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Sierra Leone's health facilities' electricity, computing-hardware, and internet infrastructures

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ABSTRACT

Background: Years of health information (HIS) investment in many countries has facilitated service delivery surveillance, reporting, and monitoring. Electricity, computing hardware, and internet network are vital for health facility-based information systems. Availability of these infrastructures at health facilities are crucial for achieving the national digital health vision.

Objectives: The objective of this study was to gain insight into the state of computing hardware, electricity, and connectivity infrastructure at health facilities in Sierra Leone using a representative sample.

Method: We sampled Seventy-two health facilities distributed in all the districts in Sierra Leone, factoring in rural-urban divide, digital health activity, health facility type, and health facility ownership. Enumerators visited each health facility over two weeks period.

Result*:* We found that 82% of surveyed health facilities do not have institutionally provided internet. The maternal and child health posts (MCHP) one type of primary healthcare unit (PHU) reported 60% have solar as their only electricity source, and the other 40% had no electricity source. Similarly, 38% of hospitals use generator as a primary electricity source, while 46% use national utility. All hospitals have at least one functional computer, though only seven of the 13 hospitals have four or more functional computers. Similarly, only two of the 59 PHUs had one computer each, and 37 of the PHUs have one tablet device.

Discussions*:* This healthcare infrastructure mapping provides the current state of internet connectivity, electricity, and computing hardware at health facilities in Sierra Leone. We can say with a 95% confidence level that alternative and non-traditional internet, electricity, and computing hardware are emerging as preferred options for health facility digital health coverage.

Conclusion: Electricity provision for off-electricity-grid health facilities using alternative and renewable energy sources is emerging. Fourty-three percent of surveyed health facilities believe inadequate electricity is the biggest threat to digitization. The current trend where all health facility internets are provided by GSM service providers can be changed to other promising alternatives. This study has shown evidence of the critical gap necessary to achieve this result.

IMPLICATIONS AND CONTRIBUTION

Despite investment in health information systems (HIS) improvements, patient-level HIS still not widely used. This study presents evidence that computing hardware, network, and electricity infrastructures are essential for scalable health facility information syste. Alternatives for bridging the infrastructure gaps were also presented.

1. Introduction

1.1. Background

Globally, health systems infrastructure has been the reason for constant debate. In 2004, the European eHealth action plan considered technology infrastructure as critical to deployed solutions [1]. Liu et al. explored the challenges and solutions of deploying eHealth infrastructure [2]. Electricity was listed as one of the essential

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amenities by WHO building blocks of the Health system [3]. Omotosho et al. surveyed the current state of ICT and related infrastructure supporting eHealth deployment in Africa [4]. Their desk survey covered computing hardware but not electricity. Sierra Leone has approximately 100MW of installed, with electricity per capita estimated between 14 and 38kW [5] [6]. As of 2016, an estimated 13% of Sierra Leoneans have access to electricity, with only one percent of those in rural areas having electricity access[6]. There are three leading mobile service providers in Sierra Leone, and broadband internet utilization remains low [7].

Sierra Leone has 1284 health facilities, including 24 district hospitals spread across her 13 healthcare districts [8]. The health systems are split between Primary Healthcare Units (PHUs) and hospitals. The PHUs are classified into Community Health Centers (CHCs), Community Health Posts (CHPs), and Maternal and Child Health Posts (MCHPs) [9]. Health facilities can be either public or privately owned, though the majority are public owned. Investments in health Information systems (HIS) resulted in regular health facility service delivery and disease surveillance reporting, using District Health Information System (DHIS) over the years [8] [10]. Other health information systems data sources are health surveys, birth registrations, census, health facility reporting, and health resource tracking (eg. health accounts) [3].

According to the national digital health strategy, service delivery data and disease surveillance data are collected and aggregated using a mixture of paper and digital health tools. These health information flow from community or PHUs or hospitals up to the district. Ninetty-eight percent of health facilities consistently sumbitted aggregated service delivery data to the central [9]. In 2017, the Directorate of Planning, Policy, and Information (DPPI) at the Ministry of Health and Sanitation (MoHS) inaugurated the eHealth coordination hub to govern the systematic application of digital health solutions for health systems improvement through data [11]. This culminated in the launch of the first national digital health strategy 2018 – 2023 [9]. The vision of the national digital health strategy is to guarantee universal health coverage using Information Communications Technology.

