

Health Technologies Impact Towards Resilient Health Systems: An Epistemological Approach at Kenyatta National Hospital, Kenya

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Abstract

The project aimed to call to mind the impact of health technologies on strengthening health systems. An epistemological approach case study at Kenyatta National Hospital, Kenya. The investigation deployed a cross-sectional study. A sample total of 263 respondents was calculated using the Krejcie and Morgan formula for the quantitative study. A strict inclusion criterion was used to select respondents from all trained health personnel at Kenyatta National Hospital. The study utilized a questionnaire and a key informant interview guide. Data were analyzed using SPSS version 27, in which associations between predictor and outcome variables were assessed using correlational statistics. Qualitative data were thematically analyzed using response themes and presented verbatim. Consent was sought from all respondents. A total of 263 respondents were engaged in the quantitative study. The study utilized a questionnaire and a key informant interview guide. Before processing quantitative data, the data were cleaned, coded, and keyed into an MS Excel database and analyzed using SPSS version 27. Descriptive statistics were used to describe measures of central tendency and dispersion. Findings were presented using frequency distributions and summary tables. Associations between predictor and outcome variables were assessed using correlational statistics. Of the 263 respondents, 84 (69.2%) had a positive attitude, 29 (10.9%) were uncertain, and 53 (19.9%) had a negative attitude toward the ICT infrastructure being conducive to the growth and expansion of HMIS. KNH has a current and up-to-date ICT infrastructure that demonstrated a moderate positive correlation with HMIS, which has been fully implemented by the hospital ($r = 0.41$, $p < 0.01$), suggesting that advanced ICT infrastructure is significantly imperative for HMIS implementation. The study concluded that HIMS is not just automation, but rather a means of augmentation and connection. As an indispensable tool for providing safe, high-quality, and high-productivity healthcare, the study recommended that KNH adopt an HIMS tailored to its clientele and spur a systems-thinking approach among staff for sustained success.

Keywords: *Health System, Digital Transformation, Health Management Information System, Interoperability, Universal Health Coverage, Health Information*

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1. Introduction

Two decades are enough for the healthcare industry to be ensconced in technology, as in other sectors; all we need is equity, political goodwill, appropriate governance, interconnectedness, honest discussions around health matters, and sustained investments [1]. In today's interconnected world, health is fundamentally tied to the environment, sociocultural dynamics, geopolitics, and the economy, among other critical factors. Recognizing this intricate relationship is essential for addressing health challenges effectively and ensuring a sustainable future [2]. The pandemic exposed weaknesses in health systems, such as insufficient workforce capacity and critical care resources [3]. Globally, healthcare systems, including the demand for high-quality and equitable distribution [4]. According to [5], digital technologies have transformed life worldwide over the last three decades. The healthcare space has been integral to this revolution, with widespread adoption of digital solutions that address various challenges in healthcare delivery.

The challenge of this era is to adopt digital technologies in alignment with the principles of equity, inclusivity, and sustainability [6]. Despite substantial budgets, only a few successful implementations of Health Information Systems (HIS) interoperability have been reported, notably in Estonia and Indiana, USA. These successful examples demonstrate that the goals of HIS interoperability are achievable, and the lessons learned from their experiences could potentially benefit other initiatives [7]. The intent globally of multisectoral action for health is to leverage health system-strengthening interventions. Such interventions would aim to address issues that extend beyond the health system and substantially affect population health and health disparities. According to [8], African policymakers are increasingly being called upon to use evidence-based research to inform policy development and decision-making.

According to [9], embracing modern innovations in healthcare technology is one among many ways to improve efficiency and reduce losses within healthcare organizations. The integration of information and health services envisaged benefits cannot be disputed; still, there are many challenges that affect and determine its effective adoption. In fact, the majority of organizations have abandoned their newly acquired systems, only to revert to their old manual systems. Health management information systems can be the impetus for managing complex health care challenges and addressing growing information needs. The implementation of HMIS is crucial for monitoring diseases, allocating resources, evaluating programs, conducting research, and enhancing healthcare systems to achieve optimal public health outcomes. Achieving universal health coverage in the digital era requires innovation, collaboration, and a focus on equity, aligning with Sustainable Development Goal 17, which aims to strengthen global partnerships [10].

