Guiding the Development of Interoperable Health Information Systems: A Conceptual IT Governance Framework

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Abstract. In the midst of dynamic healthcare needs, health information systems' lack of interoperability continues to hinder the health sector's ability to provide healthcare services. For instance, the recent COVID-19 epidemic has sparked discussion about the health department's ability to meet healthcare needs and the readiness of the National Health Insurance initiative in South Africa. Moreover, operating in resource-constrained circumstances presents a further obstacle and raises questions as to whether quality healthcare services can be delivered to patients. Following the Design Science Research Methodology (DSRM) process, this paper developed an IT governance conceptual framework, termed the HISIG-CF, to inform the interoperability of health information systems. The HISIG-CF was developed using literature and insights garnered from qualitative data using expert reviews from practitioners in the healthcare industry. The results indicated a need for more guidance to inform interoperability interventions and strengthen current health information systems through the use of well-defined IT Governance frameworks and mechanisms. Furthermore, the HISIG-CF was deemed adequate to improve health information systems interoperability within the healthcare sector in the North West, with prospects for usage across South Africa.

Keywords: IT governance · Health information systems · Interoperability · National Health Insurance · Design Science Research

1 Introduction

South Africa continues to experience poor health outcomes rooted in historic inequalities that continue to burden the current healthcare systems [1]. The World Health Organisation (WHO) notes that "at the center of this humanitarian crisis is a failure of health systems" [2]. Maintaining the current trajectory will create health systems lacking adaptability and continue to lessen the quality of healthcare and social value [3].

Health systems are a collection of organisations and people who contribute to providing and promoting healthcare to a large population [4]. Across different health systems, health information is stored with the purpose of [5]:

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- Collecting health data stored across health systems.
- Analysing health data to make more meaningful sense of its use.
- Reporting on analysis results to enhance the efficiency of health services.

Across South Africa, Health Information Systems (HIS) are largely "driven by donor-funded vertical programmes" that often operate as pilot projects that are not in alignment with the overall national health strategies set [1]. Furthermore, electronic health (eHealth) systems implementations are crippled by the lack of coordination at the highest level of government [6]. Where there is evidence of health systems, a considerable fraction are unable to share crucial information needed to effectively deliver health services [7]. The different systems are spread across different healthcare facilities, operating as silos. Subsequently resulting in the fragmentation of health information, which continues to hamper the potential realisation of health systems benefits [7, 8].

Central to the delivery of health services, is the exchange of health information stored as Electronic Health Records (EHR) [9]. EHRs provide the history of a patient's health records in a digital format, allowing access as required. This enables stakeholders to gain access to health data needed to effectively deliver much-needed healthcare.

Interoperability relates to how systems (or components thereof) communicate towards mutual goals through exchanging and sharing information [10]. Through interoperability, healthcare providers could form knowledge-sharing networks that contribute to the reduction of health information duplication [11]. Additionally, the value of interoperable health systems allows key decision-making stakeholders to gain access to information needed to strengthen the provision of quality healthcare services [11]. In South Africa, interoperability in healthcare forms part of a broader digital health ecosystem [9]. Considerable progress has been made in defining interoperability constructs and its implementation, however, interoperability is not yet at a stage of being fully enacted [11–13]. Where interoperability is present, only about 30% are able to exchange information [7]. Furthermore, a large fraction of the health systems do not adhere to standards set, at both a national and international level [7]. Without a standardized guide that can be implemented across the different systems, the lack of quality healthcare provision will remain a recurring challenge. Considering this, there is a need to explore approaches that can improve the current health systems across South Africa and how interoperability can be well-governed.

The National Department of Health (NDoH) has identified leadership, governance, and multi-sector engagement as one of the key enablers of a progressive health environment [14]. Furthermore, the "use of mechanisms, expertise, coordination and partnerships to implement the eHealth strategy and develop or adopt eHealth components (e.g. standards)" as a priority in implementing the eHealth strategy [7]. The health ministry has prioritised governance in the delivery of quality healthcare facilitated through well-functioning health systems, which calls for an improvement in governance efforts. Although governance has been acknowledged to be of great significance, its value within the health environment is yet to be realised [15]. IT Governance (ITG) still lags behind in making provisions for interoperability.

