

Framework to Develop a Resilient and Sustainable Integrated Information System for Health Care Applications: A Review

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Abstract—The reconstruction of the health sector amidst the fourth industrial revolution has been confronted with many challenges. Many benefits have been attributed to the vital role played by technology in realizing and constructing a robust health information system. However, amidst the digitalization in the healthcare system, several challenges such as integration and fragmentation have been affecting the structure of the Health Information Systems (HIS) which subsequently influences decision making and resource allocation. Therefore, this paper through a comprehensive systematic review afford a proposition for a develop a resilient and sustainable information system for Health Care applications. The study reveals the parallel impact of health information technology application in the healthcare arena and highlight the need for more in-depth research on HIS that incorporate novel scientific methods. Additionally this study also presents a body of evident that reveal the inadequacies of the HIS to tackle the constant transformative changes presently confronting the global healthcare systems.

Keywords—Health information system; integrated information system; e-health; bioinformatics

I. INTRODUCTION

Over the last decades there have been remarkable advancements in medical informatics with the development of the health information systems (HIS) championing this course [1, 2]. This has benefited the continuous changing societies in the attainment of sustainable health care as well as efficient and effective information management. An increase in life expectancy and resource allocation are among some of the known attributes foster by this progress. The current HIS developmental path has been gearing toward a global information system to cater for a universal health coverage and civil registration and vital statistics [3]. However, despite the unique contribution of the HIS in shaping health care systems and applications, there are still many current challenges associated with the implementation of the HIS.

Theoretically, the HIS is commended as a system that plays an important role in the integration of different departments as well as support information flow [4]. Practically these systems are considered to be asymmetrical, resulting to distorted functions within the health care environment [3]. Highlighting the need for efficient development and strategic management of HIS. However, despite the strong influence exerted by Information and Communication Technology (ICT) in the realizations of the diverse health care goals [5]. Previous

research on information systems has been reported to be short of due diligence in tackling the global healthcare systems transformation [6]. Hence, the need for study that employ novel scientific approaches such as an integrated data science approach and machine learning techniques is indispensable and essential for development of a framework that enhance the current HIS, as well as providing practical findings to realigns the healthcare global transformation.

Over that last decades, information technology (IT) has presented several opportunities as well as equal challenges to many disciplines. In fact, within the healthcare arena, IT through the HISs has facilitated many benefits and transformations such as eHealth [6] and apt decision making that has attracted many nations to invest and assimilate these systems [2, 6, 7]. However, amidst this digitalization in the healthcare arena, there have been several challenges presented such as integration, data quality and the structure of the HIS [3, 6, 8, 9]. Authors also highlight the lack of concerns on the transformative changes in the Healthcare industries and the need for a strengthened HIS [3, 5-7]. Therefore, studies that tackles these problems are vital and necessary for the strengthening of a nations' HIS. This paper seeks to explore extant literature base on HIS to ascertain the knowledge, constraints and perceptions on Health Information Systems deliverables, and afford a proposition for resilient and sustainable HIS.

II. LITERATURE REVIEW

The contributions of an integrated information system in the healthcare arena have been alluded in literature with several authors attesting to the value creation it brings to the field [6, 8, 10-12]. According to English, Masilela, Barron and Schonfeldt [4] a robust integrated information system is pivotal to an efficacious healthcare delivery. Many attributes have been accorded to the successful deployment of HIS especially in the current times [5, 6, 8, 13]. However, there are many persistent challenges revolving around the technological and institutional scopes [2, 4-7, 13, 14].

Research on HIS is considered to be of great importance due to the role it plays in realizing the two urgent priorities of globally health; universal health coverage, and civil registration and vital statistics systems [3, 15, 16]. Similarly, HIS's research is also asserted to be pivotal in supporting the attainment of sustainable development goals by 2030 [1, 3, 5, 17]. However, despite this disposition, a large amount of

research done on HIS recurrently highlight major shortcomings in prior studies, in meeting the developmental and anticipated transformation confronting the complex healthcare system [3, 6, 7]. Ostern, Perscheid, Reelitz and Moormann [6], criticize HIS research for focusing on trifling agenda such as, investment and failing to assimilate healthcare industries transformative concerns. Literature further reveal the unsatisfactory trepidations from scholars on addressing potential long lasting changes in the healthcare industries [6, 7].

