

Better Health

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1 Abstract

Enthusiasm for the uptake of technology and increased investment in electronic health (eHealth) systems have spurred a rapid growth in digital health solutions. However, in practice, eHealth systems are complex products of historical, social and economic forces, which rarely function systematically, are digitally walled, fragmented and unresponsive to needs. This results from having many eHealth interventions focusing on singular vertical health programs or individual aspects of the health system such as disease surveillance and clinical records. This paper responds to two questions: What is the state of maturity for HIS interoperability efforts in Ethiopia, Ghana, Malawi, and Tunisia? What are the contributing factors to observed levels of HIS interoperability maturity levels in these countries? Findings suggest that the countries assessed largely have a nascent or emerging level of maturity as regards eHealth standards and interoperability. This implies that the countries have defined digital health processes and structures, but largely have no systematic ongoing processes or measurement protocols, to track and enforce the adoption of standards and interoperability efforts. Key contributing factors to the observed status quo include: a lack of meaningful government budgets, to fund own HIS interventions; an overdependence on short-term and loosely coordinated donor funding, for HIS interventions; an overreliance on external technical assistance. All the countries assessed also have weak hardware and network communication infrastructure, to effectively facilitate systems interoperability. Another major point of weakness is that all the countries assessed lack business continuity plans. This means that national systems may have challenges recovering from any disasters that may occur, which significantly undermines HIS efforts. Despite observed challenges, countries have a good basis to build required technical expertise, required to further HIS interoperability efforts.

We recommend that countries party to this assessment should: implement interoperability monitoring and evaluation mechanisms to track efforts, coupled with appropriate incentives, to foster positive efforts, and penalties, to force compliance; reduce reliance on donor funding, by increasing local budgetary resources for HIS; reduce reliance on external technical assistance, through staffing of government departments. Countries would also do well to: develop business continuity and risk management plans; promote cross-country collaboration to share expertise and lessons; develop central repositories for all key documents, to improve institutional memory; improve connectivity infrastructure, mainly leveraging government-wide area networks, which may lower connectivity costs; improve hardware standards and availability across levels of administration. Finally, tertiary institutions provide a platform upon which required technical expertise can be developed.

2 Introduction

Enthusiasm for the uptake of technology and increased investment in electronic health (eHealth) systems have spurred a rapid growth in digital health solutions (World Health Organization [WHO] 2011). However, in practice, eHealth systems are complex products of historical, social and economic forces, which rarely function systematically, are digitally walled, fragmented and unresponsive to needs (AbouZahr & Boerma, 2005; Asah et al., 2021; Chaulagai et al., 2005; Kimaro & Nhampossa, 2005; MEASURE Evaluation, 2019). This results from having many eHealth interventions focusing on singular vertical health programs such as HIV or Malaria or individual aspects of the health system such as disease surveillance and clinical records.

Digitally walled eHealth systems are architecturally incapable of or have very limited capability to exchange information to keep their meaning, which results in the same data being collected multiple times (Measure). This compromises data quality and increases costs of maintaining eHealth systems (ibid). Consequently, it is challenging to meet set global and national goals for eHealth systems that positively contribute towards better health outcomes. In the end, countries are inundated with a proliferation of short-lived implementations (WHO 2019).

A principal concern of many countries is how to leverage disparate eHealth solutions in order to provide comprehensive patient care across medical systems. There is also a great demand to pool data from multiple domain-specific eHealth solutions to allow for more holistic analysis and planning, as well as to streamline information access (ITU, 2011; Minnesota Department of Health, 2019; Nsaghurwe et al., 2021). To allow all this, it is imperative that countries adopt industry-accepted eHealth standards to enable system interoperability (Dlodlo & Hamunyela, 2017; Galimoto, 2007; ITU, 2011; MEASURE Evaluation, 2019). It is also critical that countries should have concerted government-owned eHealth system interoperability efforts in which solution developers, service providers, citizen and development partners participate.

Interoperability describes the extent to which systems and devices can exchange data and interpret that shared data. For two systems to be interoperable, they must be able to exchange data, at least from one system to the other (MEASURE Evaluation, 2019; Nsaghurwe et al., 2021). This demands adherence to common standards for exchanging data. A standard is a definition, a set of rules or guidelines, a format, or a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices (Celi et al., 2017). Thus, eHealth standards provide context for interoperability, allowing for proper co-existence and interoperability of systems (Alunyu & Nabukenya, 2018).

The first step to promoting shared standards for systems interoperability, is an assessment of a country's eHealth landscape, to foreground human resource, governance and technological factors that foster or hinder standardization and interoperability efforts (Measure).

This paper presents an assessment of the maturity of eHealth and interoperability standards in four African countries: Ethiopia, Ghana, Malawi, and Tunisia. The assessment was done using the MEASURE Evaluation Interoperability Maturity toolkit (MEASURE Evaluation, 2019). The MEASURE Evaluation advances a self-assessment tool - Interoperability Maturity Toolkit - for countries to use in evaluating the state of their eHealth interoperability efforts, focusing on

human resource, governance and technological factors. The toolkit provides for rankings for maturity.

Table 1: MEASURE Evaluation interoperability maturity level

Level	Interpretation
1: Nascent	The country lacks digital health capacity or does not follow processes systematically. Digital health activities happen by chance or represent isolated, ad hoc efforts.
2: Emerging	The country has defined digital health processes and structures, but they are not systematically documented. No formal or ongoing monitoring or measurement protocol exists.
3: Established	The country has documented digital health processes and structures. The structures are functional. Metrics for performance monitoring, quality improvement, and evaluation are systematically used.
4: Institutionalized	The government and stakeholders use the national digital health systems and follow standard practices.
5: Optimized	The government and stakeholders routinely review interoperability activities and modify them to adapt to changing conditions.

The paper responds to the following two questions: What is the state of maturity for HIS interoperability efforts in Ethiopia, Ghana, Malawi, and Tunisia? What are the contributing factors to observed levels of HIS interoperability maturity levels in these countries?

The rest of this paper is organized as follows: The next section discusses related extant literature. The section after that, presents a methodology for the study. Thereafter, we present findings of the study, followed by a discussion of the findings. Concluding remarks follow thereafter.

3 Literature Review

Over the past two decades, there has been a growth in HIS investments in low- and middle-income countries (LMICs). Among the key drivers for this growth in HIS investments is the need to improve data reporting, analysis and access, in order to improve service planning and delivery, among other things (ITU, 2011; Karuri et al., 2014). However, studies indicate that HIS interventions in LMICs are perennially loosely coordinated, resulting in fragmented HIS that are digitally walled and largely unable to exchange data (AbouZahr & Boerma, 2005; Asah et al., 2021; Dlodlo & Hamunyela, 2017; Galimoto, 2007; Kimaro & Nhampossa, 2005). At the same time, it is widely acknowledged that siloed HIS are costly and unsustainable. In some cases, countries have taken drastic measures in order to try and control otherwise derailed HIS interventions. In 2012, Uganda put a moratorium on all digital health interventions, demanding that future interventions prioritised interoperability, sustainability and conformity to existing Ministry of Health (MoH) cyber laws and data requirements (Huang et al., 2017). Inasmuch as there is wide acceptance for the need to sanitize the HIS landscape in LMICs, there is a strong inclination towards the adoption of less drastic measures. There are growing calls for the adoption of digital health standards to foster interoperability being strongly preferred (ITU, 2011; MEASURE Evaluation, 2017; Nsagurwe et al., 2021).

eHealth standards are implemented with the aim to standardize systems mostly to enable data sharing or interoperability (ITU, 2011; Minnesota Department of Health, 2019). eHealth standards are common and repeated rules, conditions, guidelines, or characteristics that define how to collect, use, and share electronic health information (Minnesota Department of Health, 2019). Different categories of eHealth standards define the language and data types and the format, structure, transport, security and functionality (ibid).

It is essential that standards should be approved by a recognized standards development organization, or it should have been accepted by the industry (Celi et al., 2017). eHealth standards also help with protection and safety of the consumer, improved economic benefits through facilitation of market transaction, fostering competition and aiding diffusion of knowledge & technology.

eHealth standards provide context for interoperability. Most references to eHealth standards refer to the facilitation of interoperability among digital health systems. Standards are specifications necessary for proper co-existence and interoperability of systems (Alunyu & Nabukenya, 2018). Interoperability describes the extent to which systems and devices can exchange data and interpret that shared data. In order for electronic health (eHealth) systems to be interoperable, they must adhere to common standards for exchanging data (ITU, 2011; Nsagurwe et al., 2021).

Measure Evaluation identifies five types of standards with eHealth as follows: Data Interchange; Semantic Content; Security, Safety and Privacy; Pharmacy and Medicines and Architecture (MEASURE Evaluation, 2015). However, most literature group interoperability into three main areas (Glickman & Orlova, 2015):

- Semantic interoperability—shared content
 - Data Standards (vocabularies and terminology standards)
 - Information Standards (reference information models, information templates, and other)
 - Example standards include HL7, SNOMED(Dolin & Alschuler, 2011)
- Technical interoperability—shared information exchange infrastructure (transport)
 - Information Exchange Standards (message-based and document-based)
 - Identifier Standards
 - Privacy and Security Standards
 - Example standards include OpenHIE, HTTP, FTP, SOAP (*Interoperability Standards*, n.d.)
- Functional interoperability—shared rules of information exchanges (i.e., business rules and information governance (IG), “the rules of the road”)
 - Functional Standards (requirements for health information and communication technology derived from the analysis of the use case)
 - Business Processes Standards (guidelines and best practices described in the use cases)

A fully interoperable ecosystem addresses the following key challenges (Glickman & Orlova, 2015):

1. Data quality, misidentification, and integration of patient data from multiple sources (record matching on a patient represents a critical record management step, so that the information from one patient cannot be added to the chart of another patient)
2. Data accuracy, availability, and integrity issues due to configuration, security, or IT operations failures
3. Decision support failures due to incorrect or outdated medical logic, reference data, algorithms or alert triggers
4. Failures and inconsistencies in delivery, integration, or presentation of diagnostic information results
5. Failures and inconsistencies in delivery, integration or presentation of therapy information (such as radiotherapy information)
6. Insufficient attention to workflow, human factors, change management, or training of clinicians
7. Privacy breaches, data governance issues, or other causes that erode provider and consumer confidence

3.1 Role of Leadership and Governance, Human Resource Capacity and Financing

One key challenge facing LMICs in HIS implementation is the overdependence of governments of donor funding to facilitate interventions. A direct consequence of this is that governments have less control of the interoperability agenda (AbouZahr & Boerma, 2005; Dlodlo & Hamunyela, 2017). Nonetheless, governments can play a key role in providing discursive spaces for HIS

interoperability, through multi-stakeholder advisory groups. Such advisory groups can serve to align stakeholder interventions and review ongoing or planned HIS interventions. Government ownership of HIS interoperability is key for institutionalization of efforts (Ministry of Health, 2015).