The lack of clear implementation measures to improve health systems further impedes South Africa's progress towards attaining Universal Health Coverage (UHC) through the National Health Insurance (NHI) program [14]. The NHI envisions an ideal

state of health provision to enable accessible, high-quality healthcare services, regardless of individuals' economic status [14]. However, if the focus is not on providing quality healthcare by strengthening local systems, UHC will produce unrealistic outcomes through the NHI.

In this paper, constructs of an ITG conceptual framework are proposed to aid in improving the governance of interoperable HISs. This is achieved by building on ITG mechanisms developed by van Grembergen, De Haes and Guldentops [16]. The development of the conceptual framework (HISIG-CF) follows the Design Science Research Methodology (DSRM). Furthermore, the paper provides the theoretical grounding, results and analysis, conclusion, and recommendation for similar further studies.

2 Conceptual Framework (viz. HISIG-CF)

In defining the constructs of the HISIG-CF, the design was created in accordance with three overarching themes, namely; ITG, HIS, and Interoperability. Within the ITG theme, the design focused on the ITG mechanisms and the sectoral nuances in effect. The HIS theme delves into the eHealth maturity levels and eHealth building blocks capable of enhancing health systems. Lastly, the Interoperability theme concentrates on the various layers of interoperability and adoptable standards. This section concludes with a synthesised design of the HISIG-CF artefact.

2.1 IT Governance Mechanisms

Health systems require significant IT investments to operate effectively. However, such investments will be in vain without well-defined ITG. ITG can be defined as "Enterprise governance of IT is an integral part of corporate governance, exercised by the Board, overseeing the definition and implementation of processes, structures and relational mechanism in the organisation" [17]. The application of ITG aims to assist organisations align their operations with their information technology.

It is essential to note that meaningful value can be achieved by establishing pragmatic approaches to implementation. According to Van Grembergen, Haes and Guldentops [16], the deployment of ITG is facilitated by a mix of structures, processes, and relational mechanisms. Selig [18] adds to this by stating that ITG mechanisms are introduced as the critical enablers in the implementation of ITG.

The central theme of the structure mechanism is on leadership with the intent of ensuring that clear channels of responsibility are defined from the onset. Further creating an enabling environment with a definition of who the key stakeholders are and their respective responsibilities [19]. This study draws from the COBIT 2019, RACI matrix which is a tool that can be used to define who is Responsible, Accountable, Consulted, and Informed (RACI) for executing ITG activities [20].

Creating an environment conducive to the implementation of ITG far extends defining the roles and responsibilities. It also entails setting the practices that may be followed to reach the desired end goal. In ITG, processes are viewed as arrangements of formalities involved in decision-making [21]. Additionally, the process mechanism guides the

design of the forms of monitoring that are essential during the rollout of an ITG programme. As part of the process mechanism, this study focused on employing adaptive frameworks, standards and monitoring tools include the: Information Technology Infrastructure Library (ITIL) which can be used for planning and the support of IT services; VAL IT, which is useful for identifying and defining connections between functions of an organisation and IT; as well as COBIT etc., [21]. An organisation's IT goals primarily drives the selection of appropriate frameworks, standards, or tools. For instance, an ITIL framework may be adopted if an organisation's IT goal is to standardise IT delivery because it offers the relevant tools. In addition to ITG standards, this study defines the implementation process using the Continual Improvement Life Cycle Approach as determined in COBIT 2019 [20]. The approach identifies three interconnected areas of development necessary to make ITG a reality namely, program management, change enablement and the continual improvement lifecycle.

Lastly, relational mechanisms can be identified as a significant cohesive tool that enables structures and processes to operate efficiently [21]. Through relational mechanisms, the emphasis moves from strictly technical aspects of ITG and towards the integration of socio-technical factors. According to Wu, et al., [19], a range of crucial factors is necessary to implement ITG. These include (but not limited to) the active involvement of senior or critical stakeholders in an organisation, the use of well-coordinated communication processes to promote ITG, and the establishment of a relational culture to foster collaboration.

2.2 Sectoral Differences

Organisations operate under different sectoral regulations that guide their activities. Misuraca and Viscusi [22] argue that the domain in which organisations exist places a requirement for specific governance implementation strategies. Therefore, to implement the correct ITG mechanisms, it is vital to understand the pre-existing norms in a given sector. The two main sectors in which organisations exist as addressed in this study include the private and public sectors [23, 24].

