REVIEW OF THE MALAWI HEALTH INFORMATION SYSTEM DURING PUBLIC HEALTH EMERGENCIES USING COVID-19 AS A CASE STUDY

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by

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ABSTRACT

INTRODUCTION

Malawi is a Lower-Middle Income Country. The COVID-19 pandemic has disrupted the health system, leading to lost milestones towards UHC. To fight COVID-19 and future public health emergencies, the health system needs a strong HIS to help the system in managing public health emergencies better. Hence the need to review the Malawi HIS to identify its effectiveness in supporting knowledge management during public health emergencies.

METHODOLOGY

The SANRA guided the quality of the narrative review. The WHO HMN framework was used to describe the general components of the HIS, and the HI-Impact framework to holistically assess the HIS. The search terms included COVID-19, "health information", availability, Malawi, combined using AND or OR, in the VU library which is linked to PubMed. Grey literature was also included.

RESULTS

Several cadres are involved in data collection at community and facility levels. The lack of resources and logistical challenges due to the utilisation of paper-based forms affects the quality of generated health data. The system was responsive in the wake of the pandemic in generating data and disseminating information. Adjustments were made in DHIS2 to facilitate easier data sharing between sub-systems. Among other factors, the utilisation of evidence was affected by the socio-political environment and lack of access to data for research purposes.

DISCUSSION

The Malawi HIS needs detailed analysis to identify and improve gaps in knowledge generation. The MoH should facilitate the use of health data for decision-making by building the capacity of the system and facilitating data sharing and re-use.

KEYWORDS: COVID-19, Malawi, "Health Information System", "Knowledge Management" "Health Systems"

WORD COUNT: 11734

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ABBREVIATIONS

CCPF	Chipatala Cha Pa Foni (mobile phone health centre)
CMED	Central Monitoring and Evaluation Division
DHIS2	District Health Information System 2
DHO	District Health Office
EGPAF	Elizabeth Glaser Paediatric AIDS Foundation
EMR	Electronic Medical Record
GDP	Gross Domestic Product
HCW	Health Care Worker
HIS	Health Information System
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
HMN	Health Metrics Network
HSSP	Health Sector Strategic Plan
IDSR	Integrated Disease Surveillance and Response
LIMS	Logistics Management Information System
LMIC	Low and Middle Income Country
LMIS	Laboratory Information Management Systems
MEHIS	Monitoring, Evaluation, and Health Information Systems
MoH	Ministry of Health
NGO	Non-Governmental Organisation
NSO	National Statistical Office
OHSP	One Health Surveillance Platform
PHIM	Public Health Institute of Malawi
PPE	Personal Protective Equipment
TB	Tuberculosis
UHC	Universal Health Coverage
WHO	World Health Organisation

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INTRODUCTION

I am a medical doctor from Malawi. During my medical training, learning in a healthcare system with very limited resources for health, I witnessed several inequalities in health access. Malawi has one of the highest doctor-to-patient ratios in the world. It also has a high burden of disease, for instance HIV prevalence in 2019 was at 9.2% in adults (UNAIDS, 2019). The burden of disease strains the already limited system and vulnerable populations are disadvantaged even more. Most rural hospitals lack even the basic medical care services. This made me more interested in exploring ways to help reduce the inequalities and improve access to health care by vulnerable populations. My undergraduate research, "Accessibility of anti- retroviral therapy to HIV- infected inmates in Malawi prisons: A cross- sectional study of Chichiri prison in Blantyre, Malawi" was influenced by these experiences.

After completing my internship, in 2019, I volunteered at the Public Health Institute of Malawi under the Ministry of Health. I worked with the epidemiology and Knowledge Management units in analysing weekly surveillance data for the Integrated Disease Surveillance and Response (IDSR) system to produce weekly epidemiological bulletins. Through this I learnt the value of information in decision making which developed my interest in health information systems. At the start of the COVID-19 pandemic I was working as a district medical officer in a rural district in Malawi. The pandemic brought several challenges and strained our resources. I was reminded of the need for strong health systems and the role of reliable evidence in influencing decisions in health care to mitigate effects of the burden of diseases, hence the master's in international health and this review.

Through the self-tailored MIH program, I have acquired knowledge in control of communicable and non communicable diseases, management of human resources for health, GIS for global health and health policy and financing. I gained research skills through the epidemiology module from University of Bergen Norway and several research methodology tutoring sessions organized at KIT. All these motivated me and enabled me to conduct this review.

BACKGROUND

Malawi lies in the South-eastern part of Africa, covering 118,760 square kilometres.(1) In the year 2020, the total population was estimated to be 19 million people with a life expectancy of 65 years at birth.(2) It is a Lower-Middle Income Country (LMIC) with a Gross Domestic Product (GDP) of 12.18 billion United States Dollars (USD). In 2019, almost three-quarters (73.5 percent) of the population was living in poverty according to the World Bank classification, surviving on less than 1.90 USD per day.(2) The adult literacy rate was 62 percent in 2015, with more literate males (70 percent) than females (55 percent).(3)

Phones and radios are some of the most common media used to access health information.(4) According to the most recent, 2019, data from a population-based survey by the National Statistical Office (NSO), only 43 percent of Malawian individuals own mobile phones, with the highest proportion in those living in urban areas (72.3 percent), compared to those in rural areas (37.3 percent); and a higher proportion of males (44.9 percent) compared to females (37.7 percent). An even lower proportion of the population has access to the internet. Only 14.6 percent of the individuals use the internet. The highest internet access is among those in urban areas (40.7 percent) compared to those in rural areas (9.3 percent).(5) Radios are another common means of accessing health information.(4) Thirty-seven percent of individuals own a radio, with a similar pattern of higher access in the urban (60.8 percent), and lower ownership in the rural areas (32.8 percent). Radio ownership and internet access are also higher in males compared to females. The main reason for not owning a mobile phone or radio is financial affordability.(5)

The country's health system is mostly burdened with infectious diseases. The top five infections, responsible for more than half of the disease burden and deaths, are Human Immunodeficiency Virus (HIV), Malaria, Tuberculosis (TB), lower respiratory tract infections, and diarrhoeal diseases.(6) There is a gross shortage of skilled Health Care Workers (HCWs), with only 0.5 HCWs per 1000 population (7) in contrast to the 4.45 per 1000 population as recommended by the World Health Organization (WHO), to move toward Universal Health Coverage (UHC).(8)

The Malawi health system operates at four levels: community, primary, secondary, and tertiary care. These levels comprise public, private for-profit, and private not-for-profit health facilities. Most health facilities are publicly owned, and they provide free health services to all citizens. These individual units fall under and report to District Health Offices (DHOs). The DHOs are supported by four respective zonal offices, which report directly to the national level at the Ministry of Health (MoH).(9)

Health Information Systems (HIS) are part of every health system. HIS refers to all the processes and structures involved in data collection, processing, reporting, and use of the information within the health sector.(10) The HIS processes occur at all health care levels with the main aim of improving effectiveness in the delivery of services. HIS is one of the six WHO building blocks for developing and maintaining functional health systems. Health information is supposed to guide the delivery of health services and to help analyse health systems.(11) The Malawi national health information system policy of 2015 aims to improve knowledge management within the health sector by guiding data collection, aggregation, analysis, and dissemination to all relevant stakeholders to improve evidence-informed decision-making in health. This policy was applied to the Health Sector Strategic Plan (HSSP) 2011-2016, and subsequent strategic plans. Where appropriate, this policy and all other related documents will be changed upon the publication of successive HSSPs.(12)

The planning and policy development directorate is one of the 14 directorates under the MoH of Malawi. Under it are five units, including the Central Monitoring and Evaluation Division (CMED) and the policy development units. The key responsibilities of these two units include supporting data collection by health facilities, developing data collection tools, and aggregating and disseminating data to policymakers, program managers, donors, and different level health facility management teams.(13) The national HIS policy states that the responsibility of health data management rests with CMED.(12) The main system for data collection and management is the Health Management Information System (HMIS). Integrated Diseases Surveillance and Response (IDSR) is part of HMIS. Both HMIS and IDSR use the open source web-based District Health Information Software version 2 (DHIS2) as the central data repository since 2012(12,14)

IDSR is for early detection and response to outbreaks in line with the International Health Regulations (IHR). It uses standard case definitions to identify priority diseases, public health events, conditions, or other hazards in the community and report them to the necessary authorities on time. The information flow and reporting structure of IDSR follows the same structure as for the healthcare system, with reports flowing from the community level up to the national level. In Malawi, COVID-19 data are managed in the context of IDSR.(12,15,16)

According to the policy, apart from HMIS, the Malawi HIS has other subsystems. One of the subsystems is the Laboratory Information Management Systems (LIMS) which provides information on medical laboratory and diagnostic services. Other subsystems include the integrated management information systems for human resources, finances, logistics, physical assets, and the Malawi hospital management information systems. HIS health sources also include rapid assessments, annual health facility census, periodic surveys, vital registration, and the national census. The HIS has several stakeholders: Training and Education Centre for Health (I-TECH), Centre for Disease Control (CDC), WHO, Baobab Health Trust, Luke International Norway, Village Reach, health facilities, and research and academic institutions. Guided by the main principle of "information for action, action for improving efficiency, quality, and equitable coverage," the policy also recognises citizens and communities as stakeholders.(12)

The first three cases of COVID-19, in Malawi, were confirmed on the 2nd of April, 2020.(17) Prior to this, the president had declared a state of disaster on 20th March 2020 and a COVID-19 Preparedness and Response Plan was developed.(18). In terms of management of COVID-19 information, the plan detailed the need to strengthen IDSR. Some of the activities included: printing and distributing the most recent IDSR guidelines, training all health care workers in the current IDSR guidelines, and procuring mobile phones and motorcycles to ease IDSR data collection and reporting.(19) A preparedness and response strategy was developed from this plan.(16)

The national COVID-19 preparedness and response strategy and plan (July 2021-June 2022) has four goals. Summed up, the goals are focused on minimizing the clinical, social, and economic impact of COVID-19 on vulnerable populations, facilitating research on the pandemic to characterize COVID-19 in Malawi, for specific interventions, and preventing health care service disruption.(16) At the national level the response has been multisectoral, coordinated by the Ministry of Health and the Department of Disaster Management Affairs. Fifteen sectors have been involved, including health, public communication, social protection and support, and economic empowerment.(20)

There had been over 85, 000 confirmed cases as of April 2022, with over 2,000 deaths. Most of the reported cases are in urban than rural areas. The cases are concentrated in the three

major cities of Malawi, namely Blantyre, Mzuzu, and Lilongwe. The proportion of the infected amongst those older than 65 years of age is higher than the proportion of infected in younger age groups.(21) The health system struggled with the initial response, faced with a lack of resources, including Personal Protective Equipment (PPE) and adequate oxygen sources.(22)