Another key enabler for HIS interoperability is business continuity planning. As countries move towards interoperable systems, there is an increasing need for key interoperability layer components to be available around the clock. Adequate planning and preparation are resource-intensive, time-consuming activities, meaning decision makers may not allocate adequate resources to business continuity planning, especially when there are other pressing needs that require immediate funding. This can lead to organizations undertaking the easy parts of emergency planning, such as producing policy and strategy documents, with rather less work directed towards 'translational preparation' (Simpson & Sellwood, 2010).

A final factor that we consider here is technical capacity, both in term of numbers and quality. LMICs face challenges shortages of IT staff to man HIS systems, let alone facilitate interoperability efforts (Alunyu & Nabukenya, 2018; MoH, 2018). A key challenge to correcting Human capacity issue facing African countries is that existing digital health programmes lack balanced course programmes to develop desired core competencies (Alunyu et al., 2020). Thus, African countries need to develop or adopt a digital health worker competency framework and then re-organize their national health training curriculum to ensure a standardized/universal eHealth curriculum for training the digital health workforce (ibid).

To correct present challenges, it is critical to first determine what the state of interoperability efforts across various key domains. This study adopted the MEASURE Evaluation HIS Interoperability Maturity Toolkit (MEASURE Evaluation, 2017, 2019) to assess the maturity of country HIS interoperability efforts.

The MEASURE Evaluation HIS Interoperability Maturity Toolkit

Measure Evaluation collaborating with the Open Health Information Exchange (OpenHIE) identified three key areas as important for successful implementation of Interoperability. These key areas include:

1. Leadership and Governance:
 - a. Governance Structure for HIS
 - b. Interoperability Guidance Documents
 - c. Compliance with Data Exchange Standards
 - d. Data Ethics
 - e. HIS Interoperability Monitoring and Evaluation

- f. Business Continuity
 - g. Financial Management
 - h. Financial Resource Mobilization
2. Human Resources
- a. Human Resources Policy
 - b. Human Resources Capacity (Skills and Numbers)
 - c. Human Resources Capacity Development
3. Technology
- a. National HIS Enterprise Architecture
 - b. Technical Standards
 - c. Data Management
 - d. HIS Subsystems
 - e. Operations and Maintenance (for computer technology)
 - f. Communication Network: Local Area Network and Wide Area Network
 - g. Hardware

4 Methodology

The focus of this assessment was digital HIS in four African countries that are part of the BETTEReHEALTH project (<https://betterehealth.eu/>): Ethiopia, Ghana, Malawi, and Tunisia. Data were collected between June and July 2021. The assessment of national HIS systems employed the Health Information Systems Interoperability Maturity Assessment toolkit by Measure Evaluation (MEASURE Evaluation, 2019). Thus, the study followed a structured qualitative assessment, guided by a structured questionnaire, where responses to the assessment questionnaire was consensus based. A copy of the assessment questionnaire is provided as appendix 1.

Assessments for each country were conducted by in-country teams. Each country's assessment team comprised staff from ministries of health, together with a multi-disciplinary purposely sampled team of stakeholders, including implementation partners (donors, NGOs) closely working with the ministries on digital health implementations. Purposive sampling allows for the better matching of the sample to the aims and objectives of the research, which in turn improves the rigour of a study and trustworthiness of its data and results (Campbell et al., 2020). Purposive sampling was preferred for country health systems assessments, as the exercise demanded considerable working knowledge of implemented health information systems, national policies and associated funding mechanisms. It was also deemed that participants in assessment exercises needed to be familiar with in-country human resource capacity issues, as well as consensus-building or regulatory structures.

4.1 Country Assessments, Data Collection and Analysis

The assessments were conducted using consensus-centric workshops. Each country had a local coordination team that facilitated the workshops. Workshops were conducted either in person or virtually, lasting between one and three days. The assessments began with a brief on the assessment framework adopted. Stakeholders party to the assessment workshops, henceforth referred to as assessment teams, then completed the assessment questionnaire (see appendix 1). This exercise was evidence-based, requiring assessment teams to provide documentation supporting their scoring of country HIS.

After responding to the questionnaire, assessment teams completed a maturity scoring sheet (see appendix 2), to determine the level of maturity for a country. The scoring sheet maps and ranks the assessment questionnaires responses to five levels of maturity, in the following order: nascent; emerging; established; institutionalized; optimized. In going about the scoring tasks, assessment teams marked assessment features that were deemed to have been fully accomplished in green. Those that were partially accomplished were shaded in yellow, and those that were not applicable or had not been handled were not marked with any colour. After this, the assessment teams were required to determine the maturity level of each subdomain that was assessed, taking the lowest level that had been fully accomplished as the score for that subdomain. If higher levels had been partially accomplished, then a plus (+) symbol would be appended to the score. For example, if features up to level 4 of maturity had been fully accomplished but level 5 had only been partially accomplished, the score would be 4+. Figure 1 presents a sample scoring sheet.

HEALTH INFORMATION SYSTEMS INTEROPERABILITY MATURITY MODEL WORKSHEET							
Domain	Subdomain	Level 1: Nascent The country lacks HIS capacity or does not follow processes systematically. HIS activities happen by chance or represent isolated, ad hoc efforts.	Level 2: Emerging The country has defined HIS processes and structures, but they are not systematically documented. No formal or ongoing monitoring or measurement protocol exists.	Level 3: Established The country has documented HIS processes and structures. The structures are functional. Metrics for performance monitoring, quality improvement, and evaluation are systematically used.	Level 4: Institutionalized Government and stakeholders use the national HIS systems and follow standard practices.	Level 5: Optimized The government and stakeholders routinely review interoperability activities and modify them to adapt to changing conditions.	Subdomain Level
Leadership and Governance	Governance structure for HIS	Evolving governing body for health information systems (HIS) is constituted on a case-by-case basis OR no governing body exists.	An HIS governing body is formally constituted and has a scope of work that includes the people responsible for data governance oversight. The governing body oversees interoperability directly or through a separate technical working group (TWG).	The HIS governing body conducts regular meetings with stakeholder participation.	The HIS governing body is government-led, consults with other ministries, and monitors implementation of HIS interoperability using a work plan. It mobilizes resources—financial, human resources (HR), and political—to accomplish its goals.	The HIS governing body is legally protected from interference or organizational changes. The HIS governing body and its TWGs are nationally recognized as the lead for HIS interoperability. The governing body works in liaison with other similar working groups regionally and/or around the world.	4+
	Interoperability guidance documents ¹	HIS interoperability guidance documents are absent, and HIS interoperability is implemented on a case-by-case basis.	The governing body for HIS interoperability has drafted the necessary HIS interoperability guidance documents.	Interoperability guidance documents developed, tested, and adopted, and include reference terminologies and technical standards for data exchange.	The interoperability guidance documents are government-owned. They are consistently used and referenced in efforts to guide implementation of HIS interoperability.	Processes are in place to regularly monitor the implementation of the interoperability guidance documents. The interoperability guidance documents are regularly reviewed and updated based on lessons learned from implementation. These documents reflect international best practices.	4

Figure 1: Sample assessment scoring sheet

It should be noted that at times the scoring process was quite contentious, as in some cases assessment teams were of the view that the maturity model's assessment was too rigid in some aspects. Say, if level 2 was marked as being the only fully accomplished level, but significant work had been accomplished at levels 3 to 5, a score of 2+ may not communicate the correct picture regarding a country's maturity level.

Once assessment teams had scored subdomains, they proceeded to score each domain, taking the lowest score for the lowest scored subdomain as the maturity level for the domain. Thereafter, the maturity level of the country HIS was assigned the score of the lowest scored domain. Some stakeholders also contested this rigidity to scoring.

5 Findings

Results are presented in the order: Leadership and governance, human resources, and technology. A presentation of the country scores includes notes on evidence or missing technological, human resource, and governance features that justify the scoring. After presentation of individual country scores, we present the various country scores side by side.

5.1 Results for the Leadership and Governance Subdomain

All countries that were assessed have key policy documents in place, especially on safeguarding data. Malawi and Ethiopia also have key policy documents on interoperability, with Malawi having already implemented an interoperability layer, while Ethiopia does have a blueprint in place. On the other hand, Tunisia seems to lag behind in this regard. Ethiopia, Ghana and Malawi also have national multi-stakeholder advisory work groups that review digital health interventions. The assessment in Tunisia showed that there is no national advisory group.

Key weak points for all assessed countries include the absence of systematic interoperability monitoring and evaluation mechanisms. All the countries also lack business continuity plans. Although countries seem well positioned to mobilise resources, there is considerable dependence on donor funding for digital health interventions, which is likely to undermine the progress of HIS interoperability efforts.

