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DATA INTEROPERABILITY OF HEALTH INFORMATION SYSTEMS IN PUBLIC HOSPITALS IN THE GAUTENG PROVINCE OF SOUTH AFRICA***Kabelo Given Chuma^{1*}, Mpho Ngoepe²**^{1,2}*Department of Information Science, College of Human Science, University of South Africa*E-mails: ^{1*}chumakg@unisa.ac.za; ²ngoepms@unisa.ac.za*Received 25 August 2025; accepted 8 November 2025; published 30 December 2025*

Abstract. The fragmentation of health systems remains one of the most persistent barriers to achieving integrated and coordinated healthcare delivery in South Africa. Many public hospitals continue to operate within silo-based systems, which hinder the delivery of comprehensive and efficient care. In this context, data interoperability emerges as a critical enabler for bridging these gaps. Despite the existence of national digital health strategies, there is a lack of frameworks to guide public hospitals in implementing interoperable systems. This study aimed to investigate the data interoperability of health information systems in public hospitals in the Gauteng Province of South Africa, with a view to proposing a framework that can serve as a reference for breaking down data silos and ensuring data sharing and collaboration between health facilities. A convergent mixed-methods design was employed, using questionnaires with 144 clinical and administrative staff and interviews with 16 managers, complemented by document analysis. Data were analysed thematically and descriptively. The findings revealed that existing national digital health strategies are perceived as inadequate due to weak infrastructure support, limited technical guidance, and insufficient stakeholder engagement. Participants recommended the inclusion of implementation roadmaps and timelines, regulatory compliance mechanisms, defined infrastructure requirements, and strong governance structures. The study proposes a framework to enhance cohesive, efficient, and patient-centred healthcare. The framework offers practical guidance for stakeholders and contributes to the theoretical advancement of data interoperability in developing countries. Achieving effective interoperability requires not only frameworks but also active stakeholder engagement, capacity building, sustained political commitment, and strategic infrastructure investments.

Keywords: data interoperability; data silos; health information systems; universal health coverage; digital health strategies; public sector hospitals

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JEL Classifications: H4

Additional disciplines: public administration

1. Introduction and background of the study

In today's fast-paced digital landscape, data interoperability has increasingly become the heart of digital transformation in the healthcare industry, enabling a connected ecosystem, improving access to clinical data, and streamlining healthcare service delivery. It serves as a fundamental requirement for delivering efficient, equitable,

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and patient-centred healthcare (Piera-Jiménez et al., 2024). Pantuvo and Oluwarore (2024) define data interoperability as the ability of diverse information systems, applications, and devices to access, integrate, and collaboratively share data securely, seamlessly, and effectively across organisational, regional, and national boundaries. Most importantly, data interoperability is considered a foundational prerequisite and enabler of universal health coverage (UHC) through ensuring that healthcare services are delivered in a coordinated and resource-efficient manner. Chukwu and Obande-Ogbuinya (2025) recognise data interoperability as a cornerstone of a sustainable health system, essential for advancing UHC by ensuring equitable access to quality care services and enabling real-time or near-real-time data exchange across multiple healthcare settings. However, in the absence of interoperable systems, it becomes difficult for healthcare facilities and hospitals to provide consistent, coordinated care, particularly within fragmented health systems commonly found in developing countries.

Mamuye et al. (2022) stress that more African countries are excited about data interoperability, especially since their healthcare systems struggle with many infectious and chronic diseases, big differences in resources, and limited technology. As a consequence, African countries such as Kenya, Zimbabwe, Nigeria, and Uganda have made major strides towards adopting digital health interventions; however, these efforts often remain fragmented and poorly aligned with national policy frameworks, limiting their overall impact. According to Rikhotso et al. (2024), a major contributing factor to this failure is the continued reliance on outdated legacy systems, which are neither integrated nor capable of communicating with one another or consolidating patient health data across multiple platforms and care facilities. This situation has led to an uncoordinated and fragmented health landscape, where patient data remains siloed within isolated systems, resulting in delayed and compromised clinical care, increased operational costs, and poor healthcare outcomes across health facilities in Africa (Li et al., 2022).

Although numerous continental initiatives have advocated digital health and promoted the homogenisation of data interoperability, such as the Digital Transformation Strategy for Africa, the Africa Digital Health Networks, and the World Health Organization, only a few African countries have developed frameworks which can provide a clear guideline for the integration of health information systems across the public health sector. In South Africa, as in many other African countries, the situation reflects many of these challenges but also presents unique opportunities. Chuma and Ngoepe (2024) advocate the view that the country has consistently demonstrated its commitment to digital transformation through national frameworks such as the National Digital Health Strategy for South Africa (2019–2024), National Health Insurance, and National eHealth Strategy (2012–2016), all of which advocate and mandate the integration of data interoperability within healthcare information systems to improve overall healthcare and patient outcomes. However, in practice, the South African healthcare sector remains highly fragmented, segmented, and characterised by data silos and heterogeneous health systems. As Wright et al. (2017), as well as Abbott and Sigamoney (2024), would attest, public sector hospitals in South Africa frequently operate with Electronic Health Record systems (EHRs) that are vertically and horizontally fragmented, characterised by misaligned incentives and inadequate interoperability.