The landscape of information systems is in a perpetual state of evolution, adapting to the needs of the times. This ensures they remain relevant and effective in providing valuable solutions for individuals and organizations alike. The [11] notes that interoperability of health management information systems is important. As reported by [4], we need solutions that realize that financing, equity, and access are not different problems; they are linked. This means that up to 84 additional countries might meet the WHO targets for disease elimination by 2028. Such diseases include the elimination of malaria and some neglected tropical diseases, and the mitigation of public health problems if HMIS is implemented effectively. In 140 countries, the right to health is enshrined in their constitution, yet more than 50% of the world's population

lacks coverage under essential health services, and one in four people suffers financial hardship due to medical expenses.

Organizations should focus on the iterative nature of the process and carefully assess the impact of any changes. On this pedal, the collaboration will ensure universal access to quality healthcare [11]. As reported by [12], public health leaders need to embrace the role of Chief Health Strategist in their work, especially when working with all relevant partners, to drive initiatives, including those that explicitly address “upstream” social determinants of health. Specialized Public Health training should be available to the public health workforce and students. A people-centered approach means that data is intended to empower people and support their active participation in the development of a health management information system, from the design phase through implementation.

Research on the factors influencing the acceptance and use of digital health technology in low- and middle-income countries is limited and fragmented, especially regarding health workers' perspectives [13]. Although health systems vary by country in their structure and processes, they still share essential functions, including governance, health financing, the availability of medical products and vaccines, the generation of health information, the maintenance of a skilled workforce, and the delivery of health services [7]. According to [10], leveraging technology can help provide accessible, efficient, and equitable healthcare services for everyone. The digital transformation should usher in a new era in healthcare that empowers patients and communities by providing better access to care and information, reducing waiting lists and costs, and enabling health services to reach the most vulnerable populations. It also supports collaborative interprofessional practice and facilitates access to health and community resources. Governments can improve access to quality health services by implementing secure and interoperable digital solutions and strengthening health information systems. Digital transformation enhances self-care, promotes health, improves collaboration, and addresses inequities in healthcare access. A comprehensive digital transformation has the potential to improve health outcomes for all, leading to a healthier population and a more sustainable future.

Kenya has made notable investments in digital systems, including the Kenya Health Information System (KHIS), electronic community health information platforms, and various electronic medical record systems to facilitate Universal Health Coverage (UHC). Health Information Management (HIM) professionals play a crucial role in this change, ensuring that data is precise, timely, and actionable from healthcare facilities to the national level. However, gaps in training, inconsistent staffing, and the absence of standardized roles across different counties hinder the profession's potential. Many professionals lack access to the necessary tools, mentorship, and ongoing education aligned with contemporary health information technology systems [9].

2. Materials and Methods

The study was conducted at Kenyatta National Hospital in Nairobi County, Kenya. As per the healthcare tiers in Kenya, KNH is at the apex; it is a National Teaching and Referral Hospital and was therefore purposefully selected. As of the time of the study, the facility had 50 wards, 22 outpatient clinics, 24 theatres (16 specialized), and an Accident and Emergency department. It had a bed capacity of 1800, of which 209 were for the private wing. The Hospital was built to fulfill the role of being a National Referral and Teaching Hospital, as well as to provide a