Table 2: Leadership and governance scores from Ethiopia

Domain	Sub Domain	Score	Description of Sub domain Scores
Leadership and Governance	Governance Structure for HIS	3+	There is a governing body having a scope of work that includes the people responsible for data governance oversight; the HIS National Advisory group conducts regular meetings on a quarterly basis. Where necessary, the interval for meetings is shortened; the HIS governing body is government-led; the HIS governing body mobilizes resources (financial, human resources, and political) to accomplish its goals; an eHealth Architecture (eHA) TWG is responsible for managing issues related to Interoperability.
	Interoperability Guidance Documents	1+	The country has Interoperability standard Blueprint; The interoperability guidance document(s) have been drafted but not launched; The interoperability guidance document(s) are government-owned.
	Compliance with Data Exchange Standards	2+	The HIS has developed or adopted and implemented a regulatory framework through a data sharing policy for compliance with structures (working groups, steering committees, or units), processes, and procedures to guide or enforce compliance with data exchange, messaging, and data security standards;
	Data Ethics	1+	HIS users have been sensitized on the data security and privacy laws through data sharing protocols;
	HIS Interoperability Monitoring and Evaluation	1	No evidence to support progress.
	Business Continuity	1	No evidence to support progress.
	Financial Management	4+	There are budgets for national HIS, including interoperability, based on HIS workplans - Coasted HIS strategic plan and Annual plan; There are budgets developed for the subnational HIS, including interoperability, based on workplans – regional HIS plan; The HIS budget is part of the Ministry of Health’s budgeting process; Regular financial audits are carried out to promote accountability in HIS spending;
	Financial Resource Mobilization	3+	The proportion of HIS budget allocation is higher from Government sources; A costed work plan at national level is in place that covers both the information and communications technology (ICT) infrastructure (network, hardware, and software) and personnel for HIS needed for HIS strengthening, including HIS interoperability; The government and implementing partners do not have sufficient funding to implement the costed work plan; Strategic and annual plans preparation, updating and implementation lead by the Ministry

Table 3: Leadership and governance scores for Ghana

Domain	Sub Domain	Score	Description of Sub domain Scores
Leadership and Governance	Governance Structure for HIS	2+	The MOH is very involved and is taking a lead role in developing interventions to support HIS interoperability; there is evidence of strong collaboration between the National IT Agency (NITA) of Ministry of Communication and Digitalisation, MOH and its agencies in supporting HIS and the National eHealth Steering Committee; the collaboration is made up of key digital health stakeholders and meet on a case-by-case basis; the digital workspace is regulated by the Ministry of Communication and Digitalization to ensure compliance concerning privacy, confidentiality, integrity and availability of health data; there are technical institutions serving as regulators in Ghana, such as NITA, Data Protection Commission, National Communication Authority, National Cybersecurity Authority and Ghana Audit Service.
	Interoperability Guidance Documents	2+	The country has documents drafted to guide interoperability and seamless integration of eHealth system, including the electronic Government Interoperability Framework, GHS Enterprise Architecture and eHealth Strategy; the interoperability guidance document(s) are government owned.
	Compliance with Data Exchange Standards	2	Subsystems in the national HIS are required to meet compliance and certification criteria; the government enforces the regulatory framework for compliance.
	Data Ethics	4	The country has an approved health data regulatory framework; health data security and privacy laws have been implemented, and there are guidelines on how to operationalize the laws in the context of HIS (GHS HMIS SOP); HIS users have been sensitized on the data security and privacy laws through Data Protection Act 2012, Act 843 and Cyber security Act 2020, Act 1038.
	HIS Interoperability Monitoring and Evaluation	2	Methods and tools to report on HIS interoperability implementation are defined and documented; data interchange parameters are defined in Health Information Exchange (HIE) which is functional.
	Business Continuity	1	There is no government-approved business continuity plan in place for national or sub-national level of the HIS.
	Financial Management	1	No clear plan exists for financial management of HIS, including interoperability activities. However, financial audit processes are in place and are carried out regularly to promote accountability in HIS spending (GHS IT Audit report).
	Financial Resource Mobilization	1	There is no documented plan for financial resources for HIS strengthening, including HIS interoperability; financial resources for HIS strengthening, including HIS interoperability, are mostly donor driven.

Table 4: Leadership and governance scores for Malawi

Domain	Sub Domain	Score	Description of Sub domain Scores
Leadership and Governance	Governance Structure for HIS	4+	A HIS governing body is formally constituted and has a scope of work that includes the people responsible for data governance oversight; the governing body oversees interoperability directly or through a separate technical working group (TWG); The HIS governing body conducts regular meetings with stakeholder participation.; the HIS governing body is government-led, consults with other ministries, and monitors implementation of HIS interoperability using a work plan. It mobilizes resources—financial, human resources (HR), and political—to accomplish its goals.
	Interoperability Guidance Documents	4	The governing body for HIS interoperability has drafted the necessary HIS interoperability guidance documents; Interoperability guidance documents have been developed, tested, and adopted, and include reference terminologies and technical standards for data exchange; The interoperability guidance documents are government-owned. They are consistently used and referenced in efforts to guide implementation of HIS interoperability.
	Compliance with Data Exchange Standards	2	Structures (working groups, steering committees, or units) are in place to guide or enforce compliance.
	Data Ethics	2+	The country has drafted laws, policies, and a regulatory framework for data security and privacy that address issues related to health data; the country has a recognized mechanism (e.g., committee or working group) for reviewing data ethics issues in the national HIS, and for updating policies, procedures, and laws, as needed. This mechanism reflects industry best practices.
	HIS Interoperability Monitoring and Evaluation	3	The methods and tools to report on HIS interoperability implementation are defined and documented; Mechanisms to track and measure performance of HIS interoperability work are government-approved and government-led; results from monitoring of HIS interoperability are used for planning. Decisions about future activities take this analysis into consideration.
	Business Continuity	1+	No government-approved business continuity plan is in place at the national or subnational levels of the HIS.
	Financial Management	4+	High-level financial management structures, including budgets, are developed for the national HIS, including interoperability in the country based on HIS work plans; detailed financial management structures, including budgets for HIS interoperability at the national and subnational levels, are developed based on the HIS work plan; HIS expenditure is monitored against HIS budgets; The HIS budget is part of the Ministry of Health's budgeting process; financial audit processes are in place and are carried out regularly to promote accountability in HIS spending.
	Financial Resource Mobilization	3+	Financial resources for HIS strengthening, including HIS interoperability, are mostly donor driven. A costed work plan at national and subnational levels is in place that covers both the information and communications technology (ICT) infrastructure (network, hardware, and software), and personnel for HIS needed for HIS strengthening, including HIS interoperability. At a minimum, this work plan identifies the activities, timeframe, costs, and sources of funding for HIS interoperability.

Table 5: Leadership and governance scores for Tunisia

Domain	Sub Domain	Tunisia	Description of Sub domain Scores
Leadership and Governance	Governance Structure for HIS	1	The assessment team was unanimous that there is no national HIS in Tunisia and consequently there is no governing body. Currently there are some Health Information Systems in Tunisia which do not communicate. Interoperability is felt as a need but it is not yet institutionalized
	Interoperability Guidance Documents	1	HIS interoperability guidance documents are absent.
	Compliance with Data Exchange Standards	3	The HIS has developed or adopted and implemented a regulatory framework for compliance with structures (working groups, steering committees, or units), processes, and procedures to guide or enforce compliance with data exchange, messaging, and data security standards through government decree n°2020-777 of October 5th, 2020 related to the electronic data exchange is available
	Data Ethics	3	The country has an approved health data regulatory framework through Organic Act n°2004-63 of July 27th 2004 on the protection of personal data is available.
	HIS Interoperability Monitoring and Evaluation	1	No tracking is done of HIS interoperability activities related to plans, resources, and budgets for the national HIS since there is no national HIS and consequently interoperability is not yet implemented.
	Business Continuity	1	There is no government-approved business continuity plan (BCP) in place for the national level of the HIS.
	Financial Management	1	No clear plan exists for financial management of HIS, including interoperability activities.
	Financial Resource Mobilization	1	There is no documented plan for financial resources for HIS strengthening, including HIS interoperability.

5.2 Results for the Human Resources Subdomain

Ghana and Malawi have human resource policies, while Ethiopia and Tunisia are yet to develop human resource policies. All countries show that they have inadequate human capacity to support HIS. There is a dependence on technical support arrangements. Ethiopia, Ghana, and Malawi have the required level of human capacity development, scoring 3 and above. The assessment in Tunisia shows that the country has no training programs in place to build human resource capacity on digital HIS, including interoperability. However, the assessment team was in agreement that the country has begun the development of a specific training plan based on internationally recognized HIS curriculum.

Table 6: Human resources subdomain scores for Ethiopia

Domain	Sub Domain	Score	Description of Sub domain Scores
Human Resources	Human Resources Policy	1+	HR Policy is available at MOH and HIS structure and function has been established. However, given the booming digital health/HIS endeavours, there are lots of things to be done to make it more demand driven.
	Human resources capacity (skills and numbers)	1+	There are HIS/Digital Health Cadre staff for the digital health – but the number is too small to meet the emerging needs.
	Human Resources Capacity Development	3	Yes, there is a plan – both at pre-service and in-service levels. But it takes a concerted effort and significant investment to get there. The concerted efforts between government institutions, partners, academia and private sectors can realize this – and there are promising efforts already out there

Table 7: Human resources subdomain scores for Ghana

Domain	Sub Domain	Score	Description of Sub domain Scores
Human Resources	Human Resources Policy	3	In 2002, the Ministry of Health developed a five-year (2002-2006) policy and strategy document - "Human Resources for the Health". The full implementation of staffing norm was failed and in September 2007, the Ministry of Health developed "Human Resource Policies and Strategies for the Health Sector (2007-2011)". These documents did not explicitly lay out human resources (HR) related to HIS or digital health. The 2007-2-11 policy document outlines the basis for decision making regarding planning, training, recruitment, deployment, and management of only the Health Information Officers. In 2015, the Ministry of Health developed an evidenced based Staffing Norm (staffing standard) for all levels of Health Facilities. This document outlines the staffing norms for Biostatisticians, Biostatistics Assistants and Technical Officers (Health Information).
	Human resources capacity (skills and numbers)	2	There are HIS staff for the digital health, but the number is not enough to meet the needs. For digital HIS 20 % of the propositions are for external technical assistance and interoperability, whereas 80% are for local technical assistance.
	Human Resources Capacity Development	4	There is an HIS strategy to for in-service training of HIS staff, to build their skills around digital HIS and interoperability (Ghana Strategy for Technology Assessment, 2021); there are pre-service and in-service trainings in HIS available in the country. MoH training schools and Universities in Ghana provide trainings for different level of staff; each university has its own independent curriculum; mentorship and training assistance are provided by PPMED of GHS; other private training institutions (Advance Information Technology Institute – Kofi Annan Centre in Excellence in ICT, IPMC, etc.) provide intensive industry focused courses for IT professionals; in-training support also provided through NGOs (R4D); the government and some stakeholders provide resources for health ministry staff to receive training on HIS, including digital HIS and interoperability (study leave etc.).