Private sector organisations are characterised by their ability to generate positive profit margins with the intent of delivering shareholder value. ITG is considered to the extent of its influence on profit projections [21, 23]. On the other hand, public sector organisations orientate their functions towards providing value for public and societal benefits [22]. At the forefront of public organisations are the social and political goals on which their decisions making occurs.

In South Africa, healthcare services are accessible through two broader and parallel systems namely, the private and public healthcare sectors [25]. The former accounts for a large proportion of resources used to deliver health services. Over 80% of the population is reliant on public healthcare, further straining an already frail health system [26]. Additionally, 60% of resources are directed towards the private sector, which is only accessible to approximately 20% of the population [13]. These disparities not only continue the cycle of unequal access to quality healthcare but also infringe on a fundamental human right that "everyone has the right to have access to healthcare services" [27].

2.3 eHealth Maturity Levels

What eHealth aims to achieve is to address healthcare challenges through ICT [28]. It is concerned with supporting health information delivery, using electronic methods, and improving how information flows across different systems [1, 13].

It is also crucial in the implementation of ITG to consider the eHealth systems' maturity levels. Embarking on a journey to change any health system requires a clear understanding of the state of functionality characterising each system. According to NDoH and CSIR [7], eHealth systems maturity levels assist in the decision-making processes to determine the best course of action:

- **Level 1: Local paper-based systems:** Define the lowest level of recording health information (e.g., patient information). In these types of health systems, medical records are manually stored, and information is only accessible in a local health facility.
- **Level 2: Local paper-based health systems with limited IT support:** At this level of maturity, health systems are predominately paper based however, IT features are used to store patient's demographical information used to uniquely match each medical records to each patient. Information mainly remains at a single health care facility.
- **Level 3: Centralised electronic health systems with both paper-based and electronic features:** In this instance, the use of a paper-based system would occur when a healthcare worker records a patient's health information and medical record in a patient's file. To maintain consistency, standardised forms are used to record patient's information. Furthermore, paper-based functions would also be used to record samples e.g., blood tests, sent to pathologies however, the results obtained would then be electronically recorded.
- **Level 4: Fully integrated national shared health system:** This level of eHealth maturity represents the desired, end goal for a fully electronic-based Electronic Health Records (EHR) system that enables health information exchange to occur. At this level of eHealth maturity, patient's health records are stored at the localised healthcare facility's EMR. The relevant aspects of a patient's health record are then stored onto a shared EHRs system, accessible across different networks.

2.4 eHealth Building Blocks

The strength of HIS is not only reliant on its technical attributes but draws from a range of contributing building blocks as depicted in Table 1 below. The building blocks can also be used as a measure of progress made to improve health systems currently in place [2, 9].

It is imperative to state that the leadership and governance layer is at the core of each of the identified building blocks for health systems. This is aimed at ensuring accountability across the various blocks. In the South African context, the National Department of Health (NDoH) has outlined leadership, governance and multi-sector engagement as one of the key components in creating an enabling environment for eHealth. The components further describe the "use of mechanisms, expertise, coordination and partnerships to implement the eHealth strategy and develop or adopt eHealth components

Table 1. Building blocks of health systems [2, 9]

Building block	Description
Health service delivery	Quality health services delivery is a vital component for health systems. Health systems need to deliver efficient and quality health services while doing so in a secure manner
Health workforce	A sound health system relies on human capital, skills and the knowledge set it possesses to deliver quality health services while efficiently utilizing the resources available
Health information systems	Reliable and timely information is the foundation required for decision making related to health systems. Useful HISs need to achieve the following: collect relevant health data, analyse information to ensure and maintain quality and reliability, then convert the data to information that can be used to make decisions
Access to essential medicines	Health systems must provide access to essential medication of quality, that is safe and cost-effective
Health financing	At the core of health financing is ensuring that health services can be received by any individual that requires health care. Additionally, health systems need to accumulate funds that can be used for the supply of health services
Leadership and governance	Strategic policy frameworks coupled with effective oversight, the building of partnerships, regulation, and accountability are essential for efficient health systems

(e.g. standards)" as a priority in implementing the eHealth strategy [7]. Although the significance of governance has been acknowledged, its value in the health environment is yet to be realised [29]. Therefore, improving governance in the healthcare environment is fundamental as it serves as the foundation for all the other building blocks.