medical research environment. The study utilized a Cross-sectional research design. Cross-sectional studies provide an accurate profile of persons, events, or situations at a particular point in time. It allows the collection of large amounts of data from a sizable population at a very low cost. These details corroborated the Cross-sectional survey as the best strategy to achieve the study's objectives. The research design explored a case study of KNH. There were 4,490 accredited healthcare service delivery officers at Kenyatta National Hospital who, in one way or another, would have been involved in implementing the HMIS. The study included all 4,490 accredited healthcare service delivery officers at Kenyatta National Hospital across the top/managerial, middle/ and operational levels who, in one way or another, had been involved in implementing the HMIS. All other persons not involved in the HMIS implementation were excluded. KNH has 46 departments in total. From the organogram, respondents were sampled based on their relevance, yielding three cadres. Since a sample was selected from the KNH in Nairobi, it was expected that selecting one healthcare worker/respondent in Nairobi would be the same as selecting the others. In determining the target population to be surveyed, a qualitative and a quantitative sample size were calculated using the Krejcie and Morgan formula. Three factors served as the basis. Consequently, according to the Krejcie and Morgan formula, three factors were used to determine the appropriate sample size. These factors were the projected frequency of the preferred respondent characteristic (p), from which an estimated 87.5% of the health professional officers surveyed were expected to believe that the research was viable. The other factors used were the preferred level of confidence (t), set at 95% (with a standard value of 1.96), and the acceptable margin of error (m), set at 4% (with a standard value of 0.04). Given the three factors, the sample size was thus calculated using the formula:

Total number of health workers = 4,490

19 departments are directly involved with HMIS

$$N = \{t^2 \times p(1-p) \times 1\} / m^2$$

$$= 1.96^2 \times 0.875(1-0.875) / 0.04^2$$

= 0.420175 / 0.0016 = 262.609375, and thus 263 respondents at the operational level and 14 respondents in each stratum/department. A questionnaire and a key informant interview schedule were used to collect data. The data were collected through questioning and interviewing. The data collection technique involved structured and unstructured questions, as well as a key informant interview. Before processing the quantitative data collected from the field. It was cleaned, edited, and coded, then entered into software and analyzed using SPSS version 27. Qualitative data that could not be represented by numerical statistics were analyzed using qualitative content analysis. The study proposal was submitted to the Kenyatta National Hospital/University of Nairobi ethical review committee for ethical approval. Subsequent approval was vindicated upon meeting the warranted KNH/UoN ERC threshold.

3. Results

Of the 263 respondents, 184 (69.2%) had a positive attitude, 29 (10.9%) were uncertain, and 50 (19.9%) had a negative attitude toward the ICT infrastructure being conducive to the growth and expansion of HMIS in KNH. Regarding whether the cost of ICT equipment and tools affected the application and implementation of HMIS, the analysis showed that 184 (69.2%) were optimistic about the concept, 48 (18%) were uncertain, and 24 (12.8%) were pessimistic. With the foregoing, 85 (31.9%) had a negative perception, 92 (34.6%) were uncertain, and 89

(33.5%) had a positive perception that the department had an adequate pool of highly HMIS-trained skilled labor. (Table 1).

Table 1: Respondents’ feedback on Organizational factors influencing HMIS implementation at the Kenyatta National Hospital

Factors	Negative Attitude	Neutral	Positive Attitude
	n (%)		
Cost of ICT influence	34 (12.8)	48 (18.0)	184(69.2)
Conducive ICT infrastructure	50 (19.9)	29 (10.9)	184(69.2)
Expertise	85 (31.9)	92 (34.6)	89 (33.5)
Lack of training	35 (13.2)	16 (6.0)	215(80.9)
Availability of computers	260 (98.9)	3 (1.1)	0 (0.0)
Updated ICT infrastructure	93 (35.0)	70 (26.3)	103(38.7)

The study findings further indicated that 87(33.08%) of the respondents were enthusiastic that there was full implementation of the HMIS by the hospital and 51(18.80%) of the respondents were uncertain while 20 (7.52%) of the respondents were cynical that there was full implementation of the HMIS by the hospital. There was an equal percentage of those who were cynical to those who were enthusiastic 87(33.08%), on the concept: HMIS had been fully implemented by the hospital (Figure 1).