The Malawi government have had to alter policies to adapt to the changes brought by the pandemic. Among other actions, the government put up travel and gathering regulations to reduce overcrowding, and established screening and quarantine protocols.(18) While some interventions by the government were accepted by the general population, the lockdown was protested with a high court injunction as most Malawians, being in the informal sector and living on day-to-day income, were concerned with failing to earn to sustaining their living during the lockdown.(23) There were unintended, undesirable socioeconomic effects as a result of the implemented measures. The closure of schools was associated with a spike in teenage pregnancies. For the same period of March to July, in 2020 there were 11 percent more teen pregnancies in Malawi than in the previous year.(24,25)

The health sector was faced with a regression in the milestones to control infections. In April 2021, The Global Fund produced a snapshot report on the impact of COVID-19 on health care services. The assessment was conducted in 24 countries across Africa, including Malawi. In most of these countries, COVID-19 had disrupted the progress made in the fight against HIV, TB, and Malaria, which are the major contributors to the disease burden in Malawi.(6,26) More than 25 percent of the individuals stopped seeking care due to fear, mistrust, and uncertainty of getting infected with COVID-19 during facility visits.(26) A study conducted in Lilongwe, Malawi, compared HIV and TB indicators during the pre-COVID-19 season (March 2019 to February 2020), to the COVID-19 season (March 2020 to February 2021). The number of clients seen with presumptive TB declined by 45 percent in the COVID-19 period, and the number of individuals tested for HIV also declined by 46 percent in the first six months, then 31 percent in the last six months of the COVID-19 study period.(27)

PROBLEM STATEMENT AND JUSTIFICATION

The HMIS, including its IDSR subsystem, is meant to provide timely and accurate data for decision-making in public health.(12,15) A well-functioning information system, according to WHO, has three main characteristics. The system should support data collection at various levels of the health system by utilising various tools and resources. Furthermore, a good HIS improves the demand for and use of data for decision-making, not only in clinical management but also in financing, planning, and implementation, and it facilitates surveillance and early detection of diseases or conditions of public health concern.(28)

Covid-19 is a public health emergency.(29) An assessment of 16 European countries' information systems during COVID-19 showed that information systems that were well organised before the pandemic had better coping capacity to support the management of health information during the pandemic because during public health emergencies, the HIS is not the first consideration in the response plan. This assessment evaluated country's information systems by using a holistic framework. The assessment adapted the WHO's Health Metrics Network framework to assess the strength of direct health information within HIS and added a component of holistic health information. The holistic component assessed the ability of the HIS to process information not directly linked to health, for example: socioeconomic determinants of being affected by COVID-19, logistics and infrastructure information.(30) The conclusions from this and a similar study in Europe were that health systems of countries with both strong direct and holistic health information coped better with the pandemic. This was a result of well interlinked and centralised data storage systems that have mechanisms to ensure good quality data.(30,31)

Similarly for Sub-Saharan African countries, it has been shown that during public health emergencies, functional information systems aid in early detection and response to threats. In the case of the 2014-2016 Ebola Virus Disease (EVD) outbreak in West Africa, countries that were able to identify a surge in reported cases quickly were able to respond timely and contained the virus more effectively.(32) Following this observation, after the 2014 – 2016 EVD outbreak, a team in Sierra Leone designed health record forms tailored for a specific treatment centre, which were adopted and adapted for other centres, to improve the data collection process of the HIS and to be better prepared for future public health emergencies.(33)

In Malawi, the HIS has not been functioning optimally. It has been shown that health data in Malawi is usually incomplete and untimely(12,14,34) Since its implementation in 2002, the IDSR in Malawi has faced several challenges that have negatively affected the reporting rates. Both completeness and timeliness have been below the expected standard of 80 percent. Joseph Wu et al, in 2017, studied the implementation gaps and challenges for timely alert within the Malawi IDSR. The national IDSR completeness rate was good (73.1 percent) but still did not meet the 80 percent target, and the timeliness rate was poor (40.2 percent).(14) This would affect evidence-informed decision-making, a key component in managing a public health emergency like COVID-19.(32,35) MoH implemented the digital health strategy 2020-2025 with the aim of improving the effectiveness and reliability of health data through digitalisation to cope with the changing information world and some of the challenges faced due to use of non digitalised tools.(36)

The WHO HMN framework states that dissemination and utilisation of data for decision making is one of the components of an HIS, and evidence from HIS is a big component of risk communication.(11) The risk communication component has had a gross impact on the management of the pandemic. Based on EVD and COVD-19 observations, Lal et al 2020,

described failure of the HIS to influence community trust as one of the factors that let down response plans to public emergencies.(35) Effective communication and information management are deemed to be crucial in the implementation of the Malawi national COVID-19 preparedness and response plan.(16) There has been panic and distress amongst populations due to misinformation from the infodemic (overabundance of right and wrong information during an epidemic) during the COVID-19 pandemic.(37)

Globally, COVID-19 has negatively affected health care services access and delivery in over 92 percent of the countries, which has slowed down the progress towards Universal Health Coverage (UHC).(38) The infodemic has contributed to the disruption in access to health care by adding to fear and distrust in HCWs.(26) In Malawi this was exacerbated by the political environment at the beginning of the pandemic, where there was a scheduled presidential election re-run. Meanwhile the presidential taskforce on COVID-19 was mainly composed by political figures and the taskforce delivered most information on COVID-19 at the beginning of the pandemic. This created mistrust within the people in the sources of information from the government.(39,40)

There is a need for a functional HIS to build and improve the capacity of dealing with public health emergencies. The pandemic is fast-paced and has required numerous decisions to be made not just within the health system but also decisions affecting the social and economic aspects of the country due to restrictions as a form of infection control. Most of the studies that have been done on different components of the HIS in Malawi have focused on challenges facing the system and assessing the quality of data. There has been no overall assessment of the system, specifically its capacity in supporting the management of information during public health emergencies, like COVID-19.

By reviewing the current functionality of the HIS, and the impact it has had on different stakeholders during the pandemic in Malawi, this literature review will help to identify areas of the HIS that need strengthening, if any, for better rapid detection and response to public health emergencies. This is vital for the Malawi health system, which is already overburdened and limited by resources, to avoid major disruptions in service provision and to avoid losing milestones that have taken effort and time to achieve.

OBJECTIVES

This review aims to assess the effectiveness of the national health information system in supporting knowledge management during public health emergencies, like COVID-19, in Malawi. The specific objectives are:

1. To describe the Malawi health information system.
2. To determine the availability of COVID-19 information to different stakeholders.
3. To analyse the quality of COVID-19 data that are accessible by stakeholders
4. To determine the utilisation of COVID-19 information by different stakeholders.
5. To recommend best practices in the management of health information in public health emergencies to the Ministry of Health in Malawi.

METHODOLOGY

The design and methodology of review was guided by a quality assessment tool for authors and reviewers of narrative literature reviews to ensure that all important aspects of a narrative review were considered. The Scale for the Assessment of Narrative Review Articles (SANRA) was used. The scale scores six aspects of a review: the identification of the knowledge gap and justification of the study, formulation of the study objectives, the description of the literature search, the consistency of in text citations for key evidence, and the selection, and presentation of evidence.(41) Scale in appendix 1 with explanation in appendix 2.

LITERATURE SEARCH

This study is a narrative literature review conducted from February to August 2022. The literature search and results were guided by two conceptual frameworks, explained later in this section. Specific search terms were used to generate results. Google Scholar was used preliminarily to gain an overview of available literature on the research objectives, followed by a search in the Vrije Universiteit (VU) Amsterdam online library using the Libsearch tool which has access to 150 journals. Other search engines were also accessed through the VU resources license, including PubMed, Cinahl, ProQuest, and Scopus.

The search results were generated using the search terms in Table 1 below. The key terms included: COVID-19, “public health emergencies” Malawi, Sub-Saharan Africa, information, “health information system”, “health information”, “health data”, infodemic, availability, accessibility, utilisation, and quality. The terms were used in combination using AND and OR. More journal-published articles were identified by snowballing, following up on articles cited within the ones generated by the search terms. Other sources were grey literature including government documents and reports, media articles, and COVID-19 open data sources including https://covid19.health.gov.mw/. The study outline was submitted to the KIT- Royal Tropical Institute thesis advisory team.

SELECTION CRITERIA, DATA EXTRACTION AND SYNTHESIS

The main inclusion criteria for sources were the relevance of the literature to the objectives. Sources were also selected based on the language they are written in, only articles in English were included based on the language proficiency of the researcher. Another inclusion criterion was the geographical area, articles had to focus on Malawi or the Sub-Saharan Africa region, in instances where there was no literature on Malawi HIS. Resources like WHO guidelines, which are nonspecific to region, were also included. The current HIS policy in Malawi is valid for the period of the first HSSP 2011-2016 and subsequent HSSPs, therefore the articles considered for inclusion in this review are from the year 2011 to the present (2022). Articles in languages other than English, those published before the year 2011, or those not focusing on Malawi nor other countries in Sub-Saharan Africa were excluded.

From the generated results, only abstracts were read to identify articles that were in line with the objectives of this review and articles that were meeting the inclusion criteria. These articles were then read in detail, summarized, and included in the results under the relevant sections, guided by the conceptual frameworks.

Table 1: SEARCH TERMS

TERM	**AND**	**OR**
COVID-19	Malawi	
COVID-19	Information	Data
“COVID-19 information”	Availability	Access*
“COVID-19 information”	Utili?ation	
“Health information system”	Malawi	Africa
“Health Information Malawi”	Availability	Access*
“Health Information Malawi”	Utili?ation	
“Health Information Malawi”	Resources	
“Public health emergencies”	“Health Information Malawi”	“Health Data Malawi”
“Adapt* health information Malawi”	COVID-19	
“Quality health information Malawi”	COVID-19	
Infodemic	COVID-19	Malawi
“Knowledge Management”	COVID-19	Malawi

CONCEPTUAL FRAMEWORKS

Two frameworks were used to guide the literature search and organization of results. The first one is the WHO's Health Metrics Network (HMN) framework shown in Figure 1. The HMN framework has six components which are based on inputs, processes, and outputs of an HIS. The input components are the HIS resources. The process encompasses indicators, data sources, and data management. The outputs of the system include information products and dissemination and use.(11) The HMN framework was only used for the first objective to give an overview of the Malawi HIS hence only the components aspect from the left column was used. The domains that focus on principles, processes, and tools for strengthening HIS were left out as they mainly focus on the implementation of proposed interventions in strengthening HIS which is beyond the scope of this review. The components domain (left column) of the framework incorporates all aspects of the information system in Malawi as outlined in the country's national health information system policy of 2015.(12) However, it mostly focuses on the outline and functionality of the HIS and does not assess the impact the HIS has on the health system, other sectors, and the general population.(11)