Critical review of literature highlights the need for well-prepared HIS research to exploit it potentially to tackle healthcare systematic problems thoroughly. In order to afford diverse solutions apt for the healthcare industries and its many actors such as the healthcare providers, government and technology companies [6]. Lluch [11], alluded the need for further research for HIS optimal development and cost effective applications. Scholars, further indicated the deficiency of adequate HIS [5, 8]. Najimudeen, Aldheleai and Ubaidullah [8] identified the impeded widespread use of HIS to be attributed to implementation challenges such as lack of; basic facilities, experts, medical personals e-readiness and technical complexities. Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12], categories these challenges as operational basing them on the experiences of the actors in the healthcare. These authors call for more research to strengthen the HIS [4, 5, 12].

Literature also revealed many HIS research to be qualitative lacking empirical finding and scientific rigour [3, 5, 6]. Despite the growing data and advancement of ICTs in the health sector, Authors purported that there is a distinct dearth of macro analysis that elucidate impact [18]. Suresh and Singh [18], argued that impact data for ICTs in health development remain a grand challenge.

Many studies also reveal the challenges faced by developing countries implementing HIS [8, 18]. While many advances have been attained by developed nation, Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12] reveal the tussle in developing countries where several barriers hinder the development of HIS which resultantly influences decision making due to the chaotic and fragmented state of HIS [18, 19]. These authors allude the need for developing countries to pay attention to the local needs, priority, environment, infrastructure and capacity to harness technological solutions.

Additional, many studies have been conducted in developed countries like Australia, USA and Europe and practical solutions and framework for HIS have developed, implemented and adopted [18]. Whereas in developing countries there is a deficit in studies and solutions on HIS phenomena [12, 18]. Some studies have suggested that developing countries harbor many barriers to HIS development such as inadequate resources, lack of data ownership and feedback [12, 18, 19].

III. METHODOLOGY

The important of HIS has been herald in literature with the challenges hindering it implementation and optimization. The demand for a better understanding of the phenomena confronting HIS development, utilization and optimization is paramount to the effectiveness of these systems in the places where they are deployed. Couple with the necessities of the global priorities and sustainable goals for a global healthcare system. The need to comprehensive review extensive literature is paramount and a needed step in the attainment of a sustainable and resilient HIS. This study being qualitative in nature and aiming to uncover insight on HIS utilizes a comprehensive systematic review [14, 20]; adopting an abductive approach that ensue a systematic content analysis procedure on extant literature and studies of HIS research [20-23].

Preceding the review, search engines are utilized to perform search on online databases and websites using the keywords to retrieve the needed data for this study. For the purpose of adequately responding to the study objective to uncover insight that aid HIS sustainability and resilient, articles containing keywords and references to "Health Information System" AND "HIS" are analysis painstaking. Identification of these articles was done through an exhaustive literature search on prominent journals and database feature studies on HIS. Table I outlines some of the journals, databases and Keywords used.

TABLE I. INFORMATION SOURCE FOR HIS JOURNAL

Information Sources	
Journals and Databases	Keywords
Web of Sciences	Health information system
Google Scholar	Integrated Information system
Elsevier	E- Health
ProQuest	Mobile health
Science Direct	
PubMed	
Embase	

IV. DISCUSSION AND RESULT

Literature reveal the urgent parallel need for global health information systems that afford valuable aid to effective decision making which is paramount in rendering effective healthcare applications [18, 24]. The review on health information system was conducted in line with prior methodology that explores extant literature extensively to ascertain current insight and knowledge of these systems.

A. ICT and HIS

Many facets of the HealthCare segment have been significantly impacted by ICT [18]. Making the value of an effective information system indispensable in today era. Literature attribute the difference between good and bad decision to be associated with the difference between life and death [18]. Authors posit the optimization of ICT capabilities in the healthcare arena can be realize via the fusion of primeval and novel technologies [18]. According to Suresh and Singh

[18], ICT serve as an irreplaceable mediator for community access to Healthcare and information. Highlighting the detrimental role of information in effective decision-making. Similarly, Najimudeen, Aldheleai and Ubaidullah [8], revere ICT mediation in facilitating access to medical care and information, branding its support within the healthcare sector as “healing at a distance”. However, despite the involvement of ICT in improving healthcare, several authors have advocated for the redesigning of ICT within the healthcare arena [14, 25].

