical need of a well-trained work force. The recent Ebola outbreak highlighted the limitations of the healthcare system, and the policy options offered by the paper will be a short term fix that is needed and could fix the scarcity of trained health workers to address the short term and acute need in the country. [16]

In spite of the efforts and resources committed by the National Public Health Institute (NPHI) and the Ministry of Health (MoH) in Liberia with stakeholders and partners from around the world to strengthen IDSR across the country, quality data management remains a challenge. [14] Incomplete and inconsistent data were reported at different levels of IDSR continues. As part of the monitoring and evaluation strategy for IDSR, continuous improvement data quality assessment to identify gaps and success with the aim of ensuring data accurate and credibility an operational plan to address data quality needs for IDSR activities is required. [14] A data quality audit was conducted in 2017 to look at IDSR implementation in Liberia. This was done in response to the WHO response to the Ebola outbreak of 2014 – 2015 and what lessons were learned from this response. [14]

A multi-stage cluster sampling included simple random sample of five counties and a simple random sample of two districts and a simple random sample of three health facilities was employed during the study pilot assessment in Montserrado county. [14] A total of 30 facilities were targeted with 29 of them audited, respondents included health facility PHS focal persons, zonal PHS officers, district PHS officers and county PHS officers. [14] The data quality audit was conducted in five phases: phase one focused on the preparatory activities; phase two involved desk review of reported data; phase three activity was field assessment; during phase four, an action plan was developed; and phase five focused on the compilation of data, report writing, and results dissemination to stakeholders. [14]

Findings indicate that 23% of health facilities have a dedicated phone for reporting, 20% reported no cell phone network, 17% reported daily access to the internet, 56% reported a consistent supply of electricity. [14] Access to a functional laptop or computer was not reported, and 40% of health facilities reported experiencing a stockout of laboratory specimens packaging supplies in the past year. [14] Findings also indicated that 91% of facility staff were mentored on data quality check and data management including the importance of the timeliness and completeness of reporting through supervision and mentorship. [14]

The IDSR core performance indicator *supervision* was received by 65% of facilities, and 58% of health facility officers in charge gave *feedback* to the community level. [14] Data quality assessments are important in public health; in this review completeness, accuracy, and timeliness were the three most assessed aspects. Findings showed that data use and data processing have not been given adequate attention although there are other factors that determine the quality of data. Limitations were inconsistency in defining aspects of data quality and failure to address user concerns and lack of mixed methods to assess quality. [14] These gaps suggested that there was a need for consideration of the three dimension of data quality, data use and process, measuring the perceptions of end users and consumers towards data quality which will enrich our understanding of data quality issues. [14]

Disease outbreaks, conflicts, and developmental challenges pose serious threats to fragile health systems which can be overwhelmed when major health emergencies emerge. Following the devastation of a long civil war in Liberia, a post-war national health policy plan was introduced in 2007 to help build a more resilient health system and HIS system incorporating IDSR and DHIS systems.

In 2011, a new 10-year national health policy plan was established with the delivery of healthcare services taking place at three levels: primary level consists of the health clinics and health centers; secondary level comprising of county and regional hospitals; and tertiary level is the John F. Kennedy hospital in Monrovia. [15]

Following the Ebola outbreak in 2014, a 7-year investment plan was made to set the scene for post-Ebola health system recovery and resilience in Liberia. [15] A paper was written to describe the experience of Liberia in the development of the investment plan post Ebola, the approaches, process, and realignments that were undertaken and the lesson learnt and way forward. The main aim of this analysis paper was to provide lessons for countries that are recovering from crises on how to manage their system recovery and efforts. [15]

In Liberia, 40% of health facilities are privately owned, while 60% are public health facilities owned by the government. Annual government investment in health sector exceeds the target annual budget. [15] In absolute terms the health sector was

underfunded, and government expenditure including payment of user fees in public health facilities is the predominant method of health financing. [15] Underlying health systems vulnerabilities before the Ebola outbreak as a result of under-investment in health sector highlighted fragilities in the health system that led to aggravated transmissions during the outbreak. [15]