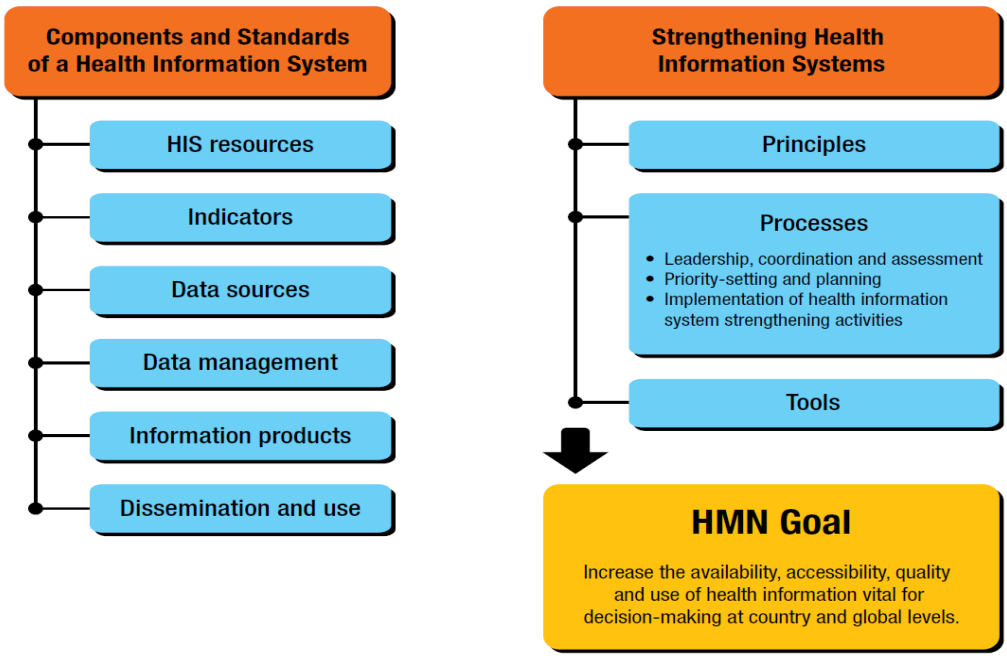

Figure 1: The Health Metrics Network Framework: Components of a Health Information System (Left-hand column)(11)

The second conceptual framework, Figure 2, was the Health Information (HI)-Impact framework: evaluation domains for monitoring the impact of national health information systems in public health policy and practice. It was developed based on a systematic review of 79 publications with over 100 knowledge translation frameworks. There is no specific conceptual framework for evaluating HIS in public health emergencies and most frameworks are not evaluated, hence the choice of this framework that is based on a systematic review of several frameworks. The HI-Impact framework has four domains: HI evidence quality, HI system responsiveness, stakeholder engagement, and knowledge integration. These components are explained in the results section, preceding results from each domain. The responsiveness domain influences all the other three components, as it describes the adaptation of the system to the context. The functionality of the other three components

reflects on how well the system has responded to the context, in this case to the COVID-19 pandemic, hence the bi-directional arrows.(42)

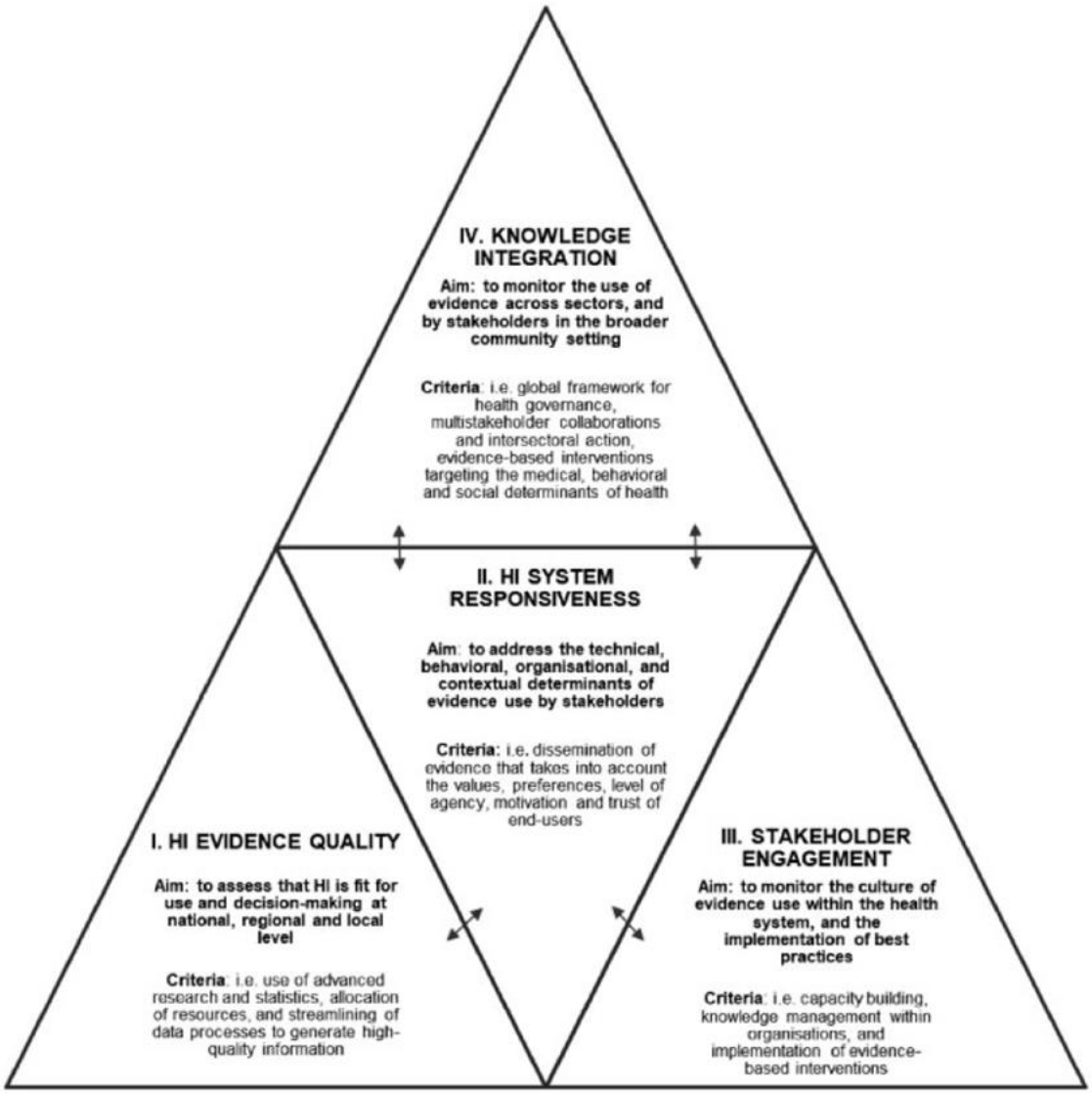

Figure 2: The Health Information (HI)-Impact framework: evaluation domains for monitoring the impact of national health information systems in public health policy and practice.(42)

This framework focuses beyond data generation, to utilisation within and beyond the health sector. It has a holistic approach as it considers the utilisation and dissemination of data beyond the health sector, to other stakeholders including the general population. This is more appropriate for COVID-19 as health data is needed for decision-making by different stakeholders, and it is crucial in informing and influencing the behaviour of the public. These aspects can affect the control of the pandemic, and as shown by literature can affect the utilisation of other health services.(26)

RESULTS

1. COMPONENTS AND STANDARDS OF THE MALAWI HIS

The Malawi HIS operates at levels similar to the organisation of the healthcare service provision system. It is comprised of the community and health facility level, reporting to the district level, then the zone and national levels at the top.(43) The different components of the system are outlined in the following sections, following the structure of the WHO HMN framework for HIS.

1.1. HIS RESOURCES

1.1.1. HUMAN RESOURCES

The Malawi HIS is heavily dependent on donor funding. The health sector resource mapping activity for the years 2018 to 2020 revealed that only 3 percent of the HIS activities are funded by domestic resources.(44) There has been a persistent shortage of human resources to fill various cadres within the HMIS. The data collectors in the community and health facilities consist of Health Surveillance Assistants (HSAs), statistical or ward clerks, medical assistants and clinical officers, program coordinators, and nurses or midwives. The district teams are led by HMIS officers, who compile all district health facility reports for the next level.(43,45) In 2012, in all the southern region districts of Malawi, the district HMIS teams mostly consisted of underqualified personnel which was regarded as a contributing factor to the low quality of the collected data. (45) The zonal and national levels mainly consist of the DHIS2 team, CMED officers - economists and statisticians - most of which belong to development partners and Non-Governmental Organizations.(43)

1.1.2. REPORTING TOOLS

There is a mixture of paper-based and electronic reporting tools, with paper-based mostly being used at community and health facility levels. Paper-based tools include HMIS 15 form which contains 150 core indicators.(46) The physical paper reports are submitted to the district level, using their own or any available transportation, including DHMT teams during their supervisory visits. The HMIS officer, at the district level, then compiles an electronic report, using DHIS2, that is accessible at the zonal and national levels. There have been challenges with these tools. In the past, challenges arose due to discrepancies in the reporting tools. According to KIIs conducted by Kasambara et al. in 2012, HMIS officers pointed out that the registers at the facility level contained more indicators than the ones in the electronic data collection form used at the district level by HMIS officers.(45)

A similar concern was described by KII participants in a study by Kang and Malmgren in 2017. The study, looking to develop a new model to support information flow in Malawi HIS, held interviews with different cadres involved in data collection for HMIS records. In this study, the differences in indicators were attributed to delays in updating the paper forms to match the updated electronic forms, with an example of updating changes to the routine immunization schedule.(47) Most challenges arising from the use of paper-based reports, including errors and storage of paper registers, could be rectified by ensuring the availability of electronic reporting at all levels. However, interruptions and inadequate coverage of electricity power supply and internet connection are some of the limiting factors, especially for health facilities in rural areas. (43,45,48)

Baobab trust has led the implementation of Electronic Medical Records (EMR); however, the utilisation is not optimal, and the implementation is for specific disease programs including HIV, ante-natal care, and out-patient departments. The fragmentation of the system leads to duplication of efforts, for instance, for the same patient electronic data might have to be extracted on paper to continue a consultation in another program that does not have EMR or

any digital tools.(36) One study conducted in the two large referral hospitals in Malawi, in 2017, investigated factors affecting the utilisation of EMRs. Even though 75 percent, of 111 participants, acknowledged that EMR use is faster and produces more accurate data due to its ability to send reminders and warnings concerning entered data, only 7.5 percent had had advanced training on how to use EMR systems. The lack of knowledge negatively affected the choice to use EMR and led the healthcare workers to continue using paper records.(49)

Other errors in using these tools were described by Haugen and Roll-Hansen using 2013 data from the Malawi HMIS. The "thousand error" was one of the most common at the facility level. This was described as errors occurring due to the accidental addition of extra digits, typically but not always, three zeros or digits. In their study, three primary level facilities in one district had this error in the indicator showing the number of fully immunized under one children, in 2013 (50)

1.2. INDICATORS AND DATA SOURCES

The HMN groups HIS data sources into population-based and institution-based sources. The population-based sources include censuses, civil registration and population-based surveys.(51)The most recent census for Malawi was the Malawi population and housing census conducted by NSO in 2018. The census report includes population distributions by age and sex and population projections that could be utilized in the planning and management of COVID-19.(52) Population-based surveys include the Malawi Demographics and Health Survey (MDHS) which includes information on determinants of health and access to health care.(53) Another health survey is the Malawi Population-based HIV Impact Assessment (MPHIA) led by MoH.(54)