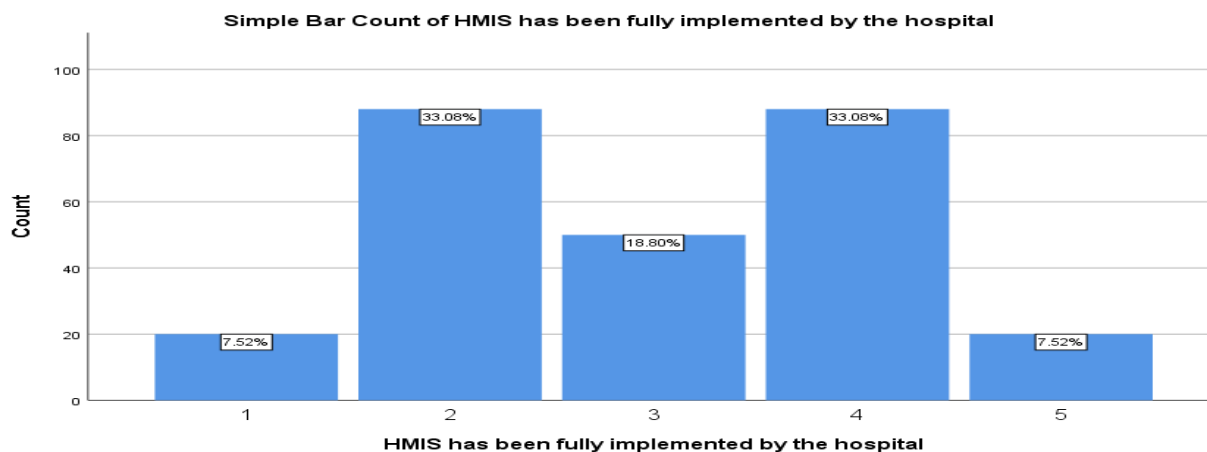


Figure 1: Respondents’ Status of HMIS Implementation at KNH

Analysis of Technological Factors Influencing HMIS Implementation at KNH

Study findings indicated a moderately strong positive correlation ($r=0.5$) between computer use and HMIS implementation, implying that departments that actively used computers were more likely to have implemented HMIS, since HMIS is a software-based system that relies on computer use. This was in tandem with [14], who stated that technology is key to achieving the

One Health strategy, ICT infrastructure showed the strongest positive correlation ($r=0.8$) with HMIS implementation, suggesting that a robust and supportive ICT infrastructure facilitates HMIS implementation. This aligned with the statement, “The ICT infrastructure is conducive for the growth and expansion of HMIS in KNH”. Trained skilled labor had a moderate positive correlation ($r=0.4$), suggesting that having a pool of trained staff familiar with HMIS facilitates its implementation. This aligned with the statement, “The department has an adequate pool of highly HMIS-trained skilled labor,” regarding expertise. A lack of proper training affects the growth and expansion of HMIS in KNH, with a moderate negative correlation ($r = -0.4$), indicating that it impeded HMIS implementation. The need for additional computers showed a weak negative correlation, suggesting that adding more computers might not directly lead to HMIS implementation. The results were echoed by [15], which stated that achieving UHC requires health system strengthening to deliver effective and affordable services that prevent ill health and provide health promotion, prevention, treatment, rehabilitation, and palliation.

The correlation plot suggested that having a supportive ICT infrastructure, trained staff, and a culture of computer use are associated with successful HMIS implementation. However, the lack of training appeared not to be associated with HMIS rollout, and factors like adding more computers might not have a direct impact unless the underlying infrastructure and skills are already in place. Conversely, showed a very weak correlation, suggesting no association with HMIS implementation (Figure 2).