The Ebola outbreak significantly impacted the delivery of healthcare services, which impeded community confidence in the health system and a decline in the demand for services. [15] Enormous resources were mobilized by the international community, to deploy human resources, treatment centers and mobile laboratories for rapid diagnosis and treatment. [15] Following the decline in cases, the post-Ebola recovery plan was initiated. While not fully mapped out at the beginning, the plan happened in three phases: phase 1 was the building of high level political and technical consensus around a common recovery strategic approach; phase 2 is the development of technical elements of the recovery strategic approach; and phase 3 is the building of the legitimacy of the common recovery strategic approach. [15] Each phase took approximately three months, with the situation analysis taken as an opportunity to relook at the health sector strategic plan in some form of midterm review. [15]

The situation analysis identified and prioritized the vulnerabilities in the healthcare system and identified nine priority investments. The process of drafting the plan was protracted and involved inclusive and consultive processes through constituencies of the various working groups. [15] These iterative processes led to refining of the plan, with the Ministry of Health working with developing partners carried out extensive analysis and costing of the plan including fiscal analysis, mapping of partners and available resources before the final editing and drafting of the plan. [15] Key strategies and actions were aimed at improving data collection, analysis, and use for program orientation and informing policy were incorporated into the plan. [15]

Key indicators for monitoring implementation of the plan were selected for use to monitor the achievement of the nine investment priorities. [15] HMIS using the DHIS-2 tool was used as an indicator for collecting information and reporting, this was to avoid multiple and fragmented data collection and reporting by different partners. [15] Cost

estimates based on the prevailing conditions of the plan, costing comprises of capital, recurrent and operational costs needed as additional investment. [15] All efforts at resource mobilization were therefore drawn from the recovery plan in addition to advocacy with Ministry of Finance and Development Planning. [15] This ensured that the government of Liberia also provided funding for some of the most critical elements of the plan, such as hiring of healthcare workers. [15]

By the end of the process, the country had a comprehensive strategic approach to guide the recovery process. With some of its elements having secured funding, the country was surely on the path towards building a resilient system able to absorb future health shocks. [15] High value was placed on government stewardship of the recovery planning process. This did not however, mean that the MoH had all the answers, but it has a clear vision of where it wanted the system to be and relentlessly pursued all actions undertaken. [15] Transparency and participation are extremely critical in building the confidence and alignment of partners around the recovery strategy. Division of labor between partners ensured that there was focus on areas where they have a comparative advantage. [15]

Liberia's investment plan for building a resilient health system harnesses key lessons learned from post-conflict health sector reforms and the Ebola outbreak to select priorities for building back a better health system. [15] There were still uncertainties and ways on how to build a resilient health system. Therefore, investments that adopt a more holistic and integrated approach in addressing the root causes of the weaknesses in the health system should be the preferred option rather than a selective remedy which has the tendency of undermining the country's effort to build a resilient health system. [15]

Current approaches focus on both investing in inputs as well as improving how the health system actually operates. Finding resources to implement the plan is vital, total budget may be high but tough decisions have to be made in allocating the resources needed despite the multiple and competing developmental priorities facing Liberia. [15] If Liberia must make progress post-Ebola towards achieving Universal Health coverage, the health SDG and health security, building a resilient health system is key. [15] The

current fiscal space is insufficient for the inflow of substantial financial resources on the implementation of the investment plan, government needs to create sufficient fiscal space to accommodate the additional budgetary resources. [15]

In conclusion, this work described the experience of Liberia in the development of an investment plan for building a resilient health system following the Ebola crisis. [15] Liberia's investment plan is ambitious and will require enormous financial resources that the government of Liberia alone does not currently have and would need external support. [15] Governance and accountability structures at the national and country levels are currently insufficient for the inflow of substantial financial resources for the implementation of the investment plan. [15] Healthcare sector leadership at all levels should be empowered to strengthen leadership, governance mechanisms and accountability frameworks in support of the implementation of the plan. [15]

Recognizing the significance of community participation in overcoming the Ebola outbreak and strengthening community systems emerged as one of the most important strategies in bridging the gap in accessing primary health care services. [17] A study was conducted to review the community health policy development process in order to draw lessons from the health system strengthening efforts post Ebola. The post Ebola health system strengthening efforts included a seven-year investment plan for building a resilient health system, and a national health policy plan. [17]