Table 8: Human resources subdomain scores for Malawi

Domain	Sub Domain	Score	Description of Sub domain Scores
Human Resources	Human Resources Policy	3+	A health Sector Human Resources Policy is available; National HRH strategy available; 2019 Health Sector Functional Review Report which establishes comprehensive staff positions in the Central Monitoring and Evaluation Division of the MoH and the Digital Health Division; Malawi National Digital Health Strategy is available; Digital Health Sustainability Paper v2.0_DRAFT; National Monitoring, Evaluation and Health Information Systems Strategy is available.
	Human resources capacity (skills and numbers)	2+	26 civil servant positions have been established based on the 2019 MoH functional review but they are yet to be filled; the national budget does not include Digital HIS activities; almost all current Digital Health Division staff and most of the Central Monitoring and Evaluation Division (CMED) national staff are seconded staff; an interoperability roadmap is available;
	Human Resources Capacity Development	4	Local Universities provide trainings through modules on digital HIS; Non coordinated independent curriculum per institutions; an MoH National HIS Curriculum is available; Mentorship is provided through the Division of Digital health's Technical assistants; OpenHIE Academy and other trainings are available for open source software; Availability of higher learning institutions; Training Institutions such as the University of Malawi and private firms such as Sparc Systems have capacity to provide trainings

Table 9: Human resource subdomain scores for Tunisia

Domain	Sub Domain	Score	Description of Sub domain Scores
Human Resources	Human Resources Policy	1	The assessment team was in complete agreement that there is no human resources policy.
	Human resources capacity (skills and numbers)	1	The assessment team was in agreement that there is no dedicated cadre of staff for maintaining digital HIS and interoperability.
	Human Resources Capacity Development	1	The country has no training programs in place to build human resource capacity on digital HIS, including interoperability. But the Assessment team was in agreement that the country has begun the development of a specific training plan based on internationally recognized HIS curriculum.

5.3 Results for the Technology Subdomain

All countries have national HIS enterprise architecture documents, but implementation is at varied stages. Tunisia has the most work to do in this aspect. Efforts on adoption of technical standards are largely underdeveloped in the countries assessed. At best, only a few systems interoperate at national level. Nonetheless, it is worthwhile noting that Ethiopia and Malawi do have interoperability frameworks implemented upon which further work can be based.

Ethiopia's assessment shows a presence of strong data management mechanisms, but the other countries are lacking in this regard. The computer networks and hardware subdomains were ranked highest in Ghana and Tunisia. It is worthwhile noting that governments across the countries are working to improve connectivity, although the work is at different stages of maturity. Malawi reported that the Government Wide Area Network, although in place, it is yet to be utilized to enhance HIS connectivity.

Table 10: Technology subdomain scores for Ethiopia

Domain	Sub Domain	Score	Description of Sub domain Scores
Technology	National HIS Enterprise Architecture	4+	A validated national HIS enterprise architecture exists that defines technology requirements and exchange formats for interoperability; the country has foundational tools and rules for HIS interoperability, they include tools such as a health information management system for routine and surveillance data, and core authoritative registries (Master Facility Registry (MFR, National Health Data Dictionary (NHDD), NCoD (National Classification of Diseases; an interoperability layer (national enterprise service bus) is planned but not fully functional; the government owns, enforces, and leads implementation of the national HIS enterprise architecture through the HIS governance manual; the OpenHIE or similar framework standards are implemented, e.g. Health Facility Registry, Health Worker Registry, Terminology Registry; Ethiopia national track & trace system – a technical architecture document, information revolution documents
	Technical Standards	2+	An HIS ICT infrastructure assessment has been conducted and the needs for a coherent HIS ICT infrastructure architecture have been documented through the PRISM, CBMP assessment tool HIS app inventory assessment; the country has adopted or developed technical standards for health data exchange, messaging, and security; and EMR standard is developed (draft stage, not yet approved, though) Data sharing protocol is under development (data sharing protocol); there is a Data Exchange Interoperability Framework for eHealth Applications in Ethiopia,
	Data Management	4+	Electronic data management procedures or the HIS are clearly developed and documented in a nationally recognized document (HMIS recording and reporting procedures manual, CHIS manual, DHIS2 manual, eCHIS manual); A roadmap is partially in place to migrate data collection and reporting from a paper system to an electronic system, complete with necessary data security safeguards; A documented mechanism is in place for maintaining data quality throughout the data supply chain (Health data quality guideline; Health data quality training manuals); National electronic data management processes are published and disseminated for the HIS; A standard operating procedure and/or data use plan is in place to facilitate data use by the country and its stakeholders (Information use Guideline, Information use training manual); A data warehouse development is started but not yet fully functional; there is an Ethiopian Public Health Institute Revised Guideline for Data Management and Sharing 2019 document
	HIS Subsystems	2	HMIS, HRIS, DAGU, CHMIS, EMR, SMART CARE, PHEM, COVID-19 tracker. These systems are not interoperability compliant.
	Operations and Maintenance	2	The country has the capacity for strong in-country computer technology maintenance. Information Communication Technology related departments available at national and

for Computer Technology		regional levels with IT and Computer science staff; Computer operations and maintenance services are part of the HIS plan or the country's strategic plan for health (HIS and digital health strategy of the health sector); Standard operating procedures do not exist that detail protocols for routine network and hardware maintenance
Communication Network: Local Area Network and Wide Area Network	2+	Connectivity is poor as we go down to the lower levels of the health system; An HIS-dedicated ICT and network support team is in place through the Health Information Technology Directorate at national level (MOH). However, the government is implementing the HealthNet Program to enhance connectivity at lower levels
Hardware	1+	The country has limited/inadequate hardware (e.g., servers, computers, printers, and supportive accessories) to support a national HIS especially at lower levels; There is no evidence for infrastructure assessment conducted and availability of backup and recovery plan for national HIS.

Table 11: Technology subdomain scores for Ghana

Domain	Sub Domain	Score	Description of Sub domain Scores
Technology	National Enterprise Architecture	HIS 3+	<p>A national HIS enterprise architecture exists that defines technology requirements and exchange formats for interoperability; the country has foundational tools and rules for HIS interoperability, which include tools such as a health information management system for routine and surveillance data, and core authoritative registries; an Interoperability Service Layer (ISL) for the HIS is operational and provides core functions, such as data authentication, translation, and interpretation.</p> <p>The government owns, but does not yet enforce implementation of the national HIS enterprise architecture; a national Digital Strategy from 2019 is in place; the OpenHIE or similar framework standards are implemented (see: www.chimgh.org/resources, HRIMS from HR).</p> <p>There are currently applications used for information management: DHIS2, DiHPART, iHOST and HAMS, National Health Insurance Scheme IT solutions and others. Ghana has deployed the DHIS2 in all the 260 districts in the country. This comprehensive HMIS is used to collect, collate, analyse and report routine health service data from public, private and faith-based facilities in the country.</p>
	Technical Standards	1	<p>An HIS ICT infrastructure assessment has not been conducted; technical standards exist for use in the country's HIS data exchange (GHS SOPs on Health Information); applications are hosted by the providers without any control from the government or Ministry of Health; NITA was set up under the Ministry of Communication and Digitalization in 2008 by an Act of Parliament as a regulator of the digital workspace.</p>
	Data Management	2+	<p>Electronic data management procedures for the HIS are clearly developed and documented in a nationally recognized document (GHS SOPs on Health Information, DHIS2 Manual); a roadmap is in place to migrate data collection and reporting from a paper system to an electronic system, complete with necessary data security safeguards; a documented mechanism is in place for maintaining data quality throughout the data supply chain; a standard operating procedure and/or data use plan is in place to facilitate data use by the country and its stakeholders (GHS SOPs on Health Information); data access and use are constantly monitored, and data management systems are updated accordingly.</p>
	HIS Subsystems	2+	<p>The country's HIS mainly consists of stand-alone program-specific subsystems directly linked to other subsystems to enable data exchange (DHIMS2 – CHIMGH.ORG); HIS presented in the country: DHIMS2, PBMIS, HRIMS, GHILMS eTRACKER FOR HIV, MCH, TB, LIGT WAVES, SOMAS/</p>

		COVID-19; the government requires all HIS subsystems to comply with the country's interoperability plan, including use of technical standards.
Operations and Maintenance for Computer Technology	4	The country has the capacity for strong in-country computer technology maintenance (Information Communication Technology departments available at national, regional and district levels (IT and Computer science staff is available, but not adequate); Computer operations and maintenance services are part of the HIS plan or the country's strategic plan for health; standard operating procedures exist that detail protocols for routine network and hardware maintenance.
Communication Network: Local Area Network and Wide Area Network	3+	The country has no reliable network connection to support a national HIS; connectivity is poor at the lower levels of the health system; an ICT infrastructure assessment has been conducted to determine LAN and WAN requirements for the country's HIS; the country is using mainly unreliable wireless (2G, 3G or 4G) modems to connect to the HIS services; a national implementation plan to meet the LAN and WAN requirements in the country exists; a national network maintenance plan exists to ensure high uptime, including clear procedures to recover from network failure; the country has begun implementing a technical solution to ensure permanent connectivity to HIS services; all national offices and at least 50% of the subnational offices of the Ministry of Health and health service providers have a strong and reliable network connection to the various HIS network services; an HIS-dedicated ICT and network support team is in place.
Hardware	1+	The country has limited/inadequate hardware (e.g., servers, computers, printers, and supportive accessories) to support a national HIS especially at lower levels; 50% or more of the Ministry of Health's national and subnational offices have the required hardware, including back-up hardware.