This national challenge is also evident in the Gauteng province, where many public hospitals and primary health care (PHC) clinics are constrained by siloed operations and fragmented data systems across departments. Bosire et al. (2020), along with Roper (2025), contend that regional and district hospitals and clinics throughout Johannesburg and Tshwane often operate independently with incompatible systems, resulting in disjointed care and significant barriers to delivering holistic, patient-centred treatment. As a result, this persistent siloisation within public hospital systems often results in disjointed care, ultimately compromising patient safety and health outcomes. Similarly, Rispel (2016) substantiates that fragmentation across South African hospitals and other healthcare facilities undermines efforts to deliver coordinated, multidisciplinary care while hindering improved clinical workflows and effective decision-making. Building on this concern, Tsegaye and Flowerday (2021) argue that the situation is further exacerbated by the absence of standardised national frameworks and models that offer clear and robust guidelines on how hospitals and clinics in South Africa can implement data interoperability to enhance care coordination and support the global health goals of the UHC initiative.

The South African government has enacted the *National Digital Health Strategy for South Africa (2019–2024)*, the *National Health Insurance (NHI)* policy, and the National eHealth Strategy (2012–2016), all of which are still applied in public hospitals. However, these national frameworks, while recognising the importance of data interoperability in healthcare, fall short of providing operational and technical guidelines to direct hospitals and stakeholders on how to achieve and sustain data interoperability across the health system. Therefore, the lack of a framework exposes a wider gap in the governance of digital health in South Africa. Addressing this gap is vital not only for improving healthcare delivery in the Gauteng Province but also for developing scalable and policy-aligned solutions that can be applied to other provinces across the country and the continent at large. Accordingly, this study seeks to investigate the interoperability of health information systems in public hospitals in the Gauteng Province of South Africa, with a view to proposing a framework that can be used as a reference to break down data silos and ensure data sharing and collaboration between health facilities.

Despite existing national interoperability frameworks in South Africa, which are particularly focused on broad policy directives, this study places itself at the operational level, tackling practical realities of data sharing among public hospitals in Gauteng Province. The province demonstrates a unique testing ground where advanced technical infrastructure coexists with attempts for data interoperability failures. By focusing on this context, the study provides valuable insights that are not only scalable in South Africa but also transferable to African countries facing similar challenges of fragmentation, resource disparities, and legacy systems.

2. Problem statement

While the South African government has invested in healthcare systems, evidence suggests that the public healthcare sector remains burdened by numerous challenges, including impediments to data sharing, system fragmentation, and information blocking—factors that collectively lead to inefficiencies in care delivery. The core issue lies in the fact that public hospitals in South Africa operate within siloed, vertically and horizontally fragmented systems, compounded by misaligned incentives and ineffective interoperability. For example, Ngoepe and Marutha (2020) highlight that the lack of integration in healthcare systems often results in a new file being created each time a patient visits a different hospital. This situation occurs even within a single province and is exacerbated when patients seek care across provincial boundaries. Such practices point to a fragmented healthcare system characterised by overlapping and duplicate records. It is therefore necessary to undertake a study using the Gauteng Province as a case study, with the aim of proposing a framework that can serve as a reference for breaking down data silos and facilitating data sharing and collaboration between health facilities. Gauteng is selected due to its status as the economic hub of the country and its relatively advanced healthcare infrastructure.

It is anticipated that the proposed framework will support the development of a cohesive, efficient, and patient-centred health environment, align with national digital health strategies, and contribute towards the establishment of a robust digital health ecosystem that can be scaled across South Africa. Despite the fact that existing interoperability frameworks used in African countries such as eHealth interoperability framework, National Health Normative Standards Framework, e-government interoperability framework, AU interoperability framework and African Union’s Digital ID framework have advanced the policy discourse, they remain short in providing infrastructural, technical and operational guidance to public sector hospitals. This study is distinct in proposing a framework that incorporates interrelated dimensions designed specifically for public hospitals, including hospital integrated networks, regulatory compliance, data security, interoperability services, action cycles, and enabling factors. This positioning addresses the critical implementation gap between national interoperability frameworks and operational requirements of health information systems.