In this review a government led healthcare system analysis approach was applied to assess, review, and revise the community health programs in Liberia looking at the lessons learned from a health system approach to inform program design and better prepare for future public health emergencies. [17] A mixed-method approach combined the use of an adapted too to access bottlenecks and solutions during workshops, qualitative survey to assess perceptions of challenges and perspectives from different stakeholders and an inter-agency framework to jointly review program implementation gaps using the evidence compiled and identify priorities to scale up of the community program. [17]

Community health working groups were reactivated, and several sub-groups headed by various MoH departments tasked with revising the community health policy in line with

the investment plan for building resilient health system in Liberia. [17] The health systems approach to revise the existing community health policy and to re-establish the community health system with an appropriate, well trained supervised and incentivized team of community workers to provide PHC services to populations with limited health care access. [17] A health systems bottleneck analysis was reached with country stakeholders meeting in workshops assessing the bottlenecks to scaling up community health programs and discussed solutions to address them. [17]

A qualitative study was conducted in five counties (Bomi, Bong, Grand Gedeh, Montserrado, and River Cess), to explore stakeholders' opinions and perceptions on strengthening the community health program. This included focus group discussions (FGDs) and in-depth interviews (IDIs), a 2-day training for interviewers, field coordinators, and note-takers, and covered field operations, ethics, interviewing techniques, transcription, and safety. [17] The semi-structured interview guide was developed through review of previous research interviews and consultations with experts involved in community health programs. Included were thematic areas of policy and strategy development, coordination, performance management, and facilitators and barriers for the planning and implementation of the community health strategy. [17] The benchmark matrix framework was used to assess the progress made in planning and implementing community health programs.

Results show that stakeholders identified key health system challenges and proposed policy and program shifts to institutionalize community health programs. Community health programs in Liberia are currently in the phase of implementation and require strengthened leadership, local capacities, and resources for sustainability. [17]

Lessons learned from this review included the importance of establishing a coordination mechanism and leveraging partnership support, using a systems approach to better inform policy shifts, strengthening community engagement, and conducting evidence-based planning to inform policymakers. [17]  This study contributed toward existing body of knowledge about policy development processes and reforms on community health in Liberia and most likely other African settings with weak health systems. Community-based health systems will play an even bigger role as we move toward

building resilience for future public health emergencies and strengthening health surveillance. This will require that communities be viewed as part of the healthcare system rather than just clients of health services. [17]

## Chapter 4: Conclusion, Limitations, and Recommendations

### 4.1 Discussion

In 1998, the World Health Organization Regional Committee for Africa (AFRO), its Member States (MS) and technical partners adopted a strategy for developing and implementing comprehensive PHS and response systems in African countries. [18] This strategy is referred to as the Integrated Disease Surveillance and Response (IDSR). The status of IDSR in AFRO member countries varies across the region with many countries at varying levels of IDSR implementation. [18]

All MS have designed national PHS and structure and identified IDSR priority diseases or conditions. Assessments done show that many MS did not have operations command and control centers to coordinate and monitor outbreaks and other reported public emergencies. [18] District level implementation of IDSR has been plagued by gaps such as …

- absence of dedicated IDSR staff in districts.
- lack of epidemic response teams and management committees.
- lack of logistic and communication capacities in the majority of MS.
- lack of consistency un the use of IDSR core indicators in monitoring and evaluating performance at all levels.

It is clear that even with these gaps and challenges, much has been achieved in the decades following the adoption of IDSR. This has created stronger public health systems that have been contributing to HIS infrastructure in African countries. Sierra Leone and Liberia have since the end of the civil wars that have devasted both countries started a journey of rebuilding their health systems and HIS systems for better disease surveillance. However, the recent Ebola outbreak and the Covid-19 outbreak have shown the weaknesses in their respective health system. Although both countries

have some form of HIS there is still more that needs to be done to create a more interoperable system that is reliable and easy to use.