2.5 Interoperability Layers

Adding to the complexity of interoperability, Amin et al., [30] notes that its facilitation is a multifaceted approach that focuses on organisational, technical, semantic or syntactical interoperability. Hardware requirements are examined at a technical and organisational level whereas software requirements are documented at a semantic and syntactical level [31]. Depending on the needs of the different healthcare facility and the maturity level at which the health system used is in, a decision can be made on the type of interoperability considered. Furthermore, different actors (doctors, healthcare providers, pharmacies) all participate in healthcare delivery and may require different sets of data relevant to their specific needs [32].

2.6 Standards of Interoperability

To guide the process of interoperability, standards play a critical role. Understanding what standards exist and how best to use them to identify effective approaches is critical to facilitating interoperability in the healthcare context. Standards define specifications that have been mutually agreed upon to achieve and maintain consistently [33]. In this study, constructs of the National Health Normative Standards Framework for Interoperability in eHealth in South Africa (HNSF), were utilised to provide a foundation for how to implements interoperability using a standards-based approach [7].

Furthermore, the specifications of a standard defined as Fast Healthcare Interoperability Resources (FHIR) is gaining prominence in healthcare [4]. FHIR has been developed to provide standards for exchanging healthcare information electronically. The standard offers an opportunity that may significantly contribute to industry and health research in the future. Figure 1 below provides a synthesized view of the constructs of the HISIG-CF.

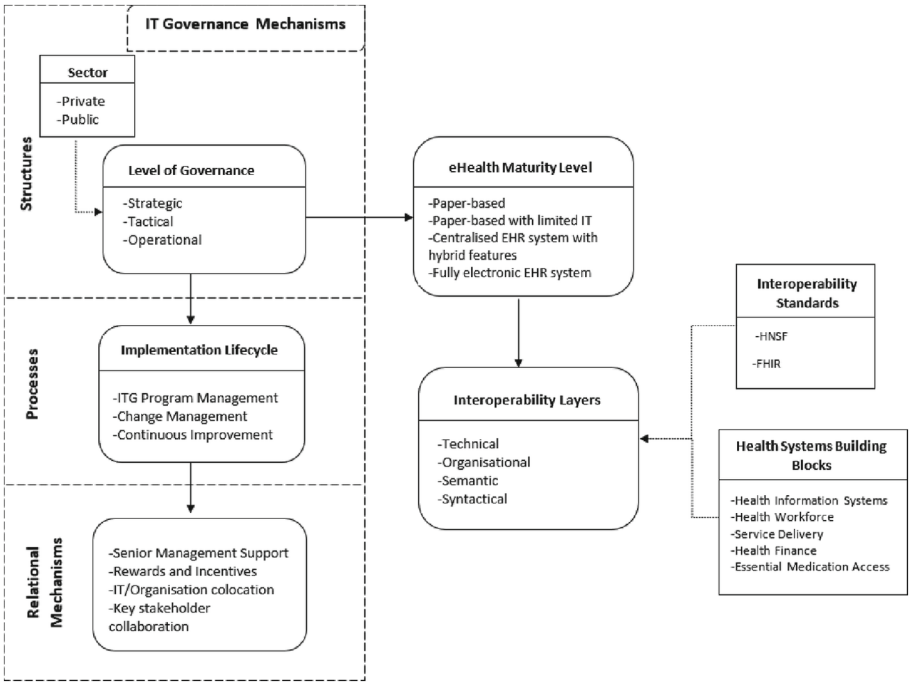

Fig. 1. The HISIG-CF

3 Theoretical Grounding

This study drew from the Institutional Theory and the DSRM process, grounded in DSR and related design theory. The Institutional Theory aided in defining the setting and

contextual influences present in the healthcare environment [34]. Through this, it was possible to establish the complexities associated with integrating an IS/IT-based solution (through the HISIG-CF) in context to the health environment.

The proposed HISIG-CF, as shown in Fig. 1, considers the goals set out by the National Department of Health to define the extent of interoperability interventions [14, 20].