3. Purpose and objectives of the study

The purpose of this study was to investigate the data interoperability of health information systems in public hospitals in the Gauteng Province of South Africa, with a view to proposing a framework that can serve as a reference for breaking down data silos and promoting data sharing and collaboration between health facilities. The specific objectives were to:

- Analyse health policies and strategies in supporting data interoperability in public hospitals in South Africa
- Propose a framework for incorporating data interoperability of health information systems in public hospitals in South Africa

4. Review of related literature on interoperability frameworks

The increasing complexity of healthcare systems and the growing diversity of patient care, particularly in developing countries such as Uganda, Nigeria, and South Africa, underscore the urgent need for data interoperability in health information systems. Saini, Reddy, Kumar, and Ahmad (2021) define data interoperability as the ability of different health information systems, applications, and technologies to exchange, interpret, and use patient data seamlessly across hospitals, clinics, and other care settings. In response to these challenges, Ndlovu, Mars, and Scott (2021) emphasise that healthcare facilities in resource-constrained environments such as South Africa must establish harmonised legal, policy, and technical frameworks that provide clear guidance for implementing interoperability across diverse systems, including cross-border networks. This literature review explores existing interoperability frameworks both globally and locally, assesses their relevance, and identifies the gaps that informed the development of a proposed framework for public hospitals in Gauteng Province.

4.1 Global and regional national frameworks for interoperability in healthcare

In the global context, many different countries have made significant efforts to establish and adopt frameworks to support the integration of interoperability in healthcare. According to Simms, Prakash and Garg (2025), the United Kingdom established the NHS Interoperability Toolkit (ITK) as the primary framework to support the integration of data interoperability in the healthcare landscape. The framework aims to address challenges arising from competing and incompatible solutions by providing technical specifications and recommended technologies. In contrast, Canada has implemented the Pan-Canadian Health Data Content Framework, incorporating Fast Healthcare Interoperability Resources (FHIR), to serve as a roadmap for achieving interoperability across hospital systems (El Sabawy et al., 2024). Similarly, Kouroubali and Katehakis (2022) underscore that countries in the European Union such as Belgium, Germany, Spain, and the Netherlands adhere to the European Interoperability Framework (EIF), which offers structured guidelines for achieving interoperability within the public sector. While existing interoperability frameworks in developed countries provide valuable insights, they do not provide a comprehensive and contextualised approach to the unique challenges of interoperability faced by low- and middle-income countries (LMICs). On the other hand, many LMICs, such as Angola, Rwanda, Nigeria, and Tanzania, have made progress towards implementing frameworks and models to integrate data interoperability in healthcare. According to Adeniji et al. (2022); Pantuvo and Oluwarore (2024); and Adegoke et al. (2025), the most commonly used interoperability frameworks in these countries include the African Union (AU) Interoperability Framework, Government Interoperability Frameworks (GIFs), the Reference Model for Open Distributed Processing (RM-ODP), the Health Information Systems Architecture (HISA) Framework, the National Digital Health Architectural Framework, the eHealth Interoperability Framework, Open Health Information Exchange (OpenHIE), and Open Group Architecture Framework (TOGAF). In these frameworks, there are many clear gaps, such as the lack of specific technical guidelines for healthcare workers like administrators, health IT staff, and records managers on how to practically implement interoperability among

health information systems in their institutions. The frameworks concentrated solely on policy principles, technical standards and protocols, as well as interoperability goals, without providing actionable implementation roadmaps or operational procedures. The South African government has established several national frameworks to promote digital data interoperability in healthcare facilities, including the National eHealth Strategy (2012–2016), the Health Normative Standards Framework (HNSF), the National Digital Health Strategy (2019–2024), and the National Health Insurance (NHI) model. While these frameworks set high goals for interoperability, they mainly lack clear instructions, standardised methods for putting them into practice, and thorough plans to help healthcare facilities, hospitals, and primary healthcare clinics maintain interoperability. Chuma and Ngoepe (2024) stress that existing national frameworks in South Africa fail to incorporate localised operational contexts, including the disparity in infrastructure between hospitals and the variation in digital literacy among healthcare workers, as well as differences in procurement cycles. Nonetheless, these gaps limit the sustainable integration of interoperability between health information systems in health facilities in South Africa.

4.2 Comparative analysis of interoperability frameworks and models proposed by scholars in Africa and South Africa

This section presents a comparative analysis of data interoperability frameworks and models proposed in South Africa and other African countries. Beyond the national framework established by the South African government, numerous academic scholars both within the healthcare domain and from other disciplines have proposed a range of frameworks and models aimed at advancing interoperability in the healthcare sector as well as in other areas of public service. Table 1 illustrates a comparative analysis of the literature on proposed frameworks for interoperability in healthcare.