### 4.2 Conclusion

Sierra Leone was selected for HIS strengthening by HMN in 2008 and 2009.These systems strengthening was a project to use DHIS-2 as a data warehouse for data reporting at district levels. HIS in Sierra Leone at this moment was characterized by fragmentation in the system with no agreed data standards across health programs. Integration of the HIS system and establishment of an eHealth system was initiated through Open Architecture, Software, and Information Systems for Africa (OASIS). OASIS and DHIS collaboration working with the Ministry of Health in Sierra Leone, HMN, and other stakeholders to implement an integrated ehealth system using a proposed OASIS-DHIS ehealth enterprise architecture. [9] Work done on this implementation show that there is a desperate need for developing human capacity and local support structures as a part of the process. However this system was designed for an uneven spread of technology, and will be able to take advantage of whatever data is collected rather than waiting for single technology to be used before providing actionable data. [9]

The adoption and use of DHIS, OASIS, and other systems in Sierra Leone continued to expand given the improvement in Infrastructure. Although there is sharing of data among stakeholders and across institutions in government sets, the format and structure vary (e.g., email, SMS, paper forms, portal reporting). [8] There is interoperability in the system, but there is no digital health foundational registry in use for any of the systems in Sierra Leone. Coordination around standardized data format to reduce duplication among implementing partners should improve the feedback loop and data use especially at health facility levels.

Interoperability is also limited due to data blocking, but mitigating this would need adding new technology such as blockchain which allows shared ownership and administration of data. Some will argue that application of big data such as AI would be beneficial, however this data application is shown to use individual-level data rather than aggregated -level data. [8] Given that no solution currently shares or exchanges

individual-level data (longitudinal patient data), opportunities for using facility-generated big data at present are greatly limited to aggregate PHS only. [8] Improving individualized information sharing is critical to achieving the vision of digital health and impact the quality of health system data and the ability and use of data.

The devastation of the Ebola outbreak impacted the health systems and populations in Sierra Leone. The outbreak caused a public health emergency and showed that the health system and the digital health system need re-building. Health systems that were in the building and implementation process were impacted with catastrophic consequences on the health system in Sierra Leone. Many steps have been taken following the Ebola outbreak to help re-build the digital health system. In the months and years following the outbreak, effort has been made towards implementation of nation-wide facility based electronic PHS, improving accuracy of IDSR, strengthening health systems using lessons learned from outbreak and helping to improve the interoperability of the system. Implementation of electronic based reporting using IDSR, monitoring of IDSR data quality and strengthening the HIS system is significant in re-building the system after the devastation of the Ebola outbreak.

The Liberian Ministry of Health is responsible for the coverage of health services to the entire population. Liberia has integrated reports from all health programs into one national system to create an integrated HIS. There is little understanding of what is meant by integration, and therefore what should and should not be integrated and at what level integration should happen are significant factors to consider when integration is implemented. [4] A strong integrated HIS in Liberia which responds to the needs of the health programs and agencies will be significant in convincing stakeholders, partners, and donors to for go their separate systems and join the integration process.

Although integration of HIS has been done, there are technical deficiencies such as internet limitations which restrict the use of DHIS in a server-based mode. Institutions have the will for HIS integration, but there is a strong need for training of staff on information analysis and use at the district and national level. There is a need for the Liberian government to look at alternatives such as cloud hosting as poor power supply makes managing servers a hard task. Internet connectivity is also an issue in supporting

a HIS infrastructure, alternate support mechanisms should be considered for the transmission of data especially from remote areas. Basic infrastructure such as electricity, good roads, good transportation, dysfunctional software, and technical support for remote areas are factors that do not support integration.

Some data collected through the integrated HIS in Liberia are used to support activities in some urban health centers. [4] This is a significant step in moving towards greater data analysis and use and are particularly encouraging. There is still more data being collected than being used, and this increases the data analysis challenges. Technical integration is still a challenge in Liberia as DHIS systems still mimic standalone systems because of limitations in internet connection. [4] There is a need for the integration of other systems such as HMIS to DHIS, this will limit the pressure put on staff to manage multiple systems. Following the Ebola crisis, Liberia is in the development of a more resilient health system. Stronger HIS is needed in Liberia to establish a health system that is more resilient and able to stand public health emergencies and crisis.