The institution-based sources are individual records, sources records, and services records. Some of these sources and the indicators used are presented here. As described in the section for reporting tools, it is mostly paper-based forms used at lower levels of the HIS. As implied most sources of individual data are paper based. These include booklets, or paper files containing clinical data. Lately, there have been some developments in digitalizing HIS in Malawi by introducing Electronic Medical Records (EMR). Some facilities utilise EMR, supported by Baobab Trust, which then act as the source of data for reports.(46)

The digitalisation is mostly occurring in vertical disease programs, supported by specific program donors.(36) Apart from the Baobab Trust supporting specific programs, another example is the introduction of E-Mastercards for the HIV program and efforts to improve the efficiency of the national Lab Information Management Systems (LIMS) to allow for real-time HIV client lab results access by clinicians. This is supported by the Elizabeth Glaser Paediatric AIDS Foundation (EGPAF).(55) According to the Monitoring, Evaluation, and Health Information Systems (MEHIS) strategy of 2017-2022, there are plans by MoH to expand the EMR system to 400 sites by end of 2022. Another target in the strategy is to introduce a comprehensive M-health IDSR system (collecting and delivering data using mobile phones) that can communicate with EMRs and DHIS2.(56) An assessment by MoH showed that most digital intervention projects within the system have an average span of five years before the project ends and donors pull out, hence they lack sustainability.(36)

The number of indicators contained in the HMIS 15 form is limited per disease or condition, as such most programs maintained parallel reporting systems. The HMIS 15 report is compiled quarterly, and most programs require monthly reports, hence the parallel reporting systems. At the community level, individual client data is collected by HSAs. In the case of IDSR, surveillance is based on case definitions. Majority of HSAs neglect this component of

the HIS because they do not understand case definitions for most reportable conditions(45,46)

Based on internal reporting forms for COVID-19, comprehensive individual data were collected but it not known which indicators were derived to summarize the data for reporting to higher levels.(57–59) COVID-19 was included in the case-based surveillance reporting forms for notifiable diseases/conditions under IDSR. This form collects information on individual demographics, residence location, travel history, vaccination status, clinical signs, and symptoms, and in case of specimen collection, laboratory sample tracking data. See appendix 3.(57) Similarly the contact tracing form had individual identification and residence fields. Interestingly the location field included geocodes which can be useful in GIS mapping. The form also allowed linkage of the contact being traced the case or contact through case ID and contact ID.(59)

When it comes to the reliability of DHIS2 as the main repository, hence also a source of health data, two main events were identified. The first was the crash of the DHIS2 servers in February of 2015 which led to the loss of most data sets including all IDSR data for that month. More recently, in October 2020, whilst trying to back up electronic patient records for central hospitals in Malawi, the server crashed again and data from the previous nine months were lost from the specific dataset.(14,60)

1.3. DATA MANAGEMENT

Within the HMIS, raw individual data are collected at the community level, by Health Surveillance Assistants (HSAs), using paper-based forms, and reported to the facility level every month. At the facility level, which includes health centres, community and district hospitals, and departments of central hospitals, both community and facility data are aggregated and reported to the district level. These reports are also in paper form and are submitted monthly. Each disease has a specific register, which is cumbersome in terms of carriage and storage capacity. Reporting from facility to district level is done by data clerks, or nurses and clinicians in-charge of specific health programs.(14,36,43)

The HMIS officer at the district electronically integrates all data from different programs within the facilities and analyses it. The first verification of data also occurs at the district level. Verified electronic reports are entered into the HMIS through the central health data repository-DHIS2. With the generated reports, the district gives feedback to the lower levels. The zonal and national health program managers have access to district data through DHIS2, from where reports can be generated. A similar process occurs in central hospitals; the ward clerks collect paper-based data and report to the departments which in turn submit reports to the hospitals' HMIS officers. (43) Figure 3 illustrates the flow and management of health data within the Malawi HIS. DHIS2 is a secured platform that requires users registered with CMED to log in. (61) DHIS2 is also used to capture and manage IDSR data. A separate reporting mechanism is used for diseases and conditions that fall within IDSR and are notifiable. Depending on the IDSR condition, reports are compiled and sent immediately, weekly, monthly or quarterly.(14)

Subsection 12 of the HIS policy describes data storage standards at the facility and institution level. All data should be secure and easy to access, and stored within the borders of Malawi, except in instances of continuity of care. Electronic records are to be backed up in password-protected external storage media. In terms of health-related research, all research data, including the meta-data files, should be shared with the national research unit of MoH at least once a year by facilities or institutions.(12) These data storage guidelines are in line with the FAIR (findable, accessible, interoperable, and reusable) data principles which aim to improve

knowledge management and enhance the findability of research data for reuse.(62) There was, however, no identified national health research repository from a google search.

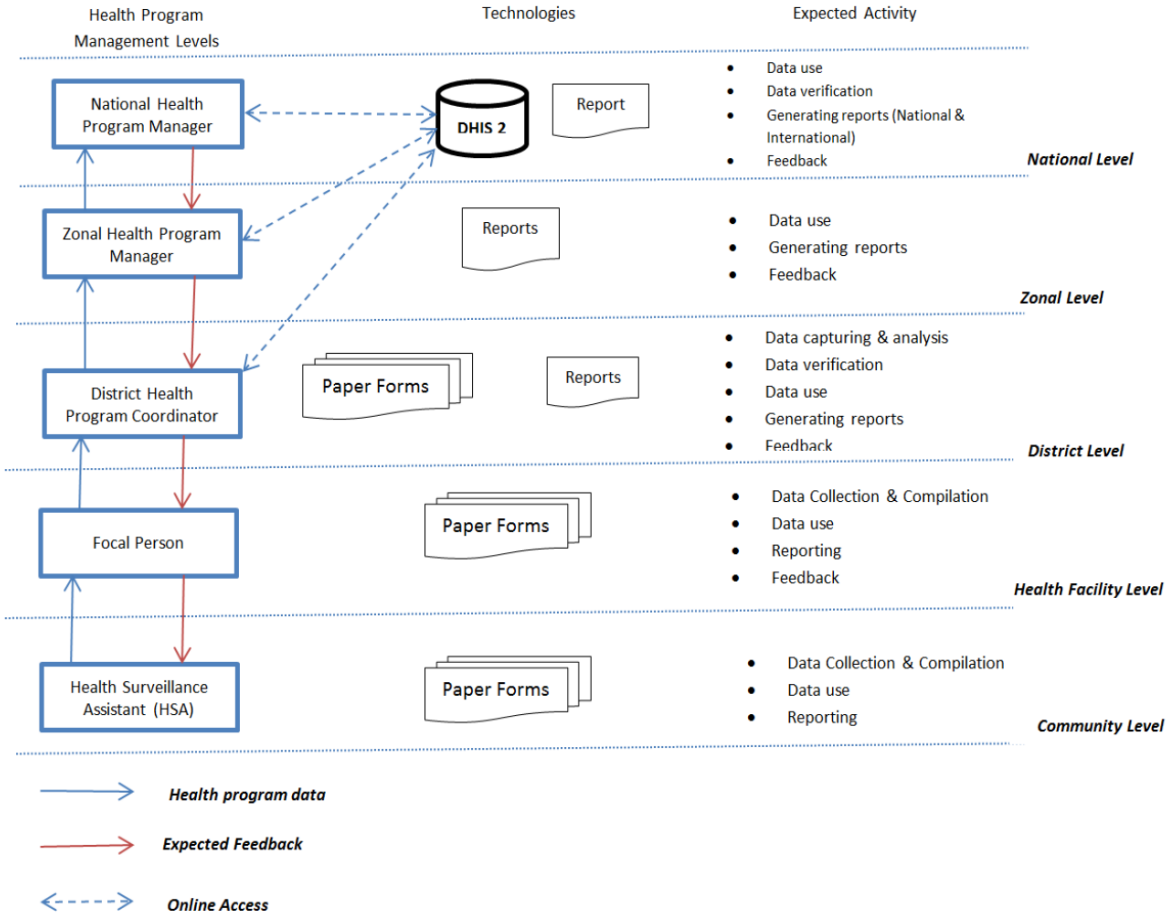

Figure 3:Data flow and management at different levels within the Malawi HIS (43)

1.4. INFORMATION PRODUCTS, DISSEMINATION, AND USE

All the levels within HMIS are required to disseminate analysed health information.(12) HMIS officers at the district level are required to produce quarterly HMIS reports for all programs and share them with all relevant stakeholders. Reports can be shared using word documents or PowerPoint presentations during review meetings. Information is also disseminated through emails and the internet. Information use is sometimes not possible when the HMIS officers or DHIS personnel are unavailable, because even though program coordinators have access to DHIS, most lack the technical skills to extract data from the system. Following the collection of facility coordinates and the introduction of DHIS2 Geographic Information System (GIS) in 2015, information products can include spatial data representation and analysis.(43)

2. HEALTH INFORMATION EVIDENCE QUALITY

The evidence quality domain of the HI-Impact framework helps to evaluate the accuracy and relevance of the data being produced by the HIS and the quality of information being derived from the data, that can be used as evidence for decision-making at different levels.(42) WHO developed a data quality review kit for routinely collected data from health facilities. The review kit indicates four domains of quality assessment: completeness, internal consistency,

external comparisons, and external consistency of population data. The toolkit has specific indicators from programs that can be used.(63) No tool for assessing COVID-19 data was found during the literature search, however, there are general data quality dimensions that can be considered. The common six dimensions are accuracy, completeness, timeliness, validity (internal and external), consistency, and uniqueness.(64) There was no literature found on studies analysing the quality of routinely collected COVID-19 data within the HMIS in Malawi as per WHO's data quality review guide. This section presents results based on information products produced by MoH for dissemination to the stakeholders including the public.