1.2. Study objective

The eHealth coordination hub commissioned a mapping of the digital health enabling environment components in Sierra Leone's health facilities in January 2019. This study unearths the state of digital health infrastructure as defined by WHO-ITU eHealth strategy development toolkit using a representative sample [12]. The infrastructure (or information structures) that support collection, processing, and knowledge mining of individualized patient data can be categorized as connectivity, computing-hardware, and electricity. This study does not discuss other architectural (non-physical) information structures like standards and interoperability components. This study will use success from elsewhere to provide evidence of the linkage between the availability of these infrastructures and the availability of individualized digital health data in support of the national vision. The methodology section discusses the overall investigation methodologies, including sampling, data collection, analysis, and interpretation. Next, we present our findings and the implications with key recommendations.

2. Methodology

The methodology for data sampling, collection, and analysis is discussed here.

2.1. Health facilities sampling strategy

Health facilities were initially classified as either urban or rural for spread and inclusion, based on information from the Directorate of Policy, Planning and Information (DPPI) at the Ministry of Health and Sanitation (MoHS), working in conjunction with the respective DHMT heads. Health facilities were further classified according to the level of their digital health activity. For this mapping exercise only, health facilities were classified as low, medium, or high digital health activity. A facility is classified as low if they have no digital health solution; they are medium if they have one or two digital health solutions. A facility is considered to have high activity if they have three or more digital health solutions. We sampled a minimum of five health facilities per district, selecting two each from urban and rural locations in each district, as pre-categorized. Each district prioritized at least one facility with high digital health activity followed by at least one health facility with medium activity, followed by one with no activity. Because each district had a minimum of one district hospital, one district hospital was selected in each district irrespective of their digital health activity. Additional health facilities were selected by repeating this selection technique until the desired number was achieved in each district. Where categories did not exist (like where there is no high activity digital health facility), the required numbers were filled with other categories.

Seventy-two health facilities were visited for this mapping exercise, 17 urban and 55 rural. The health facilities surveyed and their distribution, by ownership and type, are given in Figure 1. Ninety-six percent (n=69) of the health facilities were public sectors, which aligns with the National Digital Health Strategy and the country's current state of health facility distribution.

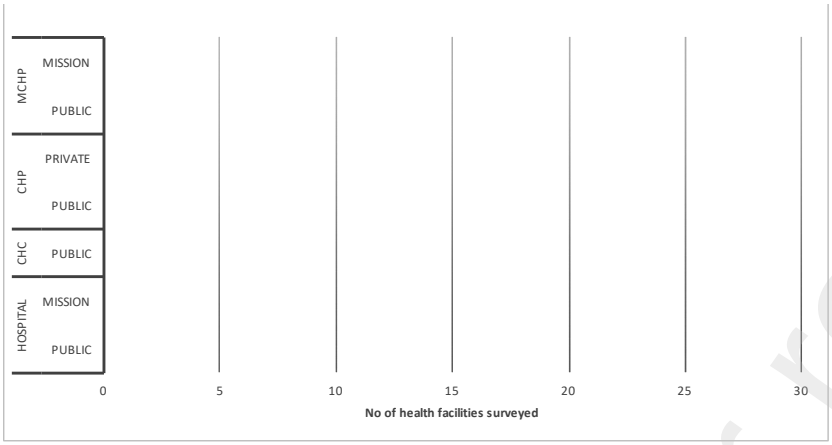


Figure 1: Health facilities surveyed, by ownership and type

2.2. Data collection and analysis

Ten study enumerators were recruited, trained, and deployed for this exercise in January 2019. The Study enumerators visited assigned health facilities and interviewed the head of health facilities while observing for infrastructures. Enumerators collected data using mobile forms, which were aggregated into an excel spreadsheet. The aggregated data were later analyzed with 'pandas' and 'matplotlib' libraries of python [13].

3. Results

Here we present our study findings with respect to the state of digital health infrastructure – internet, electricity, and computing hardware in Sierra Leone.

3.1. Internet connectivity

Respondents at 19 of the 72 health facilities surveyed reported having unofficial, private internet access at work, including at six of the 13 district hospitals surveyed. Approximately 90 percent of the PHCs surveyed did not have official institutional provided internet. One-half of the hospitals likewise did not have official internet, as illustrated in Figure 2.