Table 1. A comparative analysis of the existing literature frameworks and models for interoperability in healthcare

Author	Year	A	B	C	D	E	F	G	H	I	Features
Rikhotso, Kalema & Seaba (2024)	2024	✓	✓	✓	x	x	x	x	x	x	Model for Data Interoperability Assessment Model for Health Information System
Tsegaye & Flowerday (2021)	2021	✓	✓	✓	✓	x	x	✓	x	x	System architecture for interoperability in a South African national electronic health record system
Kotze and Alberts (2017)	2017	✓	✓	✓	x	x	x	x	x	x	Conceptual Model for an e-Government Interoperability Framework for South Africa
Adelusi, Osamika, Kelvin-Agwu et al. (2025)	2025	✓	✓	x	✓	x	✓	✓	x	✓	Federated interoperability framework for seamless health data exchange using FHIR standards
Oluwaseyi, Adebola, Nzechukwu et al. (2019)	2019	✓	✓	x	x	x	x	x	✓	x	Framework for Health information exchange and Integration for Nigerian Healthcare System
Ndlovu, Mars & Scott (2021)	2021	✓	✓	x	✓	x	x	x	x	x	Framework for eRecord systems Interoperability Framework in Botswana
Thela, Zlotnikova, Galani et al. (2025)	2025	✓	x	x	x	x	x	✓	x	x	Service-Oriented Interoperability Framework: The Botswana E-Government System Case Study
Matshaba, Nxosi, & Herselman (2023)	2021	✓	✓	✓	x	x	x	✓	x	✓	A Conceptual IT Governance Framework for Interoperable Health Information Systems
Angula & Dlodlo (2018)	2018	✓	✓	x	✓	x	x	✓	x	x	A framework for semantic interoperability of data in heterogeneous health information systems in Namibian public hospitals
Abima, Nakakawa & Kityui (2023)	2023	✓	✓	x	x	✓	x	x	x	x	Service-oriented framework for developing interoperable e-health systems in a low-income country

Note. A=interoperability, B=healthcare focus, C= South Africa, D=regulatory compliance with legislation and data standards, E= implementation guidelines, F= monitoring and evaluation, G=data privacy and security provision, H= infrastructure requirements, I= stakeholder engagement

This literature review demonstrates that, although global and national frameworks, as well as those proposed by academic scholars, offer valuable reference points, they often fall short in terms of contextual adaptability and practical implementation within public hospitals. Notable gaps, such as regulatory compliance, implementation guidelines, infrastructure readiness, data security, and stakeholder engagement, underscore the need for a framework that supports data interoperability within the unique context of the South African public healthcare system.

3. Methodology

This study was conducted at six anonymised public hospitals located in the Gauteng Province of South Africa. In line with the ethical approval by the Tshwane Research Ethics Committee, the hospitals were not identified by name to ensure institutional confidentiality and mitigate reputational risks. Instead, they were described by their type (tertiary or district) to provide contextual detail while upholding ethical requirements. These public hospitals were selected because they serve the majority of the South African population and are the primary sites for implementing national digital health strategies such as the NHI and the National Digital Health Strategy. Gauteng Province was also chosen as it is the economic hub of South Africa, with the largest concentration of tertiary and district hospitals, as well as relatively advanced health infrastructure. Despite this advantage, Gauteng still experiences significant interoperability failures, making it a suitable case for identifying both systemic challenges and scalable solutions. The insights gained here are not intended to exclude other provinces or the private sector, but to provide a replicable framework that can later be adapted and validated in other contexts. A convergent mixed-methods design was adopted, enabling a more comprehensive understanding of the challenges related to data interoperability in public hospitals. Unlike previous studies conducted on data interoperability in Africa which applied either qualitative or quantitative, this study is distinct by integrating questionnaires, interviews and document analysis. This strengthened the methodological rigor of this study through qualitative depth and quantitative breadth. A multi-level sampling technique was employed to select 144 respondents, including administrative, clinical, and IT support staff—for the quantitative phase of the study, which aimed to assess their knowledge of frameworks for integrating data interoperability. In contrast, 16 participants, comprising administrative, clinical, IT, and records managers, were purposively selected for the qualitative phase. The total sample size for this study was 160, as illustrated in Table 2. This sampling technique facilitated the inclusion of diverse perspectives by ensuring representation across various organisational strata.

Table 2 Distribution of the target population (n=160)

Clinical and Administrative staff	No. of sample surveyed	Management staff	Codes	No. of sample interviewed
Doctors	20	Clinical managers	CM	2
Nurses	17	Records managers	RM	3
Administrative clerks	23	IT managers	ITM	5
Network controllers	16	Administrative managers	AM	6
IT technicians	21			
Revenue clerks	12			
Registry clerks	16			
Ward clerks	8			
Data capturers	11			
Total	144	Total		16

Source: the authors

The quantitative data for this study were collected through an online questionnaire generated on Microsoft Forms. A questionnaire was distributed electronically via email and WhatsApp from 01 September to 30 November 2022. A request was made to the relevant managers from the ICT, records, and administrative departments to assist in gathering contact information, in particular the e-mail addresses and mobile numbers of relevant employees. In this manner, the researchers were able to compile a contact list and distribute the questionnaire link to selected

participants via email and WhatsApp. To achieve a higher response rate, key informants were encouraged to share the link with their colleagues. In contrast, semi-structured interviews were used to collect qualitative data. Interviews were conducted in the English language, and each lasted between 20 and 30 minutes. The interviews were conducted in person and via Microsoft Teams and were both audio and digitally recorded to ensure comprehensive data capture.