2.1. ACCURACY, COMPLETENESS, AND TIMELINESS

Accuracy determines how well data are representing real events. Timeliness represents the time lag between the occurrence of an event and the time of data collection and delivery to decision-makers. For HMIS and IDSR, reports have set deadlines for reaching the next level. Timeliness is calculated based on the number of reports submitted before the deadline as a percentage of all expected reports. Completeness is a percentage of available datasets out of all datasets that could be collected. (64)

Mwakilama et al. conducted a study, in August 2020, to analyse data that were informing the government's decisions on COVID-19. The key informant interviews with officials from the ten clusters involved in the preparedness and response plan showed that most decision-makers are of the view that COVID-19 data for decision-making is available, reliable, and accessible, but not accurate nor on time. These responses were, however, based on different information systems where different clusters access their relevant data, and not only the HIS. The accessibility of the data was debatable as it was argued that most information systems were using media as a means of information dissemination, and not all forms of media are accessible by vulnerable populations especially those in rural areas. (39)

Before COVID-19, in the study by Joseph Wu et. al, it was noted that IDSR data contained errors that were attributed to a lack of knowledge in case definitions by the data collectors. For instance, in 2015, there were 21 records of Viral Haemorrhagic fever cases in Malawi, but there was no laboratory-confirmed case. This was during the Ebola Virus Disease epidemic in West Africa.(14)

2.2. CONSISTENCY, VALIDITY, AND UNIQUENESS

Consistency refers to how well a dataset aligns with other datasets or a reference dataset in terms of identification and values. This includes data labels which, in the case of health data like COVID-19, would be indicator names.(64) Two online, open access sources of aggregated COVID-19 data from Malawi were identified; the COVID-19 daily updates from the Facebook page of the Ministry of Health in Malawi and the COVID-19 dashboard accessible from https://covid19.health.gov.mw. Both use data from the Public Health Institute of Malawi (PHIM). There were discrepancies in the values of different indicators. For instance, in figures 3 and 4 below, the number of cumulative confirmed cases by 25th July was 87 250 from the daily updates on Facebook, but on the website, it was 86 963 for the same day. For the same day, the number of active cases also differed. It was 388 cases on the website and 606 on Facebook. The number of recovered cases and the total number of deaths slightly differed by less than ten.(65,66)

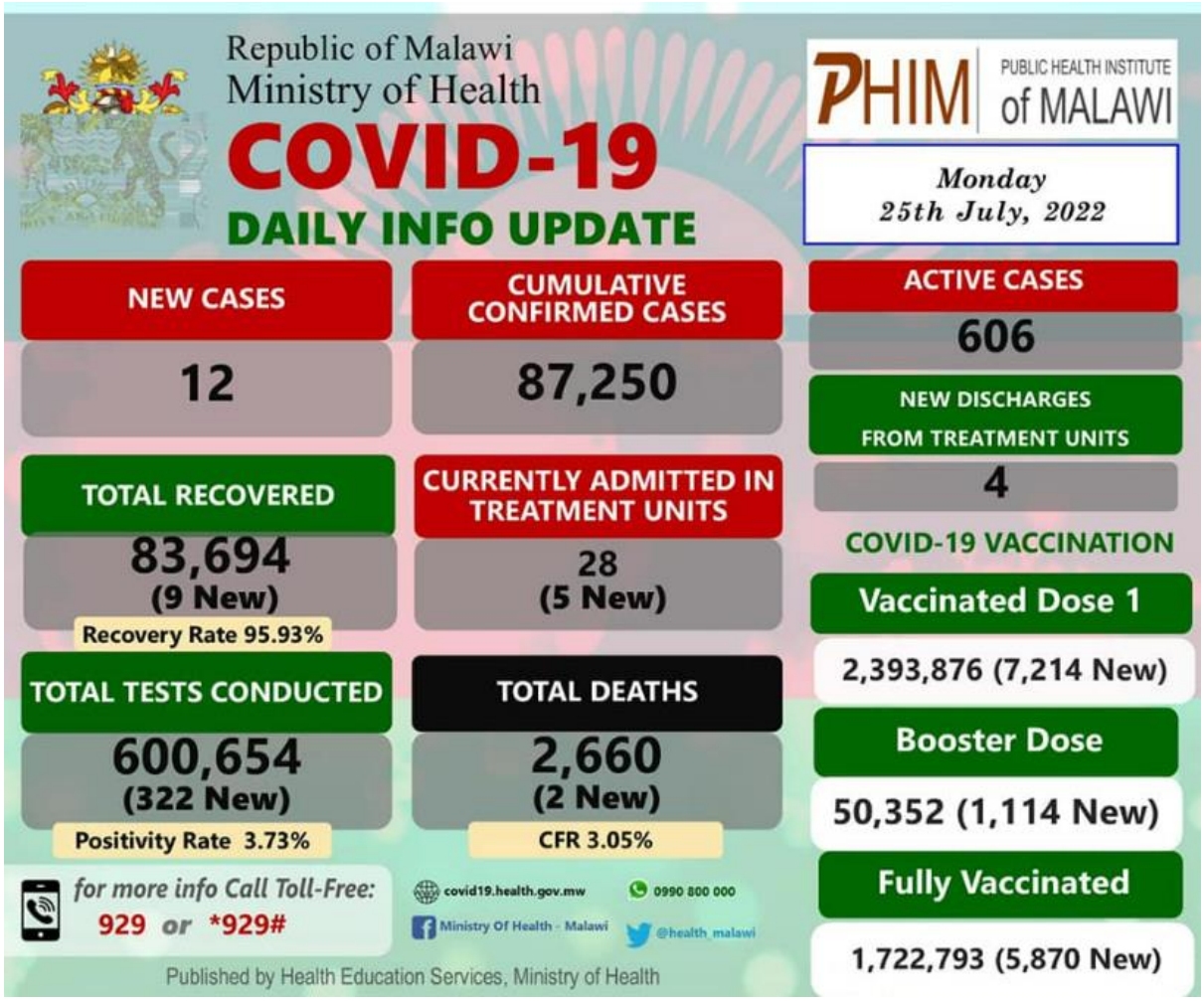

Figure 4: Daily updates from MoH Facebook page.*(65)*

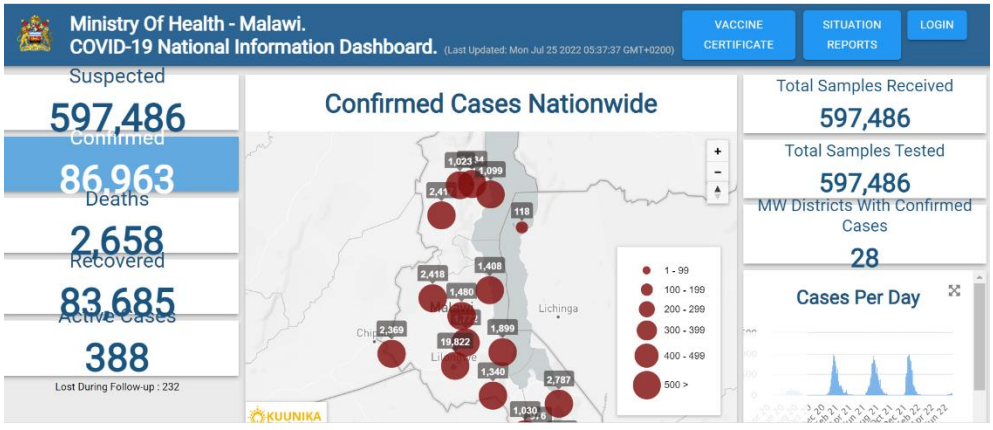

Figure 5: MoH COVID-19 information dashboard from [https://covid19.health.gov.mw](66)

In the in-depth analysis of COVID-19 data in Malawi, Divala used the situation reports and daily updates by PHIM to calculate the percentage of deaths occurring in the community out of all deaths due to COVID-19 in Malawi. The result (20 percent) was found to be lower than that registered by the National Registration Bureau pre-COVID-19 for natural death reports, which indicates that 80% of all deaths occur in the communities.(67)

The validity dimension checks if data is representing what was set out to be measured. No literature was found on studies assessing the validity of COVID-19 data in Malawi. Lastly, reducing the probability of duplication of the dataset items and reducing the chances of misidentification, forms the uniqueness dimension of data quality.(64) In the same study by Kasambara et al, HMIS officers described the lack of the system capability to eliminate repeated datasets, leading to duplication. This would happen in cases of a referred case where data for the same individual were collected at more than one health care level, for example by an HSA at the community level, and a data clerk at the health centre level. Due to the lack of unique identifiers and the system's inability to flag such duplications, data quality was compromised.(45)

3. HEALTH INFORMATION SYSTEM RESPONSIVENESS

Responsiveness refers to the system's ability to facilitate data collection, access, and use of evidence by taking into consideration barriers that might arise due to contextual, technical, and organizational factors. Together with the evidence quality component, these two aspects monitor the adherence of the HIS to FAIR data principles.(42) The following sub-sections detail ways in which the Malawi HIS was responsive or should have adapted to the needs of different stakeholders, to facilitate evidence use.

3.1. DATA COLLECTION TOOLS AND COMPOSITION

One of the main open access sources of COVID-19 information by the MoH, which was available from the website https://covid19.health.gov.mw/ by PHIM was aggregated data, only disaggregated by sex and age.(66) In their analysis, Mwakilama et. al, noted that data on the number of deaths and the recovery rates per district or region were not available on the open-source platforms. The analysis highlighted that some districts like Mchinji, Rumphi, and Phalombe had high death rates compared to the rest of the districts, which was only notable after further disaggregation of data. With the ongoing pandemic and the need for rationing of supplies and other resources by other sectors and NGOs that do not have easy access to detailed datasets, the open source data would be more relevant if it were disaggregated into further categories.(39)

3.2. TAILORED INFORMATION FOR TARGET GROUPS

The national HIS policy states that health information dissemination and use is the responsibility of CMED. CMED is responsible for the publication of regular national health statistics reports on the MoH website and other platforms. These reports should be easy to understand and in easily accessible formats by individual researchers, institutions, and the general public.(12) With regards to this, further concerns raised by KII participants in the analysis of data informing the government's decisions, by Mwakilama et al, was the dissemination of untailored information. The concern was around women, especially those who are pregnant, children, and those living in rural areas. Due to their unique needs, these groups might need special information or special ways of delivering this information.(39)

Supporting evidence was presented in the study - Assessing citizens' access to open government data on covid-19 in Malawi by Ng'ambi, in 2021. The study showed that more men (85 percent) than women (68 percent) had access to COVID-19 information. This was attributed to pre-existing disparities between men and women in literacy levels and access to media devices like mobile phones and radios. There was also was lack of consideration for people living with visual and hearing disabilities. (4,5)

3.3. INFORMATION PRODUCTS

The majority (91 percent) of interviewed Malawians that had access to the regularly published information products accessed the daily COVID-19 updates. Other products from

the health sector included situational reports and COVID-19 weekly updates. The most utilised source of COVID-19 information was the radio (91 percent) followed by friends (54 percent) and WhatsApp (53 percent). The government's website was one of the three unlikely sources.(4)

Another study, conducted in 2020, that aimed at explaining the low-risk perception of COVID-19 in Malawians found that misinformation and faulty attitudes were one of the main contributors to the low-risk perception. The main source of misinformation was WhatsApp, which also happened to be one of the top three preferred COVID-19 information sources amongst participants in the previously mentioned study. Based on misinformation most participants believed that COVID-19 would not affect them, being of African descent, because it was only for non-Africans. Participants believed the information overload from the available sources made it harder to distinguish between facts and rumours or myths. Some suggested that better communication would have occurred if community leaders, like chiefs and pastors, had been involved in the dissemination of information.(68)