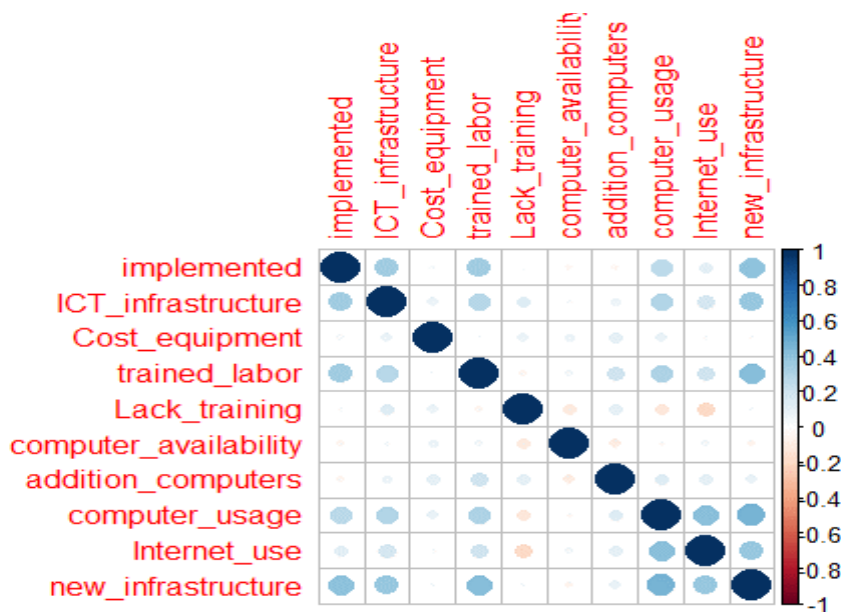


Figure 2: Correlational plot indicating Technological factors and HMIS implementation at KNH

The correlation matrix revealed interesting patterns of association between HMIS implementation and the considered factors. “The hospital has fully implemented HMIS” exhibited a weak positive correlation with “the ICT infrastructure is conducive for the growth and expansion of HMIS in KNH” ($r = 0.35$, $p < 0.05$), indicating that automation and an advanced ICT infrastructure are significantly associated with successful HMIS implementation. Similarly, “KNH has a current and up-to-date ICT infrastructure”

demonstrated a moderate positive correlation with “HMIS has been fully implemented by the hospital” ($r = 0.41, p < 0.01$), significantly suggesting that advanced ICT infrastructures are imperative towards HMIS implementation as [16] reported that, investments in digital public infrastructure are vital to enhancing national health priorities, playing a crucial role in enabling health systems to respond effectively and efficiently.

The weak positive correlation with equipment cost ($r = 0.03, p > 0.05$) was not statistically significant, suggesting that equipment cost may not be a significant barrier to HMIS implementation. This finding was consistent with the notion that the long-term benefits of HMIS justify the initial investment in equipment. However, the analysis identified challenges as well: “Lack of proper training affects growth and expansion of HMIS in KNH” showed a weak negative correlation with HMIS implementation ($r = -0.03, p > 0.05$), hinting at a potential barrier. Although the correlation was weakly negative, it suggested that addressing training deficiencies might positively affect HMIS implementation. Interestingly, “the department collects, analyzes, interprets and stores its data in Computers” and “We communicate with other departments using the Internet” demonstrated a moderate positive correlation with HMIS implementation ($r = 0.41$ and $r = 0.37$, respectively, both $p < 0.01$) implying that automation, internet and connectivity and ICT access contribute significantly to successful HMIS implementation (Table 2).

Table 2: Correlational matrix indicating Technological factors and HMIS implementation at KNH

	HMIS_impl	ICT_infras	Cost_equi	trained_la	Lack_train	computer	addition_computer	Internet_u	new_infr	
HMIS_implemented	1	0.3471	0.0295	0.3457	0.0180	-0.0395	-0.0397	0.2654	0.1185	0.4086
ICT_infrastructure	0.3471	1	0.0734	0.2715	0.1302	0.0231	0.0679	0.2944	0.1757	0.3706
Cost_equipment	0.0295	0.0734	1	0.0049	0.0726	0.0658	0.1018	0.0911	0.0171	0.0146
trained_labor	0.3457	0.2715	0.0049	1	-0.0315	0.0420	0.1923	0.3069	0.1986	0.4220
Lack_training	0.0180	0.1302	0.0726	-0.0315	1	-0.1041	0.1081	-0.1200	-0.1909	0.0141
computer_availability	-0.0395	0.0231	0.0658	0.0420	-0.1041	1	-0.0989	-0.0267	0.0420	-0.0462
addition_computers	-0.0397	0.0679	0.1018	0.1923	0.1081	-0.0989	1	0.1316	0.1075	0.0819
computer_usage	0.2654	0.2944	0.0911	0.3069	-0.1200	-0.0267	0.1316	1	0.4114	0.4613
Internet_use	0.1185	0.1757	0.0171	0.1986	-0.1909	0.0420	0.1075	0.4114	1	0.3701
new_infrastructure	0.4086	0.3706	0.0146	0.4220	0.0141	-0.0462	0.0819	0.4613	0.3701	1