The recordings were transcribed verbatim to maintain accuracy and fidelity to participants' responses. Furthermore, field notes were taken throughout the data collection process to provide contextual insights and enhance the depth of the analysis. Document analysis was also conducted to review the National eHealth Strategy (2012–2016), the Health Normative Standards Framework (HNSF), the National Digital Health Strategy (2019–2024), and the National Health Insurance (NHI) policy to examine how these national frameworks support and promote the integration of data interoperability in public hospitals.

Descriptive statistics were generated using the Statistical Package for the Social Sciences (SPSS), version 27, to compute counts, frequencies, and percentages for quantitative data. For the qualitative data, a thematic analysis was conducted using ATLAS.ti software, version 9.0, to systematically identify, analyse, and interpret emerging themes. Transcripts were carefully reviewed, and recurring patterns were grouped into broader thematic categories. In the interpretation phase, we combined the numbers and the descriptive findings to see where they matched or differed by looking at the patterns from both sets of data, which helped us better understand how to integrate data interoperability.

To ensure validity, reliability and rigour, the questionnaire was reviewed by clinical and IT managers, and their feedback was used to rephrase and refine the questions for clarity and relevance. A pilot study involving 30 respondents was conducted to test the feasibility and comprehensibility of the questionnaire, ensuring that participants could respond to the questions effectively. Data for the feasibility study were not included in the final analysis. The trustworthiness of the qualitative analysis was enhanced through the triangulation of survey data, field notes, and document analysis to validate the findings. All data were anonymised during the analysis to maintain confidentiality and uphold ethical standards. To enhance the credibility of the findings, qualitative data were converged with corresponding quantitative data, facilitating cross-validation and a more nuanced interpretation of the results. The findings from interviews, questionnaires and document analysis were systematically triangulated to strengthen analytical depth. As a result, the quantitative data offered insight into the scale of the challenges, whereas the qualitative revealed the underlying cause and document analysis provided evidence on policy gaps. During this integration, the findings moved from description to interpretation, ensuring that the convergent design was systematically applied.

Ethical approval was granted from the University in South Africa. Furthermore, permission to collect data from hospital facilities was granted by Tshwane Research Ethics Committee (Ref: GP_202207_097). Informed consent was obtained verbally and in writing, and all participants selected "Yes, I agree to participate" prior to beginning the interviews and surveys. As part of the interview phase, verbal consent was audio-recorded prior to each interview in order to ensure that there was compliance with ethical standards. Participants were clearly informed that their involvement was voluntary and that they could withdraw from the study at any time without penalty. No incentives were provided for participation.

5. Results and discussions

This section presents the findings of this study in figures, tables, verbatim quotes, as well as narration.

5.1 Health policies and strategies in supporting data interoperability in public hospitals

Respondents were asked in the questionnaire to indicate whether current national digital health policies and strategies (e.g., NHI, eHealth Strategy, Digital Health Strategy) are effective in supporting the implementation of data interoperability within health information systems at the hospital level. The majority of respondents, 57% (82), indicated that national digital health policies and strategies are not effective in supporting the implementation and adoption of data interoperability in their hospitals. In contrast, 26% (38) believed these policies and strategies are effective, while 17% (24) were unsure. Figure 1 illustrates these findings.

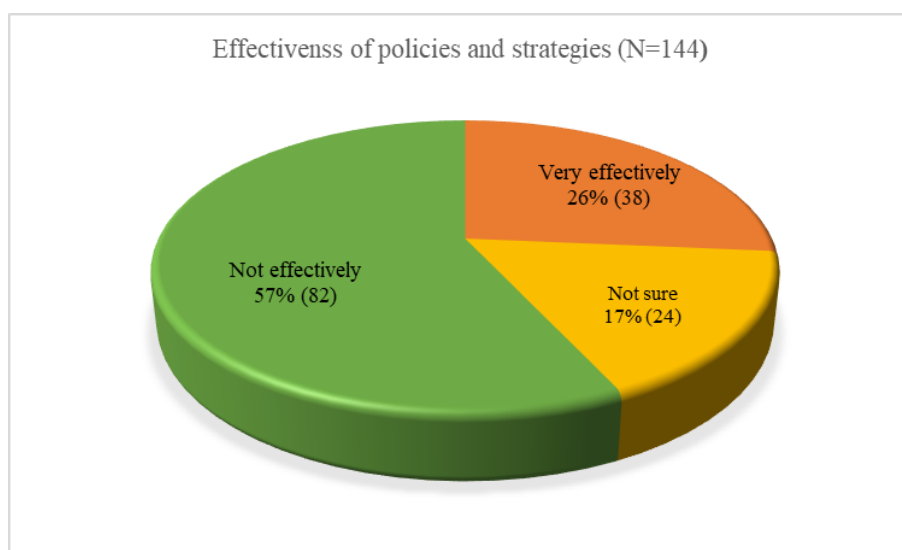


Figure 1. Effectiveness of digital national health policies and strategies for supporting data interoperability (N=144)