In addition, this study followed the guidance of the DSRM (detailed in the next section) which aided the evaluation of the utility and efficacy of the conceptual framework. The use of the DSRM aimed to align the final artefact (HISIG-CF) with the main research question: What should constitute the components of a conceptual framework that outlines IT governance mechanisms to support the development of an interoperable health information system?

4 Research Methods

To guide the initial design of the HISIG-CF, the scoping review method was used to gain an understanding of prior literature in ITG, HISs and Interoperability in the health sector. The scoping review method guides the synthesis of knowledge through the systematic mapping of literature [35]. It provides an overview of the literature in a discipline across the broader research themes established [36]. The outcome of the scoping review process as well as insights obtained from expert reviewers were used to assess the constructs of the initial design. The results obtained from both sources subsequently informed the refinement of the final HISIG-CF.

The development of the conceptual framework, which could guide interoperability in South African health systems, is done following the guidance of the DSRM process, which entails the following activities [37]:

4.1 Problem Identification and Motivation

This activity defined the research problem to be solved through the development of the proposed conceptual framework. The research problem, "What should constitute the components of a conceptual framework that outlines IT governance mechanisms to support the development of an interoperable health information system?" informed the foundational basis of the initial HISIG-CF.

4.2 Define the Objective of the Solution

Considering the motivation of the research, as presented by the research problem, the main objective of this study was driven by the need to provide a solution through an IT governance conceptual framework that would enhance the knowledge of health information systems interoperability. The HISIG-CF serves as a blueprint to understand the areas of inquiry [38] and this study followed this notion to provide a solution that would be relevant for the healthcare environment.

4.3 Design and Development

The aim of this activity was to create the actual conceptual framework, as motivated by the research problem and overall objective. The process entailed the use of knowledge drawn from literature to form the constructs of the solution, to position this study in the broader research field of IT governance in the health environment.

4.4 Demonstration

This activity involved demonstrating the use of the solution that has been designed to establish the feasibility of practical implementation [39]. The demonstration process was guided by the qualitative methodological approach undertaken for this study through conducting a thorough literature review to define the constructs of the HISIG-CF design. The literature was analysed using Thematic Analysis to search for patterns across the data sets [40].

4.5 Evaluation

Saunders, Lewis and Thornhill [41] note that evaluations enable a researcher to judge the methods used based on accuracy and consistency. Importantly, it is also a valuable measure of determining the comprehensiveness of a solution designed. Through evaluations, the researcher was able to determine the extent to which the initial conceptual framework met its intended outcome in producing a novel solution to the management of healthcare information [42]. The outcome of the evaluation contributed to the process of refining the initial proposed HISIG-CF. Evaluating the rigour of the HISIG-CF required the contribution of expert reviewers.

4.6 Communication

The final stage of this process involves communicating the knowledge a study contributes and the overall importance of the solution as informed by disciplinary knowledge. Using assumptions associated with IS research development and the different phases that this research underwent, the HISIG-CF as presented in Fig. 1 was developed.

5 Results and Analysis

To evaluate the constructs of the HISIG-CF, expert reviews were used to gain insights. The experts consisted of five individuals in management positions that have either practical or academic experience with health systems. The selection of five expert reviewers was guided by Nielsen [43], who explains that the point of saturation can be met when evaluating an artefact or research beyond five individuals. For this reason, the expert reviewers selected for this study included five experts with senior management experience in the health environment and expertise in health systems.

In order to draw meaning from the results obtained, the hermeneutics was employed. Hermeneutics is rooted in the interpretive paradigm with the intent of understanding

various parts that contribute to the functions of a whole [1]. For purposes of this study, hermeneutics functioned as a valuable analysis approach that enabled the researcher to gain an in-depth understanding of the various actors and systems involved in the healthcare environment [44].

To assess the foundations upon which the HISIG-CF was defined, it was necessary to ascertain the holistic significance of the constructs used. This was done to demonstrate how the experts perceived the design of the conceptual framework. As a result, the experts were requested to respond by indicating (using a Likert scale of 1–5) which HISIG-CF construct they would consider significant for developing interoperable HISs. According to the feedback obtained, none of the experts disputed, disagreed, or was indifferent about any stated constructs.