4. Discussion

ICT plays a key role in HMIS. It facilitates HMIS in all its processes. According to [17], the biggest barriers to adoption of electronic health records were reported as the cost of software, hardware, and physician participation. In addition [7] stated that, the end-user participation in implementation strategy was the main factor associated with successful adoption of HMIS and these findings were similar to the study; out of the 263 respondents 184(69.2%) had a positive attitude, while 29 (10.9%) were uncertain and 50(19.9%) had a negative attitude that the ICT

infrastructure is conducive for the growth and expansion of HMIS in KNH. Regarding whether the cost of ICT equipment and tools affected the application and implementation of HMIS, the analysis showed that 184 (69.2%) were optimistic about the concept, 48 (18%) were uncertain, and 24 (12.8%) were pessimistic.

As stated by [14], technology is key to achieving the One Health strategy, an evolutionary process whose pace will be determined by the willingness and commitment of political entities, sectors, and disciplines to the One Health approach. Adoption should be evidence-based, reflecting improvements in the efficacy and effectiveness of interventions in health systems, thereby ensuring social and economic benefits. ICT can improve healthcare delivery, but few government health services have a reliable IT infrastructure. According to [18], leveraging technology can help provide accessible, efficient, and equitable healthcare services for everyone.

The digital transformation should usher in a new era in healthcare that empowers patients and communities by providing better access to care and information, reducing waiting lists and costs, and enabling health services to reach the most vulnerable populations. A national health information and IT infrastructure is needed. ICT is projected to be a major pillar of the economy by 2023 [19]. With the foregoing, 85 (31.9%) had a negative perception, 92 (34.6%) were uncertain, and 89 (33.5%) had a positive perception that the department had an adequate pool of highly HMIS-trained skilled labor. Study findings indicated that ICT infrastructure had the strongest positive correlation ($r=0.8$) with HMIS implementation, suggesting that a robust, supportive ICT infrastructure facilitates HMIS implementation. This aligned with the statement, “The ICT infrastructure is conducive for the growth and expansion of HMIS in KNH”. Computer usage showed a moderately strong positive correlation ($r=0.5$), implying that departments that actively used computers were more likely to have implemented HMIS, since HMIS is a software-based system that relies on computer use. Trained skilled labor had a moderate positive correlation ($r=0.4$), suggesting that having a pool of trained staff familiar with HMIS facilitates its implementation [20]. This aligns with the statement, “The department has an adequate pool of highly HMIS-trained skilled labor.”

Achieving UHC required strengthening health systems to deliver effective and affordable services that prevent ill health and promote health, including prevention, treatment, rehabilitation, and palliation [21].

Achieving UHC requires strengthening health systems to deliver effective and affordable services that prevent ill health and promote health, including prevention, treatment, rehabilitation, and palliation [22]. The correlation matrix revealed interesting patterns in the associations between HMIS implementation and the considered factors. “HMIS has been fully implemented by the hospital,” though significant exhibited a weak positive correlation with “the ICT infrastructure is conducive for the growth and expansion of HMIS in KNH” ($r = 0.35$, $p < 0.05$), indicating that an advanced ICT infrastructure is associated with successful HMIS implementation. Similarly, “KNH has a current and up-to-date ICT infrastructure” demonstrated a moderate positive correlation with “HMIS has been fully implemented by the hospital” ($r = 0.41$, $p < 0.01$), suggesting that advanced ICT infrastructure is strongly associated with HMIS implementation. The findings were consistent with [23], which stated that health technologies are evidence-based when they meet well-defined specifications, have been validated through controlled clinical studies, or rest on a widely accepted expert consensus,