### 4.3 Limitations

There are limitations to the assessment, first there were a limited number of articles available that met the criteria for inclusion. Many relevant studies exploring HIS in Sierra Leone and Liberia have inherent biases due to study design, limited generalizability, and difference in study quality and scope. Most articles met the criteria about health systems and digital health systems building. There are still limitations to the amount of information available about the current state of digital health systems such as HIS for PHS in both target countries. It is necessary to address certain biases introduced by the inclusion and exclusion criteria used in this review. Most articles excluded did not include enough data on HIS and digital health systems. Exclusion may have inadvertently resulted in omission of relevant studies with novel or contrasting results.

*Limitations to HIS in Sierra Leone*

Digital ecosystems are ever changing and evolving due to the rapid deployment of digital interventions fueled by the Covid-19 pandemic. With many studies done in the mid 2000’s regarding digital health solutions and establishment of HIS in Sierra Leone post-civil war, there remained many elements that needed to be fixed for an

establishment of a resilient health system and HIS for PHS. The 2014 Ebola outbreak highlighted the weaknesses of the health system and the digital health system for PHS. Many digital solutions are currently being used in Sierra Leone by government run health facilities, NGOs, and other private run health facilities. Unreliable internet connectivity affects the effectiveness of the DHIS system, which is web based, and connectivity is essential to support system usage. Interoperability is a limitation to how data can be collected, what can be done with the data collected and the creation of a digital health vision. Although stakeholders share information within and across institutions, there is the need for investment in a multi-sourced data triangulation system that will serve as a low-hanging fruit for interoperability and data use for policy making. Limitations to digital health infrastructure, workforce capacity and funding remain key barriers to achieving these ideals.

*Limitations to HIS in Liberia*

The civil war in Liberia devasted the healthcare infrastructure; since then, rebuilding has been in process. Limitations to the health infrastructure especially HIS was highlighted by the Ebola outbreak. Health information systems such as IDSR and DHIS are currently used for health data collection. Training in data management is a limitation to HIS in Liberia, with surveillance officers at health facility level lacking training in data management. There is also the issue of undefined data management strategy and quality level which makes data management and generation overwhelming and less useful for decision making. Under-investment in the health system over the years created weaknesses that have led to limitations in the effectiveness of HIS in PHS and management. Fragmented HIS system is also a limitation, lack or interoperability in the existing data systems such as HMIS, IDSR and DHIS. The lack of training and knowledge of data systems such as IDSR which has only been implemented since 2015 after the Ebola outbreak is also a hinderance to health data management.

Limitations to management and use of health data reduce the time from detection to reporting of public health events. Finding solutions to mitigate these limitations will be beneficial to HIS in Liberia and help make use of all the systems that are being used for PHS.

### 4.3 Recommendations

In Sierra Leone, internet connectivity and other health infrastructure are poor. But the MoH and its supporting partners have built a HIS system that can be sustainable. DHIS is implemented nationwide and OpenMRS is implemented in hospitals in the capital. Using these systems Sierra Leone has embarked on creating a comprehensive and scalable HIS. Recommendations for HIS in Sierra Leone are that the MoH work on capacity building. District health management systems capacity investment should be a priority. Health infrastructure investment and well-functioning outbreak control activities and placing the population at the center of interventions will help in building a resilient HIS system that supports the health infrastructure as a whole.

Contextualizing public health problems at district level and providing the necessary resources will play a part in the sustainability challenge for HIS. Leveraging big data such as AI to achieve national digital health and integrating care will be significant in using data for policy change. Sustained commitment of the international community, stakeholders and partners, and meaningful collaboration between public health organizations. In Sierra Leone is critical to support health system re-building and to begin to reverse the current public health emergency exasperated by the recent Ebola Outbreak and the Covid-19 pandemic.

Despite the described deficits of HIS in Liberia, data systems and completeness are at level two with data supporting some health activities. There is an overall healthy and positive impression of the HIS with trends in integration; data use commitment and human capacity create a strong foundation. Liberia, however, is still facing the same challenges as other low-income African countries in implementing and sustaining HIS. Stakeholders, partners, and the Liberian government should give more attention to digital health solutions. Conducting regular data harmonization and audits at district and subnational level will be essential in helping health workers be more knowledgeable on the importance of quality and reliable data. Capacity building at subnational level in data management and proper training on data analysis for effective system management of HIS should be a priority.