Table 12: Technology resources subdomain scores for Malawi

Domain	Sub Domain	Score	Description of Sub domain Scores
Technology	National HIS Enterprise Architecture	3	National HIS Architecture, National Digital Health Strategy, Interoperability Layer Requirements documents as well as the Interoperability Standard Operating Procedures (SoP) are available. These documents reside with the Digital Health Division. The country has HMIS (dhis2.health.gov.mw), a One Health Surveillance Platform (ohsp.health.gov.mw); we have the Terminology Service (mau.health.gov.mw), Client Registry and Health Worker Registry development is in progress. There is an interoperability layer based on the OpenHIM (xchange.health.gov.mw) and the Master Health Facility Registry
	Technical Standards	1	A few standards for HIS subsystems exist but are yet to be established for others i.e. Health Worker Registry, Client Registry. These are coordinated by the Digital Health TWG and M&E TWG. Many HIS subsystems are hosted by partners and not fully controlled by the government. The Ministry of ICT assessed the connectivity infrastructure needs for the whole country. Documentation resides with the Ministry of ICT and Digital Health Division in the Ministry of Health. The country adopted the OpenHIE framework which offers robust standards for health data exchange, sharing and security. This information is available with the Digital Health Division. Details are available here https://www.healthdatacollaborative.org/fileadmin/uploads/hdc/Documents/Country_documents/Malawi_MoHP_MEHIS_Strategy_Signed_copy_October2018.pdf .
	Data Management	2+	National HIS Policy (2015); Standard Operating Procedure (SOP) on Data Access and Release; SOP on Data Management; Selected HIS subsystems are digitized at aggregate level, few sections of the health facility use electronic data management.
	HIS Subsystems	2+	Multiple registries are used to handle the domain specific data, HIS data exchange is mainly facilitated by a single subsystem directly linked to other subsystems (integration) to enable basic data exchange, Interoperability architecture available; An increasing number of HIS subsystems are web-based and integrated with the ISL following the national standards requirements; the government requires all HIS subsystems to comply with the country's interoperability plan, including use of technical standards
	Operations and Maintenance for Computer Technology	1	Operations and maintenance services for electronic systems are ad hoc or non-existent; Maintenance for network and hardware is a mix of reactive and evolving preventive procedures;
	Communication Network: Local Area Network and Wide	1	The country has no reliable network connection to support a national HIS; The cost of data hinders HIS from implementing electronic systems for data sharing. Despite investing in the Government Wide Area Network, it is yet to be utilized which would greatly reduce connection costs; A limited ICT infrastructure assessment has been conducted to determine LAN and WAN requirements for the country's HIS; No national network

Area		
Network		maintenance plan exists to ensure high uptime, including clear procedures to recover from network failure.
Hardware	1	The country has limited/inadequate hardware (e.g., servers, computers, printers, and supportive accessories) to support a national HIS; No ICT infrastructure assessment has been done to identify the hardware required at national and subnational levels; Less than 50% of the Ministry of Health's national and subnational offices have the required hardware (computers, printers, connecting devices, etc.).

Table 13: Technology subdomain scores for Tunisia

Domain	Sub Domain	Score	Description of Sub domain Scores
<i>Technology</i>	National Enterprise Architecture	HIS 1	The assessment team was in agreement that a national HIS enterprise architecture draft document was developed, in 2018, to define technology requirements and data exchange formats for interoperability, but it has not been validated.
	Technical Standards	2	The participants were in agreement that an HIS ICT infrastructure assessment is launched but it is not yet documented
	Data Management	1	No national document for data management procedures exists. But a “Digital Health” Development Program in Tunisia is available (Programme de Développement de la «Santé Numérique» enTunisie - Ministère de la santépublique (santetunisie.rns.tn)). The program is not yet implemented
	HIS Subsystems	1	The country’s HIS mainly consists of stand-alone program-specific subsystems working in silos addressing only the basic needs (routine HIS, surveillance system, and human resources). Some HIS are presented: -Hospital Information System developed by the ICMH; “Labess”, HIS of the National Health Insurance Fund; HIS for the Tunisian’s private healthcare sector.
	Operations and Maintenance for Computer Technology	3	Standard operating procedures exist that detail protocols for routine network and hardware maintenance.
	Communication Network: Local Area Network and Wide Area Network	2+	An ICT infrastructure assessment has been conducted to determine LAN and WAN requirements for the country’s HIS - LAN and WAN requirements for the country’s HIS has been identified and a new network has been proposed called “RNS-NG”; a national implementation plan to meet the LAN and WAN requirements in the country exists; the country has begun implementing a technical solution to ensure permanent connectivity to the HIS services.
	Hardware	2	There is a limited/inadequate hardware (e.g., servers, computers, printers, and supportive accessories) to support a national HIS; an ICT infrastructure assessment has been done to identify the hardware required for interoperability infrastructure

5.4 Assessment results summary

Tables 14 through 18 provide summaries of maturity scores for the assessment subdomains, first at country level and then side by side for all the countries assessed.

Table 14: Summary of assessment scores for Ethiopia

Domain	Sub Domain	Scores
<i>Leadership and Governance</i>	Governance Structure for HIS	3+
	Interoperability Guidance Documents	2+
	Compliance with Data Exchange Standards	2+
	Data Ethics	1+
	HIS Interoperability Monitoring and Evaluation	1
	Business Continuity	1
	Financial Management	4+
	Financial Resource Mobilization	3+
<i>Human Resources</i>	Human Resources Policy	1+
	Human resources capacity (skills and numbers)	1+
	Human Resources Capacity Development	3
<i>Technology</i>	National HIS Enterprise Architecture	4+
	Technical Standards	2+
	Data Management	4+
	HIS Subsystems	2+
	Operations and Maintenance for Computer Technology	2
	Communication Network: Local Area Network and Wide Area Network	2+
	Hardware	1+

Table 15: Summary of assessment scores for Ghana

Domain	Sub Domain	Scores
<i>Leadership and Governance</i>	Governance Structure for HIS	2+
	Interoperability Guidance Documents	2+
	Compliance with Data Exchange Standards	2
	Data Ethics	4
	HIS Interoperability Monitoring and Evaluation	2
	Business Continuity	1
	Financial Management	1
	Financial Resource Mobilization	1
<i>Human Resources</i>	Human Resources Policy	3
	Human resources capacity (skills and numbers)	2
	Human Resources Capacity Development	4
<i>Technology</i>	National HIS Enterprise Architecture	3+
	Technical Standards	1
	Data Management	2+
	HIS Subsystems	2+
	Operations and Maintenance for Computer Technology	4
	Communication Network: Local Area Network and Wide Area Network	3+
	Hardware	1+

Table 16: Summary of assessment scores for Malawi

Domain	Sub Domain	Scores
<i>Leadership and Governance</i>	Governance Structure for HIS	4+
	Interoperability Guidance Documents	4
	Compliance with Data Exchange Standards	2
	Data Ethics	2+
	HIS Interoperability Monitoring and Evaluation	3
	Business Continuity	1+
	Financial Management	4+
<i>Human Resources</i>	Financial Resource Mobilization	3+
	Human Resources Policy	3+
	Human resources capacity (skills and numbers)	2+
	Human Resources Capacity Development	4
<i>Technology</i>	National HIS Enterprise Architecture	3
	Technical Standards	1
	Data Management	2+
	HIS Subsystems	2+
	Operations and Maintenance for Computer Technology	1
	Communication Network: Local Area Network and Wide Area Network	1
	Hardware	1

Table 17: Summary of assessment scores for Tunisia

Domain	Sub Domain	Scores	
<i>Leadership and Governance</i>	Governance Structure for HIS	1	
	Interoperability Guidance Documents	1	
	Compliance with Data Exchange Standards	3	
	Data Ethics	3	
	HIS Interoperability Monitoring and Evaluation	1	
	Business Continuity	1	
	Financial Management	1	
	Financial Resource Mobilization	1	
	<i>Human Resources</i>	Human Resources Policy	1
		Human resources capacity (skills and numbers)	1
Human Resources Capacity Development		1	
<i>Technology</i>	National HIS Enterprise Architecture	1	
	Technical Standards	2	
	Data Management	1	
	HIS Subsystems	1	
	Operations and Maintenance for Computer Technology	3	
	Communication Network: Local Area Network and Wide Area Network	2+	
	Hardware	2	

Table 18: Comparative summary of status for Ethiopia, Ghana, Malawi and Tunisia

Domain	Sub Domain	Ethiopia	Ghana	Malawi	Tunisia
<i>Leadership and Governance</i>	Governance Structure for HIS	3+	2+	4+	1
	Interoperability Guidance Documents	2+	2+	4	1
	Compliance with Data Exchange Standards	2+	2	2	3
	Data Ethics	1+	4	2+	3
	HIS Interoperability Monitoring and Evaluation	1	2	3	1
	Business Continuity	1	1	1+	1
	Financial Management	4+	1	4+	1
	Financial Resource Mobilization	3+	1	3+	1
<i>Human Resources</i>	Human Resources Policy	1+	3	3+	1
	Human resources capacity (skills and numbers)	1+	2	2+	1
	Human Resources Capacity	3	4	4	1
<i>Technology</i>	Development				
	National HIS Enterprise Architecture	4+	3+	3	1
	Technical Standards	2+	1	1	2
	Data Management	4+	2+	2+	1
	HIS Subsystems	2+	2+	2+	1
	Operations and Maintenance for Computer Technology	2	4	1	3
	Communication Network: Local Area Network and Wide Area Network	2+	3+	1	2+
	Hardware	1+	1+	1	2

6 Discussion

6.1 Leadership and governance

The Leadership and governance domain was the highest scored domain of the three areas of assessment. Country assessments indicate that governments play a central role in coordinating HIS interoperability efforts, which is essential for national ownership and the continuity of efforts. Most countries also have in place documents to guide interoperability efforts, although it should be noted that these efforts are at different stages. A key weakness in that countries have weak or no interoperability monitoring mechanisms. Countries cannot register significant progress on interoperability without having robust monitoring and evaluation mechanisms in place. As evidence of how a lack of sound monitoring and evaluation mechanisms can derail progress, some of the assessed countries have had interoperability as a core concern for over a decade (Chaulagai et al., 2005; Galimoto, 2007). Another point of concern is that the countries assessed do not have comprehensive central repositories for key policy documents. This makes it challenging for stakeholders to readily access key documents, meaning they may well be unaware of the existence of certain key guiding documents.