B. Benefits of ICT in HealthCare Delivery

The appraisal of integrated information systems like HIS has always been center on the growing numbers of implementation. However, many studies have recounted that increase implementations and adoptions does not equate success. Literature, places emphases on improvement, efficiencies and effectiveness of outcomes and methods directly concerns with healthcare as a true definition of success [18]. Suresh and Singh [18] reports the important of health information that serve as vehicle to track health needs, guide health programs design and implementation and quality assessment. A similar study by Najimudeen, Aldheleai and Ubaidullah [8] enumerate on the value of HIS in health care delivery. According to Najimudeen, Aldheleai and Ubaidullah [8], HIS has afforded tremendous opportunities that includes the plunging of medical errors, advancing of healthcare admin efficiency and medical information management.

C. Challenges in Health Information Systems

Despite the advancement and development of the ICT applications in the health sectors there exist several challenges. Some authors have attributed these challenges to be foster by issues such as connectivity, ICT literacy and lack of technological convergence [14, 18, 24]. According to Fusheini and Eyles [24] the effectiveness and efficiency of healthcare delivery is significantly affected by these challenges. Contemporary studies highlight the lack of incorporation of stakeholder and technological design flaw to be contributing to these challenges[14, 25]. A study by Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12], categorizes these challenges in themes that included human resources, data issues and infrastructure among many others. The Table II summarizes these challenges identified in the diverse studies.

Funding has been identified in several studies to be a critical challenge influencing the implementation and strengthening of HIS. Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12], contend that the effectiveness and optimization of HIS is hinder and influence by financial deficiencies. Fusheini and Eyles [24] added to this claim revealing the lack of ample resources to afford funding. Many authors highlighted the need for the inclusion of financial needs associated with HIS in the annual plans [12, 26]. A similarly study by Bergum, Kusumasindra, Øren, Falch and Sahraoui [27] and Al-Nashy [28] support this assertion and emphasis on the need for a sustainable finance for HIS implementation. These authors indicate the vitality of stable and sufficient financial sources for HIS enactment. Implying the lack of acknowledgement and incorporation of funding for

HIS, results to shortage of finances needed to address financial related needs associated with HIS function and implementation as they arise.

TABLE II. EXTANT HIS CHALLENGES

Challenges	Cited Sources
Finance (Funding Sources)	Manoj et al. 2013; Al-Nashy 2015; Bergum et al. 2015; Fusheini and Eyles 2016; Dehnavieh et al. 2019.
Communication Infrastructure	Dehnavieh et al. 2019; Najimudeen, Aldheleai and Ubaidullah 2021.
Data (completeness, ownership and security)	Kiberu et al. 2014; Karuri et al. 2014; Suresh and Singh 2014; Dehnavieh et al. 2019; Farnham et al. 2020.
Political, cultural, social and structural infrastructure	Suresh and Singh 2014; Fusheini and Eyles 2016; Dehnavieh et al. 2019.
Workforce capacity	Manoj et al. 2013; Karuri et al. 2014; Kiwanuka, Kimaro and Senyoni 2015; Dehnavieh et al. 2019.
Top Management and leadership	Sheikh and Bakar 2011; Manya et al. 2012; Adalety, Poppe and Braa 2013; Manoj et al. 2013; Karuri et al. 2014; Manya and Nielsen 2015; Dehnavieh et al. 2019.
Lack of Training	Sheikh and Bakar 2011; Adalety, Poppe and Braa 2013; Manoj et al. 2013; Karuri et al. 2014; Al-Nashy 2015; Kiwanuka, Kimaro and Senyoni 2015; Manya and Nielsen 2015; Nguyen 2015; Dehnavieh et al. 2019.
Project Management	Sheikh and Bakar 2011; Manoj et al. 2013; Dehnavieh et al. 2019
Application selection criteria	Dehnavieh et al. 2019
Stakeholder coordination.	Dehnavieh et al. 2019; Grosjean, Bate and Mestre, 2020; Grosjean et al., 2022
Pre-deployment (Pilot System).	Sheikh and Bakar 2011; Manoj et al. 2013; Al-Nashy 2015; Dehnavieh et al. 2019

Communication Infrastructure which comprises of ICTs’ infrastructure for Internet, Mobile and Electricity’s infrastructure has been in the center of Healthcare sector. These infrastructures are vital to the efficient and effective functioning of operations in the healthcare arena. However, several studies have reported communication infrastructure to be inapt [8, 12]. Authors argue that the inadequacies of supporting infrastructure are among the challenges disclosed by stakeholders [8]. Several studies highlight the internet connection restriction in many countries to be problematic to the utilization of HIS in many areas [12].