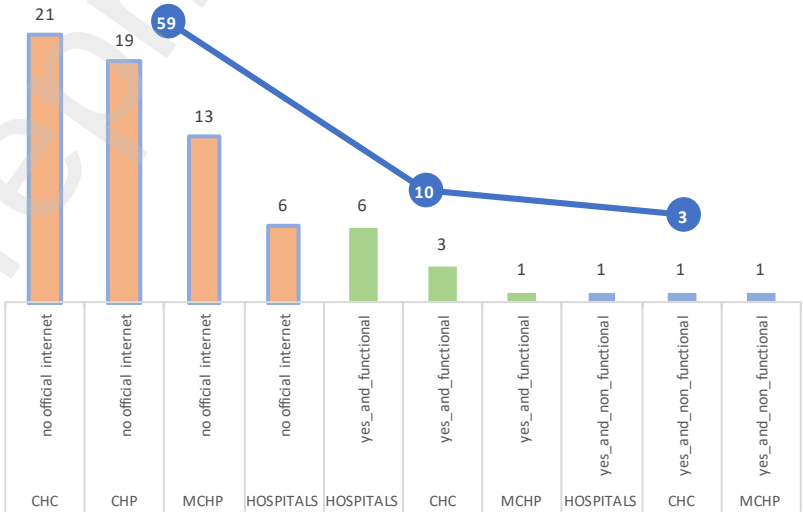


Figure. 2 – Number of health facilities that have institutionally provided internet

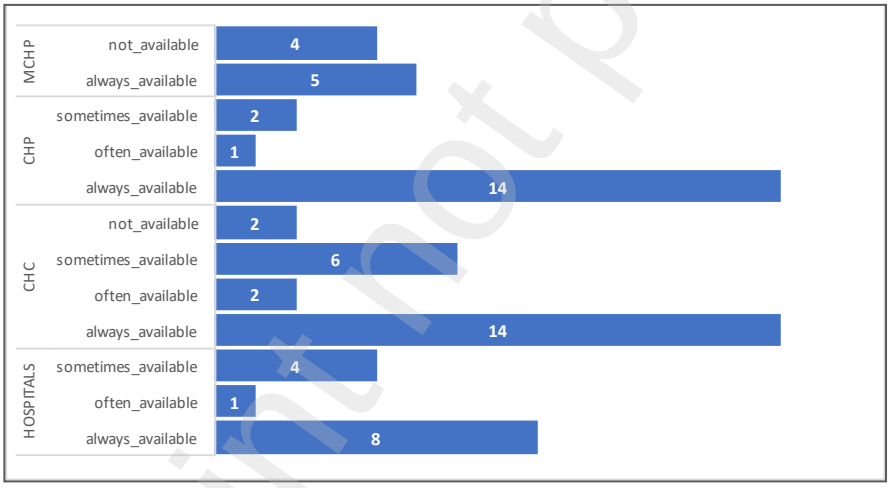
3.2. Electricity

All hospitals surveyed had an electric power source, and six of them had a national utility grid as the primary (main) source, five had generators as the primary source, and one had solar panels as the primary source. The detailed distribution of health facility type and number and type of their primary electricity source is in table 1. Approximately one-half of the PHUs surveyed did not have an alternative electricity supply source. All hospitals had one or more alternative electricity supply sources. About half of the PHUs use their primary electricity source (i.e. solar) for one purpose only, and the other half use the electricity for all health facility needs.

Table 1: Number of health facilities and their primary electricity sources.

Facility type	National utility	Generator	Solar	No electricity	Did not specify
Hospital	6	5	1	0	1
CHC	6	1	17	1	0
CHP	4	0	13	2	0
MCHP	0	0	9	6	0

Respondents at health facilities with primary electricity sources were asked how long electricity was available at their health facilities, using their recall about availability in the seven days before the survey. Approximately two-thirds of the hospitals surveyed indicated that they had uninterrupted power supply in the previous seven days. Moreover, none of the hospitals surveyed reported consistently unavailable electricity. The results for the PHUs were mixed, with the MCHPs having the worst findings (see *Figure 3*).