To complement the quantitative findings, interview participants were asked the same question. Most participants expressed their views that current national digital policies and strategies are ineffective, as evidenced by the following expertts:

“From experience working in the hospital, the national health policies and digital strategies that we have in South Africa are too broad and they lack clear and actionable guidelines as how hospitals and stakeholders can go about to implement interoperable health systems that communicate with each other and share data seamlessly. Without clear guidelines its actually difficult to make progress on interoperability in healthcare” (ITM-2).

“I think the national digital health strategies that have been put in place are not effective in terms of supporting data interoperability because there is a serious disconnection between these strategies and what is happening on the ground. This lack of alignment is what makes our hospitals left to figure things on their own. I don’t think we will achieve the highest level of data interoperability soon in South Africa” (CM-2)

“I don’t think our national strategies and policies are effective because they don’t provide practical steps and procedures that need to be followed to achieve interoperability across hospitals at various levels. We frequently receive high level documents from Department of Health every year, but they lack a clear framework to guide us through the technical aspects of attaining data interoperability in hospitals” (RM-1)

“Our national digital health strategies are not effective because there is no consistent national direction. Each public hospital is left to interpret the strategies on their own, leading to fragmented efforts. Without centralized leadership and standardization, data interoperability in South African healthcare is nearly impossible” (ITM-4)

Findings from both the quantitative and qualitative components of this mixed-methods study reveal a shared perception that current national digital health policies and strategies are largely ineffective in supporting data interoperability at the hospital level. Survey results indicated that 57% of respondents viewed national policies and strategies as ineffective. This sentiment was echoed in the qualitative interviews, where participants similarly described existing frameworks as inadequate for facilitating effective data interoperability. While the quantitative data quantify the extent of dissatisfaction, the qualitative findings provide deeper context and underscore the need for more pragmatic, clearly defined, and collaboratively developed policy frameworks to support interoperability within the South African public health sector.

5.2 Gaps/Limitations in the current national digital health policies and strategies to support data interoperability

Respondents were asked to identify the gaps or limitations they perceive in current national digital health policies and strategies in supporting data interoperability in public hospitals. An overwhelming majority of respondents, 92% (132), indicated that these policies and strategies do not specify the infrastructure and IT capacity necessary for the successful implementation of data interoperability. In contrast, 78% (112) highlighted the absence of clear, actionable directions and technical guidelines; 68% (98) indicated a limited prioritisation of stakeholder engagement; and 23% (33) noted poor alignment between national and hospital-level strategies. A minority of respondents, 19% (28), mentioned a lack of monitoring and evaluation mechanisms in existing national policies and strategies. Figure 2 illustrates these findings.

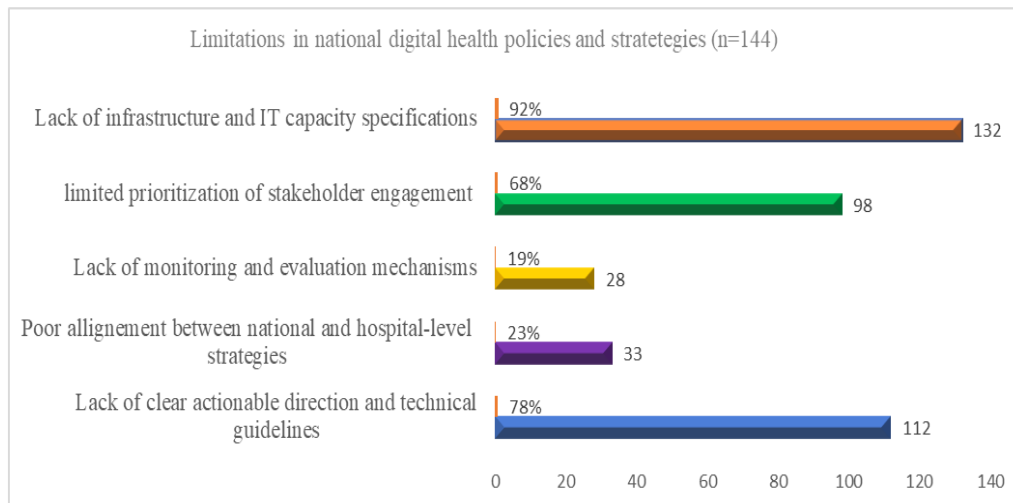


Figure 2. Gaps/limitations in current national digital health policies and strategies (N=144)

In the qualitative phase, participants were asked a similar question. Most of the participants expressed the following views:

“I think one of the major gaps in our frameworks and strategies is the absence of clear technical guidelines. The policies that we have outline the goals of data interoperability, but they don't specify the technical steps and procedures we should follow, which leaves too much room for inconsistent implementation of interoperability in our hospitals” (AM-3)

“The most noticeable gaps in our national policies and strategies for digital health is that they rarely mention the digital infrastructure and technical resources need for supporting the implementation of data interoperability between systems. Technical things like secure servers, software, reliable internet connectivity, and system integration tools are essential, but they are not adequately addressed in the national policy and strategy documents” (ITM-3).