Data management has influence several aspects in the health sector and many decision-making has been reliance on quality and analysis of data [29]. However, there is an information usage deprivation for decision making in the healthcare arena [12, 30]. Even though information and data usage has been encouraged and developed in many countries, it still remains an enormous problem. According to Karuri, Waiganjo, Daniel and Manya [19], data management has significantly influence health decision-making and funding allocation [12, 18, 19]; indicating data management to be a significant determinant in the optimization and implementation

for HIS. Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12] argue that all countries encounter data related problems with some experiencing data concerns more than the others.

Infrastructures are a formidable foundation in many HIS deployment. Literature reveals the challenges presented by infrastructures like political, cultural, social and structural to the implementation of HIS to be daunting. These infrastructures are considered to serve as a major challenge to HIS with many citations in literature [12, 24]. Hence, some authors recon they be ascertained forthright in relation to the HIS efficacy [12, 18]. Suresh and Singh [18] indicate their availability and adequacy to be paramount to HIS. Whilst, Dehnavieh, Haghdoost, Khosravi, Hoseinabadi, Rahimi, Poursheikhali, Khajehpour, Khajeh, Mirshekari and Hasani [12], further reveal several challenges such as political instability, linguistic, regional cooperation and technical-economic associated with these infrastructures that indirectly or directly influence HIS operation. Additionally, Fusheini and Eyles [24] reveal the adverse outcome of this constraint on healthcare delivery.

Workforce capacity are also among the principal challenges face by the HIS implementation and optimization. Many study reveal the efficacy of HIS to be reliance on the human competency and capacity of staff [19, 31]. However, many studies allude workforce shortage, incompetency, accuracy and motivation as dares confronting HIS efficacy [12, 19, 26].

Top Management and leadership has been herald in many information systems to be a dare that hinder the effectiveness and efficacies of these systems. Likewise, in the HIS, several top management and leadership functions have been reported to be vital in the operation of HIS. Among which are planning, participation, perception and support that are alleged to be inadequate [12, 26]. Authors highlight the need to win top management from all level that includes, national and provincial levels for HIS implementation [19, 26]. Similarly, Adalety, Poppe and Braa [32] and Many, Braa, Øverland, Titlestad, Mumo and Nzioka [33] cheer the attainment of these key stakeholders involvement in HIS deployment. Many other studies call for the restructuring of management role and early formation of team [12, 19, 34, 35].

Deficiency of Training has been professed in literature to significantly reduce the HIS optimization [12, 19, 26, 34, 35]. Many studies call for the need to provide training to stakeholders, highlighting their lack of skills and competencies to be attributed to the absence of adequate trainings [10, 12, 19, 26, 28, 31, 32]. Study done by Many and Nielsen [34] and [26], accentuate the need for training methods that include workshops and formal educational courses that incorporate biomedical informatics course.

Other challenges found in literature include project management, application selection criteria, stakeholder communication and coordination and pre-deployment (Pilot System) [12, 26, 35]. Their inadequacy serves as a major barrier to HIS implementation and efficacy.

V. CONCLUSION AND FUTURE RESEARCH

The importance of HIS and its capabilities in the delivery and deployment of quality healthcare application cannot be understated. As the call for an improve and universal healthcare advances, it is pertinent to explore and develop effective models to attain these objectives. Although many developing countries have already enacted technological solutions to enhance their healthcare section. The findings of this study show that there exists a strong body of evidence in literature that highlight the unfitnes of the HIS for the transformative changes confronting the globe today. Correspondingly, several studies reveal the need for a strong and hybrid HIS to eliminate some of the present challenges confronting the deployment of an integrated information system like the District HIS (DHIS).

Notwithstanding the commendable benefits of the HIS, the findings reveal there is a need and call for active engagements of countries to strengthening these systems in alignment with the global priorities. While many studies have been undertaken in regards to HIS, the plethora of challenges confronting its implementations and utilization seem to remain a grand huddle in the advancement of healthcare applications. Eleven of these challenges was reported in this study with seven most prominent discussed. The challenges reveal the inadequacies of the HIS to tackle the constant transformative changes presently confronting the global healthcare systems.

Additionally, the findings of this study highlights the necessity for further research on HIS deployment optimization that take into consideration their challenges and concerns. And also, provide valuable insight into HIS offerings and dares for decision maker and HIS stakeholders.

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