3.4. DATA PLATFORMS

Funded by the Global Fund, from 2018 to 2020, the MoH supported by its various partners and stakeholders in HIS created an interoperability layer for DHIS2, which is the software for HMIS, and the electronic Logistics Management Information System (LMIS) software, called OpenLMIS. By linking the key indicators from the two software, DHIS2 and OpenLMIS, responsible individuals at district and facility levels could access information and make evidence-based decisions concerning logistics. The final outputs could be accessed through dashboards on the DHIS2 platform, indicating for example, which facilities had adequate monthly stock at hand and the average monthly commodity consumption per facility. However, COVID-19 started before district-level trainings on the new DHIS2 features could commence.(69)

The ministry of health repurposed the mediator layer for COVID-19 surveillance and response. The development was used to relay laboratory data between the Laboratory Management Information Systems (LMIS) and DHIS2. Sample details could be entered in DHIS2, test information could be electronically relayed to labs, and test results could be electronically forwarded back to DHIS2, where they could be used for statistical analysis and to notify clients of their results. This reduced the logistical cost of sending paper forms between the laboratories doing the tests and the health facilities which was the practice in the early days of the pandemic when only a few laboratories in the country could conduct the COVID-19 tests.(69)

The HIS also adapted to *Chipatala Cha Pa Foni* (CCPF) as a source of data and means of informing people on COVID-19 matters. Introduced by the Village Reach organisation, CCPF is a project that uses toll-free phone lines for people to access health information from trained health professionals. It is currently owned and run by the Malawi MoH with support from health partners. Initially, it was solely used to deliver nutrition, and maternal and child health information but it expanded to accommodate COVID-19 information seekers.(70)

After the toll-free line was opened for COVID-19, there was a surge in the number of callers. The number of people trying to reach the toll-free number, per day, increased by 500 percent. The call centre answered 150 percent more calls per day. The main reason for calling was to seek information on facts, myths, and rumours concerning COVID-19.(71)This was used as a tool to fight myths and rumours rising from the infodemic.(72) Data from CCPF is stored on the One Health Surveillance Platform (OHSP), which was also linked to DHIS2 by introducing an interoperable layer so that data from the calls can be accessed through DHIS2.

By doing this, it enables the response teams to create heat maps in DHIS2, to be able to visualise where the most calls come from, and the most common rumours, which inform the health system and government public communication strategies, including the messages to communicate to specific populations.(71)

4. STAKEHOLDER ENGAGEMENT

The stakeholder engagement component of the framework assesses the readiness to use evidence in decision-making and practice. It monitors the implementation of evidence-based practices within the health sector and by other stakeholders.(42)

The Malawi government showed readiness to use data for decision-making before the first cases of COVID-19 were detected in Malawi. Malawi's health policy responses at the beginning of the pandemic aligned with the COVID-19 information produced by the HIS.(20) The closure of all schools in March of 2020 followed a global surge in the number of COVID-19 cases. However, contrary to the national COVID-19 data, after five months the schools were reopened, when the COVID-19 cases were at a high in Malawi. Other policy responses by the government and MoH in March and April of 2020, following a rise in cases, included: restriction of mass gatherings, the introduction of mandatory quarantine for travellers entering the country from high-risk countries, and border closures.(18,20,39)

The EPI of the ministry of health demonstrated use of evidence in decision making in their COVID-19 vaccine deployment plan. With limited vaccine doses for the desired proportion of the population to be vaccinated, the EPI had to identify priority groups to be vaccinated with the first vaccine consignment. Apart from HCWs, prison officers and those in the army were also prioritized based on nature of their job. People living in congested environments - prison inmates and refugees- were to be prioritised in the second available batch of vaccines.(73)

The prioritisation of groups to be vaccinated was based on national COVID-19 data. Figure 5 shows the distribution of deaths by sex and age, at the time the deployment plan was being developed, in February 2021. Most deaths occurred in the age groups including 40 years to more than 70 years.(73) However, according to the most recent population census of 2018, Malawi has a young population with only 5 percent of the population being over 60 years (appendix 4).(52) Hence the proportion of deaths in the over 60 years of age group was highest and the group was made part of the priority group to be vaccinated.(73) There was, however, no special considerations, for example in the target groups for information dissemination, for males who are at a disproportionately high risk of death across all age groups except under-ten years.

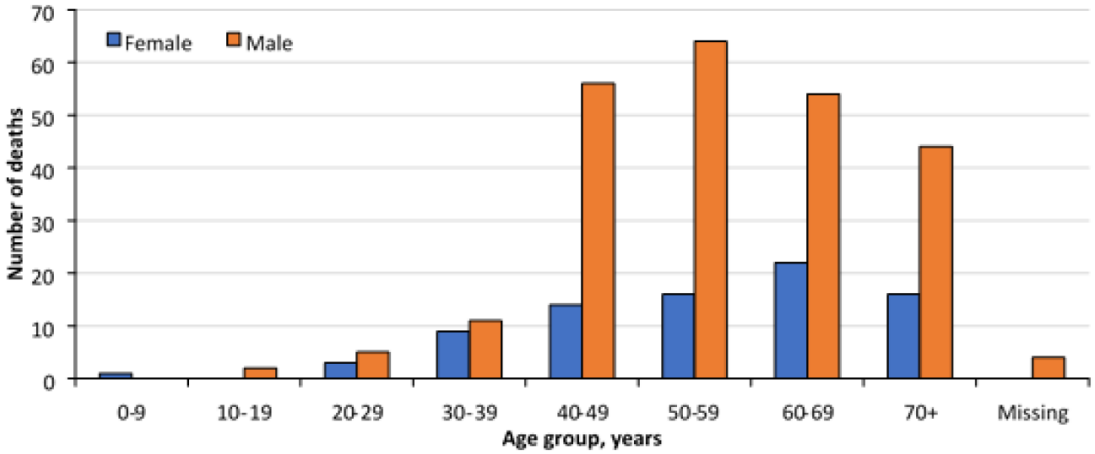

Figure 6: Distribution of COVID-19 deaths in Malawi by February 2021.(73)

Beyond decision makers to the general population, adherence to preventive measures was influenced by several factors. Chilanga et al, conducted a rapid assessment of COVID-19 risk perceptions among residents of three major cities in Malawi (Mzuzu, Lilongwe, and Blantyre)(74), using the Health Belief Model (75) as a conceptual framework. It was discovered that despite access to health information by the participants, perceptions were also based on religion and the political context. Most respondents with religious affiliations believed that the pandemic was fulfilling scriptures on the coming of Christ or that it was a punishment for the sins committed in the world. These affected the HBM concept of cues to action and self-efficacy which describe one's readiness to act. Consequently this affected the uptake of the evidence-based interventions that were implemented by the government of Malawi.(74)

In the same study by Chilanga et al, participants affiliated with the opposition political parties did not believe that the suggested lockdown or the implemented measures, like social distancing, would benefit them in reducing the risk or severity of COVID-19. Participants believed it was the government trying to cripple the campaign efforts of the opposing parties during the re-run of the presidential elections following a court ruling to nullify the initial elections.(40) These beliefs were supported by the failure of the government to enforce the adherence to implemented measures. Political parties continued to hold mass rally campaigns despite widespread information about the pandemic in Malawi.(74,75)

According to Nyasulu et al, on the contribution of socio-political events to the spread of COVID-19 cases in Malawi, the failure to adhere to evidence-informed interventions instituted by the government contributed to the rise of COVID-19 cases in Malawi. Participants attending the political gathering did not adhere to physical distancing, mask-wearing, and other public health measures. The lack of quarantining structures for the returning Malawians previously based in the Republic of South Africa also contributed to the rise in cases.(76–78)

One of the main COVID-19 preventive messages is the wearing of facemasks. In the study by Chilanga et al, health care workers had a high-risk perception of COVID-19 regardless of their political affiliations.(74) A mixed-methods study based on 31 health facilities within Blantyre, in Malawi, assessed the readiness of facilities in dealing with COVID-19 and its impacts. According to the study, up to 80 percent of frontline workers had been trained on COVID-19. However, it was observed that even amongst well-informed frontline health care

workers, and with the availability of personal protective equipment, only 52 percent were utilizing face masks at all the times they were supposed to during service provision.(79)

5. KNOWLEDGE INTEGRATION

In their model for social determinants of health, Dahlgren and Whitehead reveal that health is influenced by socioeconomic, cultural, and environmental factors.(80) Therefore the impact the information system has on these factors will also indirectly influence health outcomes. Knowledge integration assesses the impact of the HIS on civil society and across other sectors.(42)

Malawi prisons are run under the Ministry of Home Affairs and Internal Security. The prisons are congested with an inmate occupancy level of 207 percent.(81) In a situation assessment of Malawi prisons by Jumbe et. al, in 2021, it was noted that despite the access to COVID-19 information by prison officers and inmates, it was challenging to adopt infection prevention interventions. There was limited space for physical distancing, poor ventilation in cells and lack of adequate PPE. The prison officers had adequate access to health information through radios, TV, and social media, but the influence of the evidence was affected by the prisons set up, limiting the interventions that could be enforced.(82)

Valid and reliable COVID-19 vaccination documentation is useful for continuity of care, as it informs health care workers of any subsequent doses and can help guide investigations in cases where there are adverse reactions or other unintended events following vaccination. The documentation as proof of vaccination is also used for travel, work, and surveys.(83) The Malawi HIS adhered to WHO's technical guidance and recommendations on digital documentation of COVID-19 vaccination certificates. This was done in collaboration with different stakeholders: Luke International, the digital health division of the MoH, PHIM, and the Expanded Program for Immunization (EPI). The electronic vaccination registry is hosted on the Malawi one health surveillance platform with data from DHIS2.(83,84) Some of the technical guidance requirements include unique identifiers per vaccinated individual, availability of the digital or paper copy vaccination certificate to the vaccinated individuals, and data privacy and security. The digital COVID-19 certificate can be generated from the website using individual-specific identification numbers.(66,83)

An analysis of the sources of data used, by the Malawi government for decision-making during the COVID-19 pandemic, showed that out of nine sources, one was MoH. This was a COVID-19 dashboard showing the daily number of new cases, deaths, recoveries, and hospitalised patients. It was available from the website https://covid19.health.gov.mw/, run by the Public Health Institute of Malawi.(39) Some of the social determinants were indirectly influenced, not by the HIS, but by decisions based on the HIS. The closure of schools following a rise in COVID-19 cases for example, led to the rise in teen pregnancies.(25)

Following the data confidentiality and access clauses in the HIS policy(12), PHIM only releases raw data to the researchers seeking to perform in-depth analyses, having acquired written ethical clearance from relevant ethical review committees. However, some researchers noted that it takes PHIM longer than expected to release such data.(4)

DISCUSSION

METHODOLOGY AND CONCEPTUAL FRAMEWORKS

The main objective of this review was to assess the capability of the Malawi HIS in handling and supporting knowledge management during public health emergencies, in this case, using COVID-19 as an example. However, it was deemed necessary to give an overview of the system in general, including during the pre-COVID-19 times. This was done to give a clear picture of the state of the HIS in Malawi and to be able to note any changes that might have been caused by the pandemic. It was difficult to identify one framework that examines both the components of the information system and its impact, but both dimensions were considered very important for this review. This invited the use of two conceptual frameworks.