The countries assessed seem largely reliant on donor funding for their health interventions. For example, the assessment for Malawi suggests that the government funds no more than 1% of the funding towards HIS interventions. Donor dependence has been documented to result in fragmented HIS that are not responsive to needs (AbouZahr & Boerma, 2005; Dlodlo & Hamunyela, 2017; Kimaro & Nhampossa, 2005). At the same time, it should also be noted that key HIS gains registered in the countries that participated in this assessment are due to donor funding. Thus, to better leverage investments made, countries should make concerted efforts regarding how they can best leverage donor investments in a way that aligns competing donor interests. Countries should also significantly increase their HIS investment, especially considering that donor funding is largely project-based and few efforts fund the maintenance of key national systems that may facilitate interoperability.

A major point of concern is that all the countries assessed lack sound business continuity plans. Interoperability can seldom function in environments with weak business continuity arrangements, especially when we consider real-time systems such as patient care systems. For interoperability to work, countries should embark on serious business continuity processes, ensuring that emergency plans between different levels in the same system (e.g. health organization at national, regional and local levels), between agencies and between neighbouring countries must ideally interlink and at least not conflict (Simpson & Sellwood, 2010).

6.2 Human Resources

The assessment of country human resources is a mixed bag, with little consistency in the development of human resource subdomains across countries. Among the assessed countries, Tunisia seems to have the most amount of work to do, showing as lack of systematic development in all human resource aspects. Across the countries only the human resource capacity development subdomain is rated as being institutionalized in Ghana and Malawi (see the table that follows next).

Table 19: Human resources subdomain maturity

Subdomain	Country Maturity Level			
	Ethiopia	Ghana	Malawi	Tunisia
Human Resources Policy	Nascent	Established	Established	Nascent
Human resources capacity (skills and numbers)	Nascent	Emerging	Emerging	Nascent
Human Resources Capacity Development	Established	Institutionalized	Institutionalized	Nascent

The country assessments also revealed key shortages in technical staff to drive interoperability efforts. The importance of human resource capacity cannot be ignored as programmes plan to scale-up interoperability efforts. Unless educational institutions support the development and training of more skilled personnel, and pre- as well as in-service training is introduced, a lack of adequate technical capacity may remain an obstacle to scale (Kolowitz et al., 2012; Manda, 2015; Monawe et al., 2015). Thus, the countries assessed herein need to put in place concerted efforts in order to have a strong cadre of personnel that can maintain HIS and drive interoperability efforts. A key challenge in expanding and retaining quality technical IT personnel might be limited government budgets towards digital health investments. Literature also suggests that correcting is not an easy undertaking, due to high staff turnover rate (Malakoane et al., 2020).

6.3 Technology Subdomain

A strong component under the technology subdomain are efforts on defining national HIS architectures and implementation of interoperability frameworks, especially for Malawi and Ethiopia. All the same countries need to improve across the board. A key concern is the limited number of systems that have been linked, even where interoperability layers are said to have been implemented. More effort is also required in completing development of key components for the interoperability layers. Literature observes that system interoperability remains a key challenge across countries beyond those assessed herein, requiring long-term multi-stakeholder engagement. For example, it is reported that as in 2017, of the 67 HIS identified in the Namibian health sector, only 3 were integrated (Dlodlo & Hamunyela, 2017). Similar challenges with HIS linkages have been observed elsewhere (Dehnavieh et al., 2019; Malakoane et al., 2020).

Countries can also do well in ensuring systematic efforts in the development of SOPs across all the subdomains across the technology domain. The assessment gives the indication that the development of SOPs is loosely coordinated across subdomains. A systematic mapping of available SOPs and a drawing up of roadmaps to address gaps could be helpful.

Critical weak points across the all the countries are the Technical Standards, Communication Network: Local Area Network and Wide Area Network and Hardware subdomains, which are largely rated as nascent or emerging. This situation requires immediate corrective action, as the components are foundational to system linkages. Tanzania may serve as good learning point,

considering its progress in HIS systems interoperability (Nsaghurwe et al., 2021). It should however be noted that here too there is considerable work that needs to be done to ensure wider HIS interoperability.

7 Conclusion and recommendations

This work responds to two questions: What is the state of maturity for HIS interoperability efforts in Ethiopia, Ghana, Malawi, and Tunisia? What are the contributing factors to observed levels of HIS interoperability maturity levels in these countries?

Results suggest that the maturity of HIS interoperability efforts in the aforementioned countries is nascent or emerging. Nonetheless, countries have over the past few years made significant progress in enhancing HIS interoperability efforts, through drafting or implementing national HIS architecture blueprints. Some countries have also made stride in the implementation of interoperability layers, although a significant number of enabling interoperability layer components are under development. Of the countries assessed, Tunisia seems to be the one with the most work to do.

Factors undermining interoperability efforts include: dependence of donor funding for HIS interventions, which has been noted to contribute towards HIS fragmentation; inadequacy of IT staff, which has led to a dependence on external Technical Assistance; a lack of concerted efforts at national level, to unify curriculum development and offering; a lack of central repositories for keeping key guiding documents, meaning stakeholders may be unaware of key national HIS interoperability documents; a lack of business continuity plans; poor and expensive data communications networks; insufficient hardware at various levels of operation.

Based on the study's findings we urge countries that participated in this assessment to:

- Reduce reliance on donor funding for interventions, increase local funding and enhance the processes to ensure proper investment and management of allocated funds at the National and Local Government for eHealth. Dependence on donors often leads to loosely coordinated and fragmented system. These problems are long standing.
- Reduce reliance on external technical assistance.
- Leverage local universities and private organizations in the development and implementation of locally and regionally relevant HIS curriculum for pre- and in-service offerings. We also encourage countries to develop long-term capacity-building activities for HIS staff across both national and sub-national levels.
- Develop business continuity and risk management plans, which are largely missing across all countries.
- Promote cross-country collaboration to share expertise and lessons.
- Develop central repositories for all key documents to improve institutional memory.
- Implement interoperability monitoring and evaluation mechanisms to track efforts. Also introduce incentives to foster positive efforts and penalties for non-compliance. Countries need to define mechanisms and procedures to guide and encourage compliance with technical standards (including standards for data exchange, transmission, messaging, security, privacy, and hardware) for HIS and HIS subsystems.

- Improve connectivity infrastructure, mainly leveraging government-wide area networks, which will also lower connectivity costs.
- Improve hardware standards and availability across levels of administration.
- Implement long term ICT maintenance plan for HIS to ensure high uptime and reliable and permanent network connection to access the various HIS network services, including clear back-up and recovery procedures.

8 References

- AbouZahr, C., & Boerma, T. (2005). Health information systems: The foundations of public health. *Bulletin of the World Health Organization*, 83, 578–583.
- Alunyu, A. E., Munene, D., & Nabukenya, J. (2020). Towards a Digital Health Curriculum for Health Workforce for the African Region: A Scoping Review. *Journal of Health Informatics in Africa*, 7(1), 38–54. <https://doi.org/10.12856/JHIA-2020-v7-i1-265>
- Alunyu, A. E., & Nabukenya, J. (2018). A Conceptual Model for Adaptation of eHealth Standards by Low and Middle-Income Countries. *Journal of Health Informatics in Africa*, 5(2).
- Asah, F., Kaasbøll, J., Nielsen, P., & Seukap, R. (2021). Organizations failing to learn: Roadblocks to the Implementation of Standardized Information Systems. *Journal of Health Informatics in Developing Countries*, 15(1).
- Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: Complex or simple? Research case examples. *Journal of Research in Nursing*, 25(8), 652–661.
- Celi, L. A. G., Fraser, H. S. F., Nikore, V., Osorio, J. S., & Paik, K. (2017). *Global Health Informatics: Principles of EHealth and MHealth to Improve Quality of Care*. MIT Press. <https://books.google.mw/books?id=8p-rDgAAQBAJ>
- Chaulagai, C. N., Moyo, C. M., Koot, J., Moyo, H. B., Sambakunsi, T. C., Khunga, F. M., & Naphini, P. D. (2005). Design and implementation of a health management information system in Malawi: Issues, innovations and results. *Health Policy and Planning*, 20(6), 375–384.
- Dehnavieh, R., Haghdoost, A., Khosravi, A., Hoseinabadi, F., Rahimi, H., Poursheikhali, A., Khajehpour, N., Khajeh, Z., Mirshekari, N., & Hasani, M. (2019). The District Health Information System (DHIS2): A literature review and meta-synthesis of its strengths and operational challenges based on the experiences of 11 countries. *Health Information Management Journal*, 48(2), 62–75.
- Dlodlo, N., & Hamunyela, S. (2017). The status of integration of health information Systems in Namibia. *Electronic Journal of Information Systems Evaluation*, 20(2), pp61-75.
- Dolin, R. H., & Alschuler, L. (2011). Approaching semantic interoperability in Health Level Seven. *Journal of the American Medical Informatics Association: JAMIA*, 18(1), 99–103. <https://doi.org/10.1136/jamia.2010.007864>
- Galimoto, M. (2007). *Integration of health information systems: Case study from Malawi*.
- Glickman, M., & Orlova, A. (2015). Building interoperability standards and ensuring patient safety. *Journal of AHIMA/American Health Information Management Association*, 86(11), 48–51.