“The current policies and strategies we have in South Africa they lack clear direction on how to comply with existing legislation, regulations and health data standards. This creates uncertainty around legal risks, especially when exchanging patient data across platforms” (AM-6)

“One of the greatest limitations is that our digital health strategies and policies are too high-level and don’t provide enough operational detail. We need clearer implementation frameworks that outline both infrastructure requirements and compliance checkpoints” (RM-2)

The document analysis conducted to review digital health strategies and policies in hospitals revealed several critical gaps, including a lack of emphasis on stakeholder engagement, inadequate specification of the infrastructure required for interoperability, limited attention to legislative compliance, and the absence of clear roadmaps for achieving interoperability. Both survey respondents and interview participants identified the absence of clearly defined infrastructure requirements, insufficient technical guidance, and limited stakeholder engagement as major shortcomings in existing digital health strategies and policies. The qualitative data added further depth, revealing that current frameworks are often overly high-level, lacking practical implementation steps, legal specificity, and alignment with the operational realities of hospitals. The document analysis corroborated these findings, highlighting minimal attention to implementation frameworks, infrastructure requirements, and compliance with established standards. Collectively, these insights underscore a significant disconnect between policy intent and operational execution, which ultimately hinders the sustainable implementation of data interoperability in the public health sector.

5.3 Core elements to be included in national digital health policies and frameworks to ensure effective data interoperability in public hospitals

Respondents were asked, through the questionnaire, to identify the key components that should be incorporated into national digital health policies and frameworks to ensure the sustainable implementation of data interoperability among public hospitals. As presented in Table 3, the majority, 83% (120), indicated that these policies and frameworks should include clear implementation roadmaps, guidelines, and timelines. Furthermore, 78% (112) emphasised the importance of incorporating best practices in stakeholder engagement, while 66% (95) pointed to the need for specifying the digital infrastructure and technical resources required. Additionally, 29% (42) of respondents highlighted the need for alignment with regulatory compliance, including relevant legislation and standards, whereas a minority, 22% (32), underscored the importance of strong data governance and security measures.

Table 3 Elements to be incorporated in national digital health policies and strategies (N=144)

Responses	Frequency (N)	Percentage (%)
Strong data governance and security measures	32	22%
Clear implementation roadmaps and timelines	120	83%
Digital infrastructure and technical resources required	95	66%
Regulatory compliance with legislation and standards	42	29%
Good practice in stakeholder engagement	112	78%

Source: the authors

In the interviews, participants responded as follows:

“Our national digital health strategies and policies need to prioritise targeted investment in digital infrastructure and related technical and human resources. They should explicitly outline the specific infrastructure requirements for hospitals to support the sustainable implementation of data interoperability between different health systems” (ITM-1).

“Stakeholder engagement is often neglected and overlooked in most frameworks. I believe that our national policies and frameworks for digital health should be revised to place greater emphasis on involving key stakeholders throughout the process, as their input is essential for the effective implementation of interoperable health systems” (RM-3).

“I think our national digital health strategies should provide clear, practical guidelines and detailed roadmaps for achieving system interoperability. Hospitals and relevant stakeholders need to understand both the legal and technical expectations to implement this technology effectively and confidently.”(AM-4)

The findings demonstrate strong alignment between the quantitative and qualitative data regarding the essential components required in national digital health policies to support sustainable data interoperability in public hospitals. The interviews echoed these priorities, with participants calling for practical guidance, targeted investments in infrastructure and resources, and meaningful involvement of key stakeholders throughout the policy development process. While these views were prevalent in the survey responses, the qualitative insights offered richer context, highlighting operational challenges and underscoring the need for a more practical and actionable framework to inform policy formulation. Despite descriptive frequencies revealed the magnitude of challenges, for instance 92% (132) of respondents indicated inadequate infrastructure and IT capacity whereas 83% (120) emphasised the establishment of clear implementation roadmaps, the qualitative findings provided significant insights, revealing that infrastructure was understood by participants as a reliable internet and integration tool, while roadmaps as step-by-step processes and timelines. In contrast, document analysis further confirmed that these elements are either absent in current strategies. These triangulated insights provide a more analytical understanding of why existing national digital health policies remain ineffective in practice.