To comprehend data was distributed among the participants, variance and mean were calculated for the sample population. Based on the results presented in Table 2 below, the variance is relatively low (i.e. 0.2). Variance is used to determine the average difference between the values in a data set [41]. Furthermore, the mean was calculated to determine the average results obtained from the data collected from the various experts. Considering the sample size used, the average mean was relatively high in terms of the agreeability between the respondents (i.e. 4.8). Both variance and mean results depict a positive outcome across the data set, which further validates the constructs that have been identified as being relevant for HIS interoperability intervention using ITG.

Table 2. Expert Review Results

	Sample size	Variance	Mean
Overall results per HISIG-CF construct	5	0.2	4.8

The results were analysed following the guidance of the Framework for Evaluating Design Science (FEDS) as a strategy for evaluation [42]. Furthermore, this study followed the criteria established by [4] to evaluate the utility of the HISIG-CF, which is founded on the belief that the usefulness of a DSR artefact should demonstrate: validity, utility, quality and efficacy.

On the grounds of utility, the results revealed that the HISIG-CF was necessary for the healthcare environment. Expressed by one of the experts, it was noted that the HISIG-CF "acknowledges the other challenges experienced, namely the varying levels of eHealth maturity, which is a major challenge when considering that also the key decision-makers in healthcare are exposed to and familiar with different levels of eHealth maturity." As such, the framework's utility goes as far as considering the contextual influences of the health environment, which could be an essential contributor towards further development.

To further evaluate the efficacy of the designed framework, the experts needed to determine whether the HISIG-CF would produce results for the healthcare environment. Another reviewer indicated that they could already identify aspects of the framework that could be used to provide direction and structure from the provincial departments of

health to the management of hospitals in the district. Thus, revealing the value of the implementing the framework within the healthcare environment.

The experts were requested to provide their views on the rigour of the conceptual framework and how it has been developed. All expert that took part expressed that the framework was rigorously done. One of the experts revealed that the linkage of the SRQs to the constructs and how these have been applied to the actual HISIG-CF demonstrates a logical outline of its use and further enabled the constructs to be critically synthesised.

The last aspect of evaluation related to the efficiency of the HISIG-CF. The experts were requested to provide their view of the efficiency of the conceptual framework and determine whether the constructs used were simplistic enough to understand in their current form. The consensus was that the HISIG-CF was simple to follow through and to make sense of. One of the experts expressed their opinion regarding the efficiency by stating that the order of the structures and the differentiation between structures, processes, and relational mechanisms provide a logic of sequence and causality. Thus, showing that the HISIG-CF presents potential value for the healthcare environment.

6 Conclusion

Society's changing health needs call for an improvement in HISs that can adapt to ensure that efficient health services are adequately provided. HISs operating across different health facilities with no ability to share the most crucial health information require solutions to improve operation. However, in seeking ways to improve and strengthen current operational health systems, a multi-faceted approach to development is required. In light of the National Health Insurance (NHI), which is currently being piloted across South Africa, and the need for overall improved healthcare through interoperable health systems, this study sought to develop an ITG conceptual framework that would assist in this regard.

Although well-defined policies are in place to guide health interventions, implementation is still lagging in South Africa. The novelty of this research was illustrated by drawing from IT governance, health information systems, and interoperability literature to develop the HISIG-CF. Experts evaluated the conceptual framework in the health environment and academia to assess and validate its constructs and the foundation on which the framework design occurred. The designed HISIG-CF is suitable for the health environment (health systems) to guide management on using ITG to drive HIS interoperability.

7 Recommendations and Future Research

The primary focus of interoperability should not be solely on defining implementation based on technical aspects, but rather on formalised provisions and understanding the contextual needs being solved. This could include integrating social factors into technical solutions. As a consequence, interventions in HIS interoperability will reduce the perception of strictly technical solutions being out of reach or too complex. This, when combined with health literacy, has the potential to lead to more effective solutions that people can maximise.

Although the findings in this study were primarily drawn from a South African context, the foundation and literature used to provide a comprehensive study drew from global studies. Furthermore, the HISIG-CF employed constructs that are applicable in a variety of healthcare settings. The HISIG-CF is yet to be empirically tested, but its design has been approved as fit for purpose by health professionals and health researchers.

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