- Huang, F., Blaschke, S., & Lucas, H. (2017). Beyond pilotitis: Taking digital health interventions to the national level in China and Uganda. *Globalization and Health*, 13(1), 49. <https://doi.org/10.1186/s12992-017-0275-z>
- Interoperability Standards. (n.d.). <https://www.hln.com/knowledge/interoperability-standards/index.html>
- Karuri, J., Waiganjo, P., Daniel, O., & Many, A. (2014). DHIS2: The tool to improve health data demand and use in Kenya. *Journal of Health Informatics in Developing Countries*, 8(1).
- Kimaro, H. C., & Nhampossa, J. L. (2005). Analyzing the problem of unsustainable health information systems in less-developed economies: Case studies from Tanzania and Mozambique. *Information Technology for Development*, 11(3), 273–298.
- Kolowitz, B. J., Lauro, G. R., Barkey, C., Black, H., Light, K., & Deible, C. (2012). Workflow Continuity—Moving Beyond Business Continuity in a Multisite 24–7 Healthcare Organization. *Journal of Digital Imaging*, 25(6), 744–750. <https://doi.org/10.1007/s10278-012-9504-4>
- Malakoane, B., Heunis, J. C., Chikobvu, P., Kigozi, N. G., & Kruger, W. H. (2020). Public health system challenges in the Free State, South Africa: A situation appraisal to inform health system strengthening. *BMC Health Services Research*, 20(1), 58. <https://doi.org/10.1186/s12913-019-4862-y>
- Manda, T. D. (2015). *Developing capacity for maintenance of HIS in the context of loosely coordinated project support arrangements*. 1–10.
- MEASURE Evaluation. (2015). *Interoperability Considerations in the Design, Development, and Implementation of mHealth Projects*. MEASURE Evaluation. https://www.measureevaluation.org/resources/publications/fs-15-152-en/at_download/document
- MEASURE Evaluation. (2017). *Health Information Systems Interoperability Maturity Toolkit: Users' Guide*. MEASURE Evaluation.
- MEASURE Evaluation. (2019). *Health Information Systems Interoperability Maturity Toolkit*. MEASURE Evaluation. <https://www.measureevaluation.org/tools/health-information-systems-interoperability-toolkit.html>
- Ministry of Health. (2015). *Malawi National Health Information System Policy*. Ministry of Health. https://www.healthdatacollaborative.org/fileadmin/uploads/hdc/Documents/County_documents/September_2015_Malawi_National_Health_Information_System_Policy.pdf
- Minnesota Department of Health. (2019). *Minnesota e-Health Standards Guidance*. Minnesota Department of Health. <file:///C:/Users/Tiwonge/Documents/Work/BetterEHealth/Report%20Paper/guidance.pdf>
- MoH. (2018). *The Monitoring, Evaluation and Health Information Systems Strategy*. Ministry of Health and Population. https://www.healthdatacollaborative.org/fileadmin/uploads/hdc/Documents/County_documents/Malawi_MoHP_MEHIS_Strategy_Signed_copy_October2018.pdf
- Monawe, M., Chawani, M. G., Kapokosa, G., & Moyo, C. (2015). *Strengthening health management information systems in Malawi: Gaps and opportunities*. 1–7.

Nsaghurwe, A., Dwivedi, V., Ndesanjo, W., Bamsi, H., Busiga, M., Nyella, E., Massawe, J. V., Smith, D., Onyejekwe, K., Metzger, J., & Taylor, P. (2021). One country's journey to interoperability: Tanzania's experience developing and implementing a national health information exchange. *BMC Medical Informatics and Decision Making*, 21(1), 139. <https://doi.org/10.1186/s12911-021-01499-6>

Simpson, J., & Sellwood, C. (2010). The Role of Emergency Planning, Business Continuity and Exercises in Pandemic Preparedness. *Introduction to Pandemic Influenza*, 74.

Standards and eHealth. (2011). ITU. https://www.itu.int/dms_pub/itu-t/oth/23/01/T23010000120003PDFE.pdf

Appendix 1: Questionnaire

- Notes:
1. Please note that the numbering of the questions should be maintained even where they are out of sequence.
 2. Fill in the questionnaire by selecting all questions that are applicable providing enough evidence for your selections. Evidence can be in form of notes and documents. List and annotate/mark all attached evidence for each question/sentence.

1. Leadership and Governance

a. Governance Structure for HIS

The exercise of technical, political, and administrative authority to manage national HIS affairs at all levels of a country's health system. The governance structure consists of the mechanisms, processes, and institutions through which actors and stakeholders articulate their interests, exercise their rights, meet their obligations, mediate their differences, and oversee the functioning of the HIS

Statements	Check all applicable	Evidence
B2. The governing body has a scope of work that includes the people responsible for data governance oversight.	<input type="checkbox"/>	
B3. The governing body oversees interoperability directly or through a separate technical working group (TWG).	<input type="checkbox"/>	
C1. The HIS governing body conducts regular meetings with stakeholder participation.	<input type="checkbox"/>	
D1. The HIS governing body uses a work plan (or another tool) to monitor the implementation of HIS interoperability.	<input type="checkbox"/>	
D2. The HIS governing body is government-led.	<input type="checkbox"/>	
D3. The HIS governing body mobilizes resources (financial, human resources, and political) to accomplish its goals.	<input type="checkbox"/>	

b. Interoperability Guidance Documents

The documents (policies, strategies, and frameworks) that guide decisions, implementation, and the course of action for HIS interoperability. They are important reference materials for stakeholders who are developing the HIS from its current status to a mature status.

Statements	Check if applicable	Evidence
B1. The country has at least one of the following documents drafted to guide interoperability: interoperability strategy or policy; eHealth/digital health strategy that includes interoperability; or interoperability roadmap.	<input type="checkbox"/>	
C1. The interoperability guidance document(s) have been launched.	<input type="checkbox"/>	
D1. The interoperability guidance document(s) are government-owned.	<input type="checkbox"/>	
E1. Processes are in place to regularly monitor the implementation of the interoperability guidance documents.	<input type="checkbox"/>	
E2. The interoperability guidance documents are regularly reviewed and updated based on lessons learned from implementation.	<input type="checkbox"/>	

c. Compliance with Data Exchange Standards

Adherence to organizational policies, procedures, and best practices related to HIS, including standards for data exchange, messaging, and security. It also means adherence to applicable laws, relevant industry standards, and internal policies (e.g., codes of conduct).

Statements	Check if applicable	Evidence
C1. The HIS has developed or adopted and implemented a regulatory framework for compliance with structures (working groups, steering committees, or units), processes, and procedures to guide or enforce compliance with data exchange, messaging, and data security standards.	<input type="checkbox"/>	
D1. The government enforces the regulatory framework for compliance.	<input type="checkbox"/>	
D2. The subsystems in the national HIS are required to meet compliance and certification criteria.	<input type="checkbox"/>	

d. Data Ethics

Data ethics addresses the moral dimensions of data management. This includes ensuring adherence to ethical principles throughout data generation, recording, curation, processing, dissemination, sharing, and use. Ethical practices should strive to ensure respect for the people behind the data; use of data in accordance with the intentions of the disclosing party; matching privacy and security safeguards to the expectation of individuals and populations from whom data are drawn; and

following the law regarding personal health data privacy and security. These practices are also sometimes referred to as responsible data practices

Statements	Check if applicable	Evidence
C1. The country has an approved health data regulatory framework.	<input type="checkbox"/>	
D1. The health data security and privacy laws have been implemented, and there are guidelines on how to operationalize the laws in the context of HIS.	<input type="checkbox"/>	
D2. HIS users have been sensitized on the data security and privacy laws.	<input type="checkbox"/>	
D3. The government and HIS stakeholders consistently enforce the data security and privacy laws.	<input type="checkbox"/>	

e. HIS Interoperability Monitoring and Evaluation

Use of indicators/attributes from the maturity model to facilitate the tracking of inputs, processes, and outputs against desired results of HIS interoperability implementation, and using these data to make decisions.

Statements	Check if applicable	Evidence
B1. The methods and tools to report on HIS interoperability implementation are defined and documented.	<input type="checkbox"/>	
C1. Implementation of HIS interoperability activities is regularly monitored and reviewed.	<input type="checkbox"/>	
D1. Mechanisms to track and measure performance of HIS interoperability are government-approved and government-led.	<input type="checkbox"/>	

f. Business Continuity

Business continuity is the capability of the organization to continue the delivery of products or services at acceptable predefined levels following a disruptive incident. Business continuity is about devising plans and strategies that enable an organization to continue business operations, and enable it to recover quickly and effectively from any type of disruption, whatever its size or cause. Interoperability will not function as intended if the HIS and all its components do not function correctly. Therefore, business continuity of the national HIS is imperative for continuity of strong interoperability services of HIS. This includes putting in place systems for data recovery, continuity of healthcare, continuous flow of funding, staff transition plans, etc.

Statements	Check if applicable	Evidence
B1.=The HIS has developed a BCP that outlines the processes needed to ensure continuity of critical business processes.	<input type="checkbox"/>	
C1. There is a BCP implementation which has been audited.	<input type="checkbox"/>	

g. Financial Management

The legal and administrative systems and procedures put in place permitting a government ministry and its agencies and organizations to conduct activities that ensure the correct use of public funds, and which meet defined standards of probity and regularity. Activities include management and control of public expenditures, financial accounting, reporting, and asset management, in some cases.