As stated in the methodology section, the health impact framework was designed based on 16 European countries. There are obvious differences in the economic status and health system structures between these countries and Malawi. The information systems also differ, with predominantly digitalized systems in Europe than Malawi. However, due to its broad scope and lack of a specific assessment tool, this framework allowed for a broader exploration of the literature resources at hand. This proved to be important in this instance with COVID-19 data, which were mostly found through sources other than the main health data stream, HMIS. The HMIS provides important information on the flow of clinical data, but as observed in this review, the HIS during COVID-19 has been broader than HMIS only, and it was important to assess the broad impact of the HIS, including outside the health sector.

The frameworks successfully covered all objectives. The WHO HMN framework aided the description of the HIS in Malawi and the HI-impact covered the rest of the specific objectives. The responsiveness dimension of the framework covered availability and utilisation of information. Utilisation was also covered under stakeholder engagement and knowledge integration, and the quality of data was analysed under the evidence quality dimension. The recommendations will be derived from these results.

THE GENERAL STATE OF THE HEALTH INFORMATION SYSTEM IN MALAWI

The studies done on the information system in the past years reveal a slowly developing system. Despite challenges with resources, just like the whole health system in Malawi, the information system has managed to make positive changes and is striving to improve its standards and effectiveness by digitalizing.(14,36,61,69) The introduction of DHIS2 in 2012 as the central data repository was a major milestone in improving knowledge management within the system. However, its effectiveness has been hindered by a lack of personnel with the technical skills to fully utilise the system. The commonly assessed attributes of DHIS2 data quality, which include completeness and timeliness of reporting rates, have continued to fall below the target.(14,34,45,50) This is an indication of the need for more resources and technical skills building to strengthen the system. In the long run, this would help to reduce the reliance on partners.

The diverse range of health and digital organizations that MoH in Malawi maintains as stakeholders and partners in the information system(12,36) is beneficial for developing the system further. As presented in the results, most officers at CMED belong to non-governmental partners. These partners have been crucial in the digitalization and integration of the HIS sub-systems. For instance, the introduction of the interoperability layer between the logistics system and the HMIS, and also the HMIS with the mobile phone health centre data (CCPF).(69,71) If well established, these developments can help reduce the demand for more resources, that are required by the non-digitalized system. However, it is equally

important for MoH to recruit and equip more people within the sector for knowledge management. This would ensure the continuity of projects and initiatives when non-governmental partners are no longer available.

THE HEALTH INFORMATION SYSTEM IN MANAGING THE INFODEMIC

One of the main reasons for not only focusing on the HMIS component of the information system in this study was to cover the role of the HIS in managing the infodemic. COVID-19 information overload affected the global population. WhatsApp being the main source of information from MoH and also a common source for rumours(4,5), meant that most Malawians were subjected to rumours. The HIS, through the risk communication activities by the health education unit, involved community leaders. However, in one of the studies conducted at the beginning of the pandemic(68), most participants thought the community leaders had not been involved and indicated that they would trust community leaders more.

The tendency to follow leaders, at the community and national level was also cemented by the rapid assessment of perceptions in the major cities, which revealed how people's views were shaped by religion and politics, guided by leaders.(74) It is paramount, therefore, in the context of Malawi to ascertain that political, religious, and traditional leaders are specifically targeted early in health emergencies and that they have the right information to positively influence the perceptions and behaviour of the general population within their reach.

The increase in the phone calls to the mobile health centre (CCPF) suggests that most people in Malawi were willing to learn about COVID-19 and that they trusted the numbers provided by MoH on the information products. However, even though the results showed that the attempts to reach the toll-free lines increased by 500 percent, the percentage increase in the calls picked by the CCPF was only 160.(71) Though the factors that contributed to this were not described in the article, it suggests that the system did not fully utilise this opportunity to disseminate the correct information to those seeking it. Even though there were discrepancies in ownership between urban and rural, favouring urban populations, mobile phones were the media source owned by most people.

DATA QUALITY AND MANAGEMENT, AND THE FAIR DATA GUIDELINES

The development of a tailored data collection tool in the fight against EVD in Sierra Leone (33) sets an example of how health systems can use information systems to strengthen HIS and improve its effectiveness in response to public health emergencies by improving the quality of data at the collection points. This activity was documented and shared with other institutions for adaptation. The lack of similar literature in Malawi and Sub-Saharan Africa in line with COVID-19 data indicates a gap in the evaluation of information systems, with regard to public health emergencies, across the region. If such exercises have occurred but are not easily accessible during searches, then the FAIR guidelines are not being followed. This leads to duplication of efforts within the scientific community and slows down developments in fighting public health emergencies, especially for new diseases that require learning different approaches.

The HIS policy in Malawi indicates the submission of data and meta-data to the research unit at MOH.(20) This would ensure that all health data being collected in the country is in one place which would make access easier. However, due to the absence, or non-findability of the research unit repository online, it is impossible to tell if health research data are being submitted to the unit or not. If the institutions are submitting the data, it is still inaccessible because of the lack of, or not easily findable repository. If this component of the HIS were to be functional during public health emergencies like COVID-19, it would make it easier to

find and access evidence that could be used in establishing disease patterns and organizing the response. It would also avoid duplication of efforts in research.

During this review, it had been over two years since the beginning of the pandemic in Malawi, but there was a lack of adequate resources on the quality of COVID-19 data and information that the HIS is producing in Malawi. It is hard to comment on the factors leading to this lack of the assessment of data quality, as there could be several factors that go beyond the scope of this review. It could be the lack of a culture of utilising routine HMIS and other DHIS2 data by individuals and institutions. It could also be the lack of a culture of publishing or making resources accessible online, hence the literature would not have been picked up in this narrative review. This would be a failure to meet the findability criteria item of the FAIR guideline principles for knowledge management. This also applies to the lack of updates by CMED. As stated in the Malawi HIS policy, CMED should provide updates on the MoH websites. With the rate of the pandemic, different parties in the health sector were taken by surprise, however, more than two years have passed since the start of the pandemic and the expectation would be that there should be a structure for response in all the departments, including CMED.

From the available resources, however, one of the main COVID-19 data quality concerns that were noted was the inconsistencies in the two information products that have the same source of data, and with the National Registration Bureau.(65–67) The differences in figures in the daily information updates on social media platforms and the MoH website dashboard raise concerns about the data management structures. Both the cumulative cases and the number of deaths indicators had a difference of more than 200, for the same day. This might pose problems for individuals or institutions trying to use this open access data for research or data analysis to inform decisions. This is a setback in encouraging data utilisation as access to disaggregated data is rightly limited, and as described in the results sections, there are delays in granting access.

The inconsistency between the percentage of deaths occurring in communities for all deaths vs for COVID-19 (67) also raises concerns about underreporting during the pandemic. With the general decline in utilisation of health services at the start of the pandemic, the expected change would have been a higher percentage of COVID-19 deaths occurring in the communities than in the health facilities. Since HSAs are the main cadre responsible for data collection and reporting at the community level(7,43,45), this could be an indication of a knowledge gap among the cadre or a consequence of the pre-existing lack of human resources for the required work. The same factors could have contributed to the inaccurate labelling of cases, especially of notifiable conditions, like the false viral haemorrhagic fever cases(14), which might cause unnecessary panic. Though it was not indicated at which level this error occurred it demonstrated serious gaps in knowledge within the system.

READINESS OF THE SYSTEM TO SUPPORT KNOWLEDGE MANAGEMENT IN PUBLIC HEALTH EMERGENCIES

The HIS in Malawi integrated different subsystems to facilitate easier information flow and access. The various ways in which the information system responded in the wake of COVID-19 show the ability of the system in adapting to public health emergencies. However, the poor quality of data at the data collection levels, as seen in the assessments that occurred before COVID-19(14,47,48,50) might undermine these efforts. Apart from the quality of data being input into DHIS2, this central repository level also has had challenges that led to data loss.(14,60) This would cause setbacks in a public health emergency and the general health system.

There have been efforts to analyse the publicly available routinely collected data.(67) However, these analyses were done earlier on in the pandemic. The pandemic has carried on, many waves have passed with virus variants, and more data has been collected. There is a need to encourage similar analyses with more recent data, by parties within the information system, to continue to inform decisions in the response strategies. This would not only help to understand the current epidemiology of the pandemic but also assess the quality of data being collected by the system, and its relevance. Gaps in indicators can also be identified through the analyses, facilitating the inclusion of more specific data.

READINESS OF STAKEHOLDERS TO USE EVIDENCE

The component of stakeholder engagement in the HI-impact framework analyses the utilisation of information by stakeholders. Although this dimension focuses on aspects that can also be majorly influenced by other factors other than the HIS, it is useful in identifying priority areas for HIS. In the study by Chilanga et. al, for instance(74), the views formed due to politics and religion are not fully a reflection of the functionality of the information system, but they indicate how knowledge from the HIS is received by stakeholders. This can help in guiding information generation and dissemination. Outside of the information system, it can also guide enforcement measures formulated by the government by assessing the willingness of the population to adapt to new measures. The health belief model could also be applied in this instance, to explain why health care workers would have poor adherence to COVID-19 guidelines, even though their perceived risk is high. This knowledge would guide the adaptation and introduction of interventions.

It is also important to consider that the use of evidence can also be impacted by state restrictions, for instance, in the case of prisons and refugee camps. In this case it would be challenging to assess evidence utilisation.

LIMITATIONS

This study utilised a narrative literature review but the lack of peer-reviewed published articles on HIS during COVID-19 in Malawi and Sub-Saharan Africa, calls for a different approach in the assessment of the HIS concerning COVID-19 knowledge management. Due to the nature of narrative literature reviews, the depth of the review per each objective was controlled by the availability of literature concerning the objective. Hence, whilst there were numerous resources for some, other dimensions of the impact of the HIS were not well explored including the data collection processes specific to COVID-19 within the IDSR and HMIS, and evidence of knowledge integration.

CONCLUSION AND RECOMMENDATIONS

The Malawi HIS has positively impacted different sectors during the current COVID-19 pandemic. However, the system is limited by several factors to do with resources, skills, and lack of preparedness for public health emergencies. The impact of the system is marred by the effects of the infodemic that came with this pandemic. The information overload influenced people's perceptions that affected the reception of information from the MoH sources. There was proof of evidence-based decision-making at the start of the pandemic within the government and MoH, however the political and social environments influenced some decisions by the government and political leaders. There is lack of regular quality assessments of the HIS to analyse its overall effectiveness. The following recommendations to the MoH can help identify major gaps in the information system to improve the effectiveness of the HIS in Malawi in supporting knowledge management during public health emergencies.

POLICY RECOMMENDATIONS

1. To reduce reliance on external partners, MoH should ensure that part of the memoranda of understanding with partners and funders include training and equipping personnel within the MoH with technical skills to start adapting to digital tools and building capacity withing the system for continuity.
2. MoH should enforce the conduction of routine assessments of the HIS by CMED as stipulated in the HIS policy to ensure quality data is produced to prepare the system in responding to future public health emergencies.