Always available	Uninterrupted availability per day in the last 7 days
Often available	Average less than 2-hour interruptions per day in the last 7 days
Sometimes available	Average more than 2-hour interruptions per day in the last 7 days
Not available	Consistent unavailability in the last 7 days

Figure 3: Duration of electricity availability at health facilities

Eleven of the 13 hospitals had a generator, and most of the generators at these hospitals were functional. One hospital had a non-functional generator, and one had no generator. At the time of the survey visit, only eight of the 11 hospitals with a functional generator had fuel in the event of a power outage. Similarly, only one of the six PHUs with functional generators had fuel at the survey period. Nine of the PHUs with solar as primary electricity source has partially functional solar and inverter system.

3.3. Computing hardware

All 13 hospitals had at least one functional computer at the time of enumerator visits. Besides, only two PHUs had a functional computer. However, only seven hospitals had four or more functional computers. One hospital had 15 functional computers. Thirty-seven of the health facilities with tablet-based digital health solutions had just one tablet. Other statistics from the survey show that only eight PHUs had one smartphone. Also, one hospital had eight smartphones. One PHU had two feature phones, and one hospital had one feature phone. Six PHUs had one basic-phone (dumbphone) that could only be used for calls and SMS. Three hospitals had internet modems. One hospital had one modem, one hospital had two modems, and one hospital had three modems.

4. Discussions

Infrastructure in support of information systems is at the core of the success of HIS [14]. Individualized care can be better optimized for data use when seamless HIS electricity, computing-devices, and internet-network infrastructures are available. This work mapped seventy-two health facilities. This sample gave a 95 percent confidence level and a confidence interval of 11 using [15]. This means that the findings in this report were statistically generalizable. This study focused on Sierra Leone, considered an excellent example of an LMIC, though we are aware that LMICs may vary in their characteristics [16].

The trends from our findings show the increasing use of solar solutions for PHUs, located mostly in rural locations. These rural facilities are often disconnected from the national electricity utility grid. This is a crucial lesson Sierra Leone shares with other LMICs with similar infrastructure deficit [17]. Some MCHPs still do not have any electricity source, and any health facility digitization depends on electricity. Renewable energy sources are bridging these gaps, as can be seen from our findings that 66% of PHUs use solar as their primary electric energy source, and another 15% have had no electricity source. This means that over 80% do not use the national utility as a primary electricity source at the PHU level. This mapping show without doubt that Direct Current (DC) based, renewable-enery alternatives are better suited for targeting off-grid PHUs [18]. See [19] for technical differences between Direct Current and Alternating Current electricity systems.

The internet distribution at these health facilities shows that 82% of all health facilities do not have official institutional provided internet. However, 26% had private internet across health facility type as in Figure 4. There were three mobile telecommunications service providers (Africell, Orange, and SierraTel) providing internet in all health facility visited. Alternative internet networks like fibre provided by Ministry of Information (MIC) [20]; and satellite based internets like spaceX can better serve off the grid facilities [21]. In the event of no internet, an off-line first HIS solution will be most appropriate.

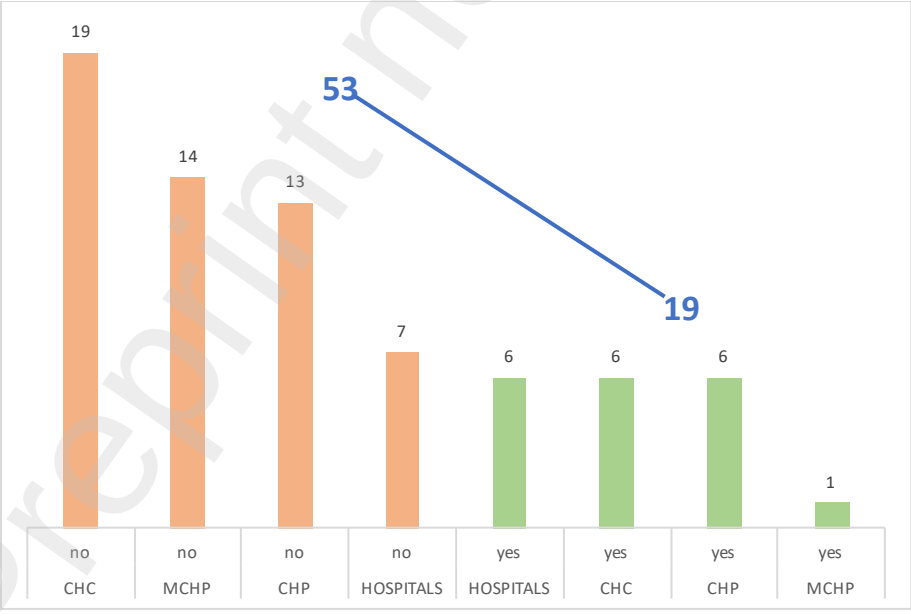


Figure 4: Infrastructure - private internet at health facilities (health facility survey)