and thus become solutions to health problems [18]. ICT formed the backbone of services for preventing, diagnosing, and treating illness and disease. HITs were only one category among the vast array of technologies that may be useful. Given the right policies, organization, resources, and institutions, HITs were a powerful tool in the hands of those working to improve health [24]. However, the analysis also identified challenges: “Lack of proper training affects growth and expansion of HMIS in KNH” showed a weak negative correlation with HMIS implementation ($r = -0.03$, $p > 0.05$), suggesting a potential barrier. Although the correlation was weakly negative, it suggested that addressing training deficiencies might positively affect HMIS implementation. Interestingly, “the department collects, analyzes, interprets, and stores its data in Computers” and “We communicate with other departments using the Internet” demonstrated a moderate positive correlation with HMIS implementation ($r = 0.41$ and $r = 0.37$, respectively, both $p < 0.01$). This implies that active computer usage and internet access contribute significantly to successful HMIS implementation.

The findings also agreed with [25], a report that stated digital health, or the use of digital technologies for health, had become a salient field of practice for employing routine and innovative forms of information and communications technology (ICT) to address health needs and the use of the digital revolution to scale up health interventions and engage civil society [26]. Regarding computer utilization, communication and interaction with other departments, and HMIS implementation, the study demonstrated moderate positive correlations ($r = 0.41$ and $r = 0.37$, respectively; both $p < 0.01$). Where health systems, particularly in developing countries, need to optimize resource use and expand population coverage, the process of improvement and scaling up should be significantly grounded in sound local strategies for quality to achieve the best possible results from new investments [27]. The weak positive correlation with equipment cost ($r = 0.03$, $p > 0.05$) was not statistically significant, suggesting that equipment cost may not be a significant barrier to HMIS implementation. This finding was consistent with the notion that the long-term benefits of HMIS justify the initial investment in equipment. A lack of understanding of the specific challenges in the domain is the major contributor to the failure to deliver and fulfill the big promises. In addition, the KNH digital technologies should have an infrastructure that supports and accommodates emerging strategies crucial to evidence-based policymaking and the appropriate use of resources, to avoid downtime and improve patient turnaround time.

Health systems globally are investing significantly in digital transformation. However, the effectiveness of these investments may be compromised without skilled health information management (HIM) professionals [28]. In various countries, particularly in low and lower-middle-income nations and small island developing states (SIDS), HIM professionals often face challenges related to undervaluation and lack of recognition. In many cases, they are classified within outdated administrative categories, which limits their visibility and the strategic contributions they make to health systems. The importance of their roles may only become apparent when issues arise within these systems [29].

5. Conclusion

Global digital health spending is projected to exceed US \$540 billion by 2035. It is essential that HIM professionals be integrated into the foundational aspects of this development, rather than treated as an afterthought. By embracing inclusive, ethical, and secure digital solutions, the global health community and governments can transform healthcare models, empower

patients and providers, and establish resilient health systems that effectively prevent and tackle diseases while promoting well-being for all. Health systems are crucial for patient care, research, and public health. KNH's fragmented approach to HIMS leads to inefficiencies and gaps. Improving HIMS has the potential to reshape healthcare globally. The SDGs highlight the need for robust health systems. HIMS should be viewed as investments that recoup their costs. HIMS should be viewed as investments and not expenses. As always, the brunt is borne by the most vulnerable populations, which are primarily in LMICs. Technologically, Digital technologies in healthcare, such as KNH HIMS, play a vital role in creating a better healthcare environment. They support evidence-based policymaking and the appropriate use of resources. Technological innovation involves individuals, organizations, and society. Improved health systems are needed for effective interventions against tropical and infectious diseases. HIM professionals are connectors who work at the intersection of healthcare, data, and technology. They play a critical role in ensuring that health information is accurate, secure, and usable. KNH HMIS can be used for local and international comparisons to assess differences in healthcare and disease. HIMS danger zones are strained resources, expertise, and an exacerbated suboptimal technology with an archive of a hideously bleak health information culture. Health policymakers should understand that achieving specific health system goals can significantly improve overall societal well-being. The study concluded that HMIS is not merely automation but a means of augmentation and connection.

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