Statements	Check if applicable	Evidence
B1.=There are budgets for national HIS, including interoperability, based on HIS workplans.	<input type="checkbox"/>	
C1. There are budgets developed for the subnational HIS, including interoperability, based on workplans.	<input type="checkbox"/>	
D1. The HIS budget is part of the Ministry of Health's budgeting process.	<input type="checkbox"/>	
D2. Regular financial audits are carried out to promote accountability in HIS spending.	<input type="checkbox"/>	

h. Financial Resource Mobilization

All activities involved in securing new and additional financial resources for an organization (in this case, the HIS). It also involves making better use of and maximizing existing financial resources.

Statements	Check if applicable	Evidence
B1.=Financial resources for HIS strengthening, including HIS interoperability, are mostly donor driven. <i>Indicate proportion of government funding.</i>	<input type="checkbox"/>	
C1. A costed work plan ⁴ at national level is in place that covers both the information and communications technology (ICT) infrastructure (network, hardware, and software) and personnel for HIS needed for HIS strengthening, including HIS interoperability.	<input type="checkbox"/>	
D1. The government and implementing partners have sufficient funding to implement the costed work plan.	<input type="checkbox"/>	

D2. The government owns the costed work plan (takes the lead in its review and updating, and leads its implementation).	<input type="checkbox"/>	
E1. The costed work plan for supporting ICT and human resources for HIS strengthening, including HIS interoperability, is long-term (five or more years).	<input type="checkbox"/>	

2. HUMAN RESOURCES

a. Human Resource Policy

A set of principles, guidelines, and norms that an organization adopts to help manage its employees.

Statements	Check if applicable	Evidence
A1. There is no human resources policy that recognizes HIS- related cadres.	<input type="checkbox"/>	
B1.=A national needs assessment has been completed showing the number of staff and type of skills needed to support HIS, including digital HIS and interoperability.	<input type="checkbox"/>	
C1. A human resources policy and/or strategic plan exists that identifies the HIS, digital HIS, and interoperability skills and functions needed to support the national digital HIS.	<input type="checkbox"/>	
E1.=A long-term plan (five or more years) is in place to grow and sustain staff with the skills needed to sustain HIS and digital HIS and interoperability.	<input type="checkbox"/>	

b. Human Resources Capacity (Skills and Numbers)

Availability of adequate personnel with characteristics, attributes, and capabilities to perform a task/set of tasks to achieve clearly defined results.

Statements	Check if applicable	Evidence
A1. The country has no dedicated cadre of staff for maintaining digital HIS and interoperability.	<input type="checkbox"/>	
B1. The country depends on technical assistance from external stakeholders to support the national and subnational digital HIS and interoperability. Indicate proportion of external TA compared to government staff.	<input type="checkbox"/>	
C1. The country has sufficient national-level staff with the relevant skills to support digital HIS and interoperability activities.	<input type="checkbox"/>	

c. Human Resources Capacity Development

An organized activity with clear learning outcomes that aims to impart knowledge and skills, shape attitudes, and develop specific competencies and capabilities in personnel.

Statements	Check if applicable	Evidence
C1. A plan exists for in-service training of HIS staff to build their skills around digital HIS and interoperability, based on a nationally or internationally recognized HIS curriculum.	<input type="checkbox"/>	
D1. The country has the capacity to train enough staff to support digital HIS and interoperability, through in-country pre- service and in-service training institutions or partnerships with other training institutions.	<input type="checkbox"/>	
D2. The government and its stakeholders provide sustainable resources for health ministry staff to receive training on HIS, including digital HIS and interoperability.	<input type="checkbox"/>	

3. TECHNOLOGY

a. National HIS Enterprise Architecture

Enterprise architecture is a method and an organizing principle that aligns functional business objectives and strategies with an information technology (IT) strategy and execution plan. A national enterprise architecture for an HIS defines how HIS subsystems interact and exchange data, and shows the necessary services for that data exchange, such as an interoperability services layer.

Statements	Check if applicable	Evidence
B1. A validated national HIS enterprise architecture exists that defines technology requirements and exchange formats for interoperability.	<input type="checkbox"/>	
C1. The country has foundational tools and rules for HIS interoperability. They include tools such as a health information management system for routine and surveillance data, and core authoritative registries (Facility Registry, Metadata Dictionary, Master Patient Index, and Health Worker registry).	<input type="checkbox"/>	
C2. The Interoperability Services Layer (ISL) for the HIS is operational and provides core functions, such as data authentication, translation, and interpretation.	<input type="checkbox"/>	
D1. The government owns, enforces, and leads implementation of the national HIS enterprise architecture, including the ISL and core authoritative registries (Facility Registry, Metadata Dictionary, Master Patient index, and Health Worker registry).	<input type="checkbox"/>	
F: The OpenHIE or similar framework standards are implemented. Eg Health Facility Registry, Health Worker Registry, Terminology Registry – List those that are implemented		

b. Technical Standards

An established norm based on a set of requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that digital health systems, health information services, and processes are appropriate for their purpose. Standards provide a common language and set of expectations that enable interoperability among systems and/or devices. The technical standards include standards for data exchange, transmission, messaging, security, privacy, and hardware

Statements	Check if applicable	Evidence
B1. An HIS ICT infrastructure assessment has been conducted and the needs for a coherent HIS ICT infrastructure architecture have been documented.	<input type="checkbox"/>	
B2. The country has adopted or developed technical standards for health data exchange, messaging, and security.	<input type="checkbox"/>	
C1. An interoperability lab ⁷ exists for new partners to test technical standards or for onboarding new HIS subsystems.	<input type="checkbox"/>	
C2. A certification mechanism exists for new HIS subsystems to be integrated in the national HIS.	<input type="checkbox"/>	
D1. Technical standards for national data exchange have been published and disseminated in the country under the government's leadership.	<input type="checkbox"/>	

c. Data Management

Data management consists of the development, execution, and supervision of plans, policies, programs, and practices that control, protect, deliver, and enhance the value of data and information assets for decision making. Data management includes procedures on how data are captured, stored, analyzed, transmitted, and packaged for use across the data supply chain.

Statements	Check if applicable	Evidence
B1. Electronic data management procedures or the HIS are clearly developed and documented in a nationally recognized document.	<input type="checkbox"/>	
C1. A roadmap is in place to migrate data collection and reporting from a paper system to an electronic system, complete with necessary data security safeguards.	<input type="checkbox"/>	
C2. A documented mechanism is in place for maintaining data quality throughout the data supply chain.	<input type="checkbox"/>	
D1. National electronic data management processes are published and disseminated for the HIS.	<input type="checkbox"/>	
D2. A standard operating procedure and/or data use plan is in place to facilitate data use by the country and its stakeholders.	<input type="checkbox"/>	
D3. A data warehouse, integrating data from all HIS subsystems and allowing for data triangulation and quality control, is fully functional and in use.	<input type="checkbox"/>	
E1. Data access and use are constantly monitored, and data management systems are updated accordingly.	<input type="checkbox"/>	

d. HIS Subsystems

A system that collects one or more of the data sources in a national HIS. Examples include routine HIS, health management information systems, civil registration and vital statistics systems, logistics management information systems, and human resource information systems.

Statements	Check if applicable	Evidence
A1. The country's HIS mainly consists of stand-alone program- specific subsystems working in silos addressing only the basic needs (routine HIS, surveillance system, and human resources).	<input type="checkbox"/>	
B1. <i>List the Country's key HIS Sub Systems eg LIMS, LMIS, FMIS, HRMIS etc. State the proportion of those that are Interoperability Standards Compliant</i>	<input type="checkbox"/>	
C1. Guidelines for compliance with technical standards for HIS subsystems interoperability with the national HIS have been disseminated.	<input type="checkbox"/>	
D1. The government requires all HIS subsystems to comply with the country's interoperability plan, including use of technical standards.	<input type="checkbox"/>	

e. Operations and Maintenance (for computer technology)

A set of procedures to ensure a high uptime for computer hardware, software, and network resources.

Statements	Check if applicable	Evidence
C2.-Standard operating procedures exist that detail protocols for routine network and hardware maintenance.	<input type="checkbox"/>	
D1. The country has the capacity for strong in-country computer technology maintenance.	<input type="checkbox"/>	
D2. Computer operations and maintenance services are part of the HIS plan or the country's strategic plan for health.	<input type="checkbox"/>	
D3. A disaster recovery plan for digital HIS is in place and meets best practices.	<input type="checkbox"/>	

f. Communication Network: Local Area Network and Wide Area Network

A communication network is several computers linked together to allow them to share resources. Networked computers can share hardware, software, and data. Most computer networks have at least one server. A local area network (LAN) and a wide area network (WAN) are typically distinguished by the geographical coverage of

the network, with a LAN usually covering and offering services to a relatively small geographical area as compared to a WAN.

Statements	Check if applicable	Evidence
B1. An ICT infrastructure assessment has been conducted to determine LAN and WAN requirements for the country's HIS.	<input type="checkbox"/>	
C1. A national implementation plan to meet the LAN and WAN requirements in the country exists.	<input type="checkbox"/>	
C2. A national network maintenance plan exists to ensure high uptime, including clear procedures to recover from network failure.	<input type="checkbox"/>	
C3. The country has begun implementing a technical solution to ensure permanent connectivity to the HIS services.	<input type="checkbox"/>	
D1. All national offices of the Ministry of Health have a strong and reliable network connection to access the various HIS network services.	<input type="checkbox"/>	
D3. An HIS-dedicated ICT and network support team is in place.	<input type="checkbox"/>	

g. Hardware

An assembly of tangible physical parts of a system of computers, including servers and virtual private networks that provide services to a user in the HIS.

Statements	Check if applicable	Evidence
A1. The country has limited/inadequate hardware (e.g., servers, computers, printers, and supportive accessories) to support a national HIS.	<input type="checkbox"/>	
B1. An ICT infrastructure assessment has been done to identify the comprehensive hardware required for interoperability infrastructure.	<input type="checkbox"/>	
D2. There is a back-up and recovery plan for the national HIS.	<input type="checkbox"/>	