Investment in HIS infrastructure is crucially needed for data capturing tools, internet connectivity and trained human resources will be an added benefit to improving data analysis and quality. Policy development and implementation in the areas of digital health systems should be a part of government-led health systems approach to better improve public heath response to disease outbreak and national community health.

Sierra Leone and Liberia like similar countries implementing electronic PHS or mHealth activities in resource-constrained settings should consider…

- mitigating unreliable network connectivity by using cloud-based systems to store and transmit data.
- capacity to transmit data for multiple modes.
- utilizing multiple data providers to maximize coverage.
- using applications that are easy to use with features such as context-specific data and feedback messages.
- rapid integration of modifications can enhance overall system quality and user acceptance.

The success of HIS is feasible on a national-scale in limited-resource settings. Many of the challenges mentioned are mitigated with support from governments, stakeholders, and partners.

**References**


1. Elston, J.W., et al., *Impact of the Ebola outbreak on health systems and population health in Sierra Leone.* J Public Health (Oxf), 2016. **38**(4): p. 673-678.
2. Shoman, H., E. Karafillakis, and S. Rawaf, *The link between the West African Ebola outbreak and health systems in Guinea, Liberia and Sierra Leone: a systematic review.* Globalization and health, 2017. **13**(1): p. 1-1.
3. Njuguna, C., et al., *Institutionalized data quality assessments: a critical pathway to improving the accuracy of integrated disease surveillance data in Sierra Leone.* BMC Health Serv Res, 2020. **20**(1): p. 724.
4. Braa, J., et al., *Situation Assessment of Health Information Systems in the ECOWAS Region - West Africa*. 2012.
5. Kesselly, R.Y., et al., *The status of health services in the 15 counties of Liberia.* South Eastern European Journal of Public Health (SEEJPH), 2018. **10**(1).
6. Organization, W.H., *Everybody's business--strengthening health systems to improve health outcomes: WHO's framework for action.* 2007.
7. Health Metrics, N. and O. World Health, *Framework and standards for country health information systems*. 2008, World Health Organization: Geneva.
8. Chukwu, E., et al., *Digital Health Solutions and State of Interoperability: Landscape Analysis of Sierra Leone.* JMIR formative research, 2022. **6**(6): p. e29930-e29930.
9. Braa, J., et al., *Comprehensive yet scalable health information systems for low resource settings: a collaborative effort in sierra leone.* AMIA Annu Symp Proc, 2010. **2010**: p. 372-6.
10. Martin, D.W., et al., *Implementing Nationwide Facility-based Electronic Disease Surveillance in Sierra Leone: Lessons Learned.* Health Secur, 2020. **18**(S1): p. S72-s80.
11. Sæbø, J., et al., *Integrating health information systems in Sierra Leone*. 2009. 379-391.

12. Kruk, M.E., et al., *Population preferences for health care in liberia: insights for rebuilding a health system.* Health Serv Res, 2011. **46**(6pt2): p. 2057-78.

13. Nagbe, T., et al., *The implementation of integrated disease surveillance and response in Liberia after Ebola virus disease outbreak 2015-2017.* The Pan African medical journal, 2019. **33**(Suppl 2): p. 3-3.

14. Nagbe, T., et al., *Integrated disease surveillance and response implementation in Liberia, findings from a data quality audit, 2017.* The Pan African medical journal, 2019. **33**(Suppl 2): p. 10-10.

15. Zolia, Y., et al., *Setting the Scene for Post-Ebola Health System Recovery and Resilience in Liberia: Lessons Learned and the Way Forward.* Health Systems and Policy Research, 2017. **04**.

16. Budy, F.C.T., *Policy Options for Addressing Health System and Human Resources for Health Crisis in Liberia Post-Ebola Epidemic.* International journal of MCH and AIDS, 2015. **4**(2): p. 1-7.

17. Simen-Kapeu, A., et al., *Strengthening the community health program in Liberia: Lessons learned from a health system approach to inform program design and better prepare for future shocks.* J Glob Health, 2021. **11**: p. 07002.

18. World Health Organization. Regional Office for, A., *Technical Guidelines for Integrated Disease Surveillance and Response in the African Region October 2010*. 2010, World Health Organization. Regional Office for Africa: Brazzaville.