PHUs surveyed had majorly one tablet. Depending on the solutions deployed in these health facilities, one tablet per health facility may or may not be enough [22]. Some advanced solutions may also not work on tablets, given that only two of the 59 PHUs had one computer each. Software solutions targeting these PHUs should be designed to be tablet compliant. Hospitals, on the other hand, did not all have the same number of computers. One hospital had 15 functional computers, another had nine, and six hospitals had four or fewer functional computers. This shows that computing devices across the hospitals are not evenly distributed, indicating a significant computing infrastructure gap at the hospitals. Fourty-three percent of surveyed health facilities think lack of aqequate power supply was the biggest threat to digitization as shown in figure 5.

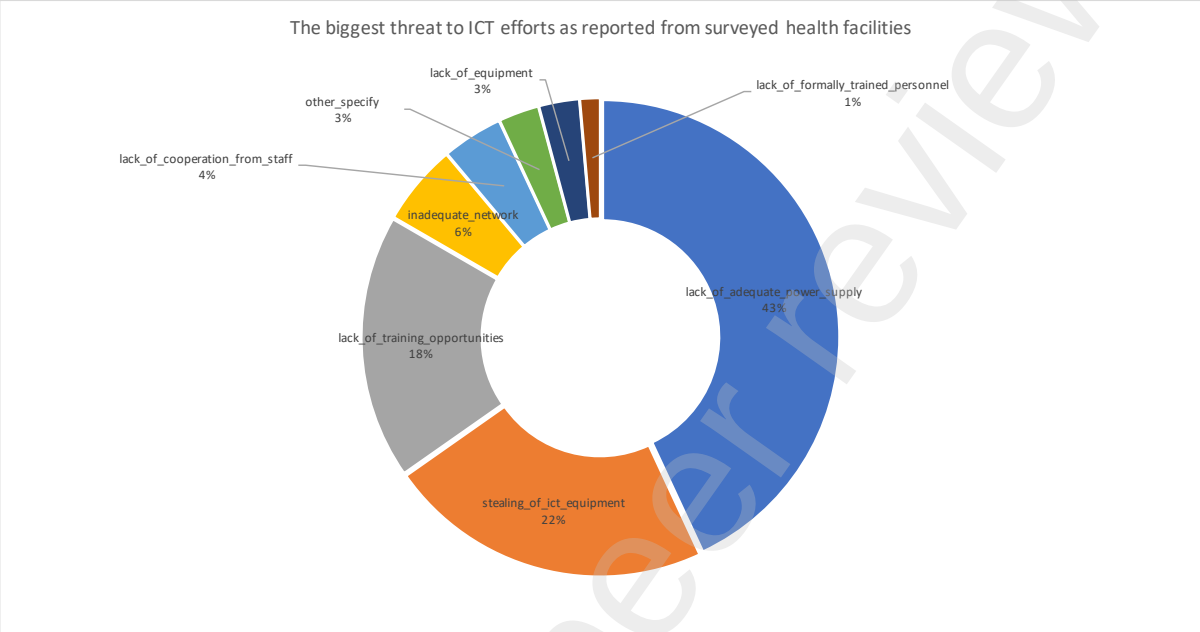


Figure 5: The biggest threats to ICT efforts at the health facilities surveyed

5. Conclusion

In this study, we have explored the state of infrastructure enabling the digital health environment in Sierra Leone. We surveyed their primary and secondary electricity sources, the type and nature of computing hardware, and the internet and connectivity available at these health facilities. We aggregated how often these health facilities have electricity to help determine if a health facility information system can be viable. Disconnected PHUs or hospitals can use alternative electricity sources, fibre or Satelite internet, and tablet hardware. This research will support the government to implement strategies for bridging health facility infrastructure gaps. The next step from this study will be to extrapolate and determine the current infrastructure (electricity, internet, and computing-hardware) costs from the national digital health costed plan [9].

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Contributions

FS is the approving authority for this study. EC designed and prepared the initial draft of this paper. EF and AK facilitated the data collectors recruitment, training, field visits, and report reviews. RW and LG provided technical inputs and review for the study article draft.

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