INTERVENTION RECOMENDATIONS

3. The MoH should develop standard, easy-to-use data collection tools that can be utilised during public health emergencies. Adapt the data collection tools to the context of Malawi health system, and per future public health emergencies. The adaptation can be based on several factors, for example, the HCW to patient ratio to guide the amount and prioritization of data to collect; the clinical management protocols to guide what data can be collected, by which cadre and with which tools (in the case of highly infectious diseases), and the knowledge of data collectors. An electronic tool would be ideal considering the existing shortage in human resources and it is easier to have built-in quality check mechanisms in electronic forms which improve the quality of data. Continued efforts in improving the whole HIS system through digitalization and skilled human resources would improve the health response during public health emergencies.
4. CMED should ensure that more interoperable layers should be created between DHIS2 and sub-systems within HIS for easier data sharing, reducing delays in access to information by stakeholders due to logistical challenges.

RESEARCH RECOMMENDATIONS

5. Through the next national health research agenda, the MoH research unit can guide future research by MoH, its partners and other stakeholders to include holistic assessments of the HIS and approaches in improving its effectiveness. Data on public health emergencies research in the country should be easy to find and access for re-use. A national health research repository within the MoH could help achieve this. To be able to manage and transform data generated by data collectors within the system into evidence accessible by all stakeholders including the general population, the MoH through its research unit should facilitate the utilisation of routinely collected data for research purposes. This could be done through easily accessible databases of aggregated data, within the data sharing and re-use ethical allowance, as per the

policy. Part of this research should address the knowledge gap on the current quality of routinely collected data being produced by the system beyond the concepts of timeliness and completeness to better adapt data collection tools. It should involve thorough assessments of the HMIS using quality assessment tools like the WHO data quality review kit for routinely collected data.

6. Following varied perceptions towards the risk communication approach during the COVID-19 pandemic in Malawi, as part of community engagement, more research should be done, by MoH and partners, on preferred and trusted means of risk communication during public health emergencies. Similar research should be done for decision makers to ascertain information sources and products that are easy to access and use in decision making to tailor future information dissemination strategies.

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Appendix 1: SANRA scale

Scale for the Assessment of Narrative Review Articles – SANRA

Please rate the quality of the narrative review article in question, using categories 0–2 on the following scale. For each aspect of quality, please choose the option which best fits your evaluation, using categories 0 and 2 freely to imply general low and high quality. These are not intended to imply the worst or best imaginable quality.

1) Justification of the article's importance for the readership

The importance is not justified. — 0
The importance is alluded to, but not explicitly justified. — 1
The importance is explicitly justified. — 2

☐

2) Statement of concrete aims or formulation of questions

No aims or questions are formulated. — 0
Aims are formulated generally but not concretely or in terms of clear questions. — 1
One or more concrete aims or questions are formulated. — 2

☐

3) Description of the literature search

The search strategy is not presented. — 0
The literature search is described briefly. — 1
The literature search is described in detail, including search terms and inclusion criteria. — 2

☐

4) Referencing

Key statements are not supported by references. — 0
The referencing of key statements is inconsistent. — 1
Key statements are supported by references. — 2

☐

5) Scientific reasoning

(e.g., incorporation of appropriate evidence, such as RCTs in clinical medicine)

The article's point is not based on appropriate arguments. — 0
Appropriate evidence is introduced selectively. — 1
Appropriate evidence is generally present. — 2

☐

6) Appropriate presentation of data

(e.g., absolute vs relative risk; effect sizes without confidence intervals)

Data are presented inadequately. — 0
Data are often not presented in the most appropriate way. — 1
Relevant outcome data are generally presented appropriately. — 2

☐

Sumscore ☐

Appendix 2: SANRA tool explanation

SANRA – explanations and instructions

This scale is intended to help editors assess the quality of a narrative review article based on formal criteria accessible to the reader. It cannot cover other elements of editorial decision making such as degree of originality, topicality, conflicts of interest or the plausibility, correctness or completeness of the content itself. SANRA is an instrument for editors, authors, and reviewers evaluating individual manuscripts. It may also help editors to document average manuscript quality within their journal and researchers to document the manuscript quality, for example in peer review research. Using only three scoring options, 0, 1 and 2, SANRA is intended to provide a swift and pragmatic sum score for quality, for everyday use with real manuscripts, in a field where established quality standards have previously been lacking. It is not designed as an exact measurement of the quality of all theoretically possible manuscripts. For this reason, the extreme values (0 and 2) should be used relatively freely and not reserved only for perfect or hopeless articles.

We recommend that users test-rate a few manuscripts to familiarize themselves with the scale, before using it on the intended group of manuscripts. Ratings should assess the totality of a manuscript, including the abstract. The following comments clarify how each question is designed to be used.

Item 1 – Justification of the article's importance for the readership

Justification of importance for the readership must be seen in the context of each journal's readership.
Consider how well the manuscript outlines the clinical problem and highlights unanswered questions or evidence gaps – thoroughly (2), superficially (1), or not at all (0).

Item 2 – Statement of concrete/specific aims or formulation of questions

A good paper will propose one or more specific aims or questions which will be dealt with or topics which will be reviewed.
Please rate whether this has been done thoroughly and clearly (2), vaguely or unclearly (1), or not at all (0).

Item 3 – Description of the literature search

A convincing narrative review will be transparent about the sources of information on which the text is based. Please rate the degree to which you think this has been achieved. To achieve a rating of 2, it is not necessary to describe the literature search in as much detail as for a systematic review (searching multiple databases, including exact descriptions of search history, flowcharts, etc.), but it is necessary to specify search terms, and the types of literature included. A manuscript which only refers briefly to its literature search would score 1, while one not mentioning its methods would score 0.

Item 4 – Referencing

No manuscript references all statements. However, those that are essential for the arguments of the manuscript – "key statements" – should be backed by references in all or almost all cases. Exceptions could reasonably be made for rating purposes where a key statement has uncontroversial face-validity, such as "Diabetes is among the commonest causes of chronic morbidity worldwide."
Please rate the completeness of referencing: for most or all relevant key statements (2), inconsistently (1), sporadically (0).

Item 5 – Scientific reasoning

The item describes the quality of the scientific point made. A convincing narrative review presents evidence for key arguments. It should mention study design (randomized controlled trial, qualitative study, etc), and where available, levels of evidence.
Please rate whether you feel this has been done thoroughly (2), superficially (1), or hardly at all (0). Unlike item 6, which is concerned with the selection and presentation of concrete outcome data, this item relates to the use of evidence and of types of evidence in the manuscript's arguments.

Item 6 – Appropriate presentation of data:

This item describes the correct presentation of data central to the article's argument. Which data are considered relevant varies from field to field. In some areas relevant data would be absolute rather than relative risks or clinical versus surrogate or intermediate endpoints. These outcomes must be presented correctly. For example, it is appropriate that effect sizes are accompanied by confidence intervals. Please rate how far the paper achieves this – thoroughgoingly (2), partially (1), or hardly at all (0). Unlike item 5, which relates to the use of evidence and of types of evidence in the manuscript's arguments, this item is concerned with the selection and presentation of concrete outcome data.

Appendix 3: Case based reporting form by PHIM

Republic of Malawi Ministry of Health

CBS Reporting form Version 4.2. 2021

PHIM PUBLIC HEALTH INSTITUTE of MALAWI

CASE-BASED SURVEILLANCE REPORTING FORM

Reporting Facility:		**Reporting District:**		**Type of Case:**	□OPD □IPD □POE
Reporter Name:		**Reporting Phone #:**		**Reporting Da te:**	____ / ____ / _____

Type of Reporting Disease/Condition: □AFP □Cholera □Diarrhoea with blood(Shigellaosis) □Neonantal Tetanus □Measles □Menigitis □Plague □AHFS □Yellow Fever □Rabies □SARS/MERS/COVID □Typhoid fever □AEFI □Anthrax □ILI □SARIs □Dengue fever □Listeriosis □Smallpox □Maternal Death □Monkey Pox □Perinatal Death □Unexplained cluster □Other (*specify*):_____

Last Name of Case:			**First Name of Case:**				
Date of Birth (dd/mm/yyyy)	_____ / _____ / _____		**Age of Case(if DOB unknown):**	year: ____ months:____ days:____			
Nationality:			**Cases UID:**	□Passport □NID _____			
District of Case Residence:		□Urban □Rural	**Sex:**	□Male □Female	**Occupati on:**		
Physical Address:			**Nearest Landmark:**				
Phone number of Case:			**Parent or Care Taker Name:**				
Date Seen at Facility:	_____ / _____ / _____		**Vaccinati on:**	□No □Measles □NT (TT in mother) □Menigitis□YellowFever □COVID-19 □Cholera □AFP □Typhoid	**# of Doses**		
					Type of Vaccine		
Date Facility Notified District:	_____ / _____ / _____		**Date of Last Vaccination:**	_____ / _____ / _____			
Recent Travel History:	□Indiginous □International **Where:**_____ **Date of Return:** _____ / _____ / _____						
Any contact with OT case:	□No □Suspected □Confirmed		**Any Clustering:**	□No □Family □School □Hospital □Workplace			
Date of Onset:	_____ / _____ / _____		**Pregnancy** (if case if female):	□Yes □No	**Trimest er:**		

Presenting Symptom(s), tick if any presented:	□No(Asymptomatic) □Fever □Cough □Headache □Muscle ache □Vomit □Nausea □Diarrhea □ Fatigue □Abdominal pain □Chest pain □ Shortness of Breath □Bleeding □Skin rash □Other:_____	
Underlying Condition(s), tick if any presented:	□No □DM □Hypertention □HIV □COPD □TB □Stroke □Asthma □Cancer □Liver Dz □Kidney Dz □Cardiovascular Dz □Neurological Dz □Mental □Other:_____	**Covid (+) Hist.** □Yes □No
Person Completer Form:	Name_____ Function: _____ Signature:_____	

For health Faiclity: If lab specimien is collected, complete the following information. And send a copy of this form to the lab with spcimen.			
Date specimen collected:	_____ / _____ / _____	**Date specimen sent to lab:**	_____ / _____ / _____
Specimen type:	□Blood □Plasma □Serum □Aspirate □CSF □Pus □Saliva □Biopsy □Stool □Urethral/Vaginal discharge □Urine □Sputum □NP swab □OP swab □Food sample □Water sample		

For the lab: Complete this section and return the form to district team and clinician / confirm the result is apearing in the National LIMS □**Entered**			
Specimen condition	□Adequate □Not Adequate	**Date lab received specimen:**	_____ / _____ / _____
Type of test(s) performed:		**Testing Platform:**	
Final Laboratory Result:	□**P**ostive □**N**egative	**Date lab sent result to district:**	_____ / _____ / _____
Date result sent to HCW:	_____ / _____ / _____	**Date district received result:**	_____ / _____ / _____

Case Final Outcome:	□**A**live □**D**ead □**TO** □**L**ost	**Case Final Classification:**	□**C**onfirmed □**P**robable □**C**ompatible □**D**iscarded

Appendix 4: Population pyramid for Malawi, 2018