5.4 Stakeholders involvement in the development of national digital health policies and strategies

Respondents were asked to identify stakeholders who should be involved in the development, implementation, and governance of national digital health policies and strategies to ensure the effective and sustainable implementation of data interoperability in public hospitals. As shown in the results, the majority of respondents 79% (114) indicated that IT and health information professionals should be actively involved in the development of national digital health policies and strategies. This was followed by 69% (99) who cited the National Department of Health, and 67% (97) who identified systems and database vendors as key stakeholders. Additionally, 37% (53) highlighted the importance of involving policymakers and legislative bodies, while 14% (20) mentioned administrative support staff, and 13% (19) pointed to provincial health authorities (see Figure 3 below).

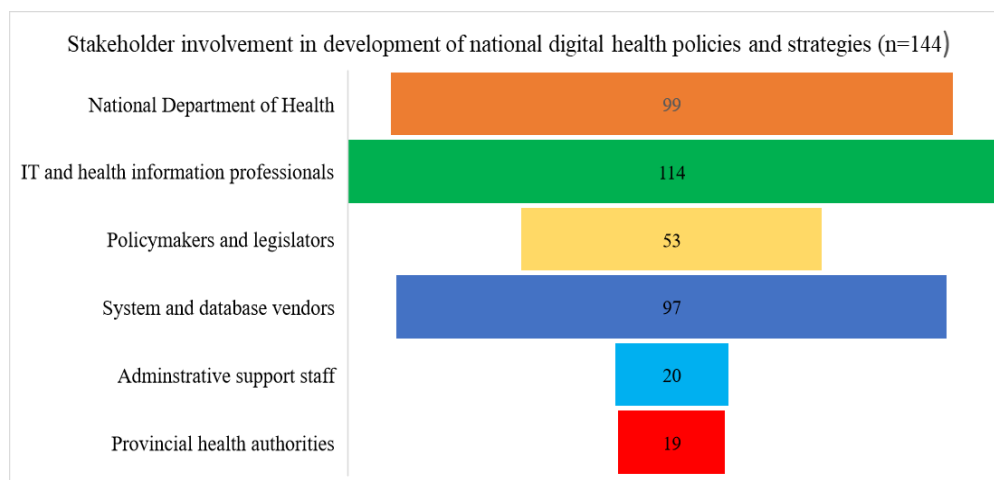


Figure 3. Stakeholder involvement in the development of national digital health policies and strategies (N=144)

“Personally, I believe that the Department of Health, IT and cybersecurity professionals, data vendors, and clinical staff should be actively involved as key stakeholders in the development of digital health policies and strategies” (AM-6)

“During the development and implementation of national policies and frameworks for digital health interoperability, it is crucial for the government to engage a broad range of stakeholders such as policymakers, legal experts, healthcare workers, provincial and district health authorities, and IT professionals to ensure effective and contextually relevant execution” (ITM—5).

“I believe that the development of digital health strategies and related frameworks should include meaningful participation from the National Department of Health, IT personnel, policymakers, and patient advocacy groups. These voices are essential to creating technologies that truly support and enhance healthcare delivery” (CM-1)

This study found a strong convergence between the quantitative and qualitative data regarding the key stakeholders required for effective and sustainable interoperability of healthcare data in public hospitals. A large majority of respondents identified IT professionals, health information professionals, the National Department of Health, and system and database vendors as essential stakeholders, with additional support for the inclusion of policymakers and administrative staff. Participant interviews reinforced these views by emphasising the importance of broad and inclusive stakeholder engagement, incorporating clinical staff, IT and cybersecurity experts, legal professionals, and patient advocacy organisations. While the quantitative data highlighted the stakeholder groups considered most relevant, the qualitative responses offered deeper insight into why their involvement is critical, underscoring the importance of cross-sector collaboration to ensure that digital health policies and strategies are both contextually appropriate and technically feasible. Beyond widely recognised challenges such as legacy systems, inadequate infrastructure and regulatory gaps, this study offers new empirical evidence from public hospitals, where a large majority of respondents called for the establishment of clear implementation roadmaps (83%) and infrastructure specifications (92%) for hospitals. Moreover, these quantitative insights together with qualitative perspectives, offered a well-grounded contribution to health interoperability research in African countries.

6. Proposed framework for incorporating data interoperability of health information systems in public hospitals

This study addresses a critical gap in the literature and highlights the shortcomings of key national policy documents; namely, the South African National eHealth Strategy (2012–2016), the HNSF, the National Digital Health Strategy (2019–2024), and the National Health Insurance (NHI) model, which collectively hinder data interoperability in public healthcare. In response, the study proposes a framework designed to foster a cohesive, efficient, and patient-centred health environment. This framework aligns with national strategic goals and

contributes to the development of a robust and integrated digital health ecosystem in South Africa. Figure 4 illustrates the proposed framework for incorporating data interoperability in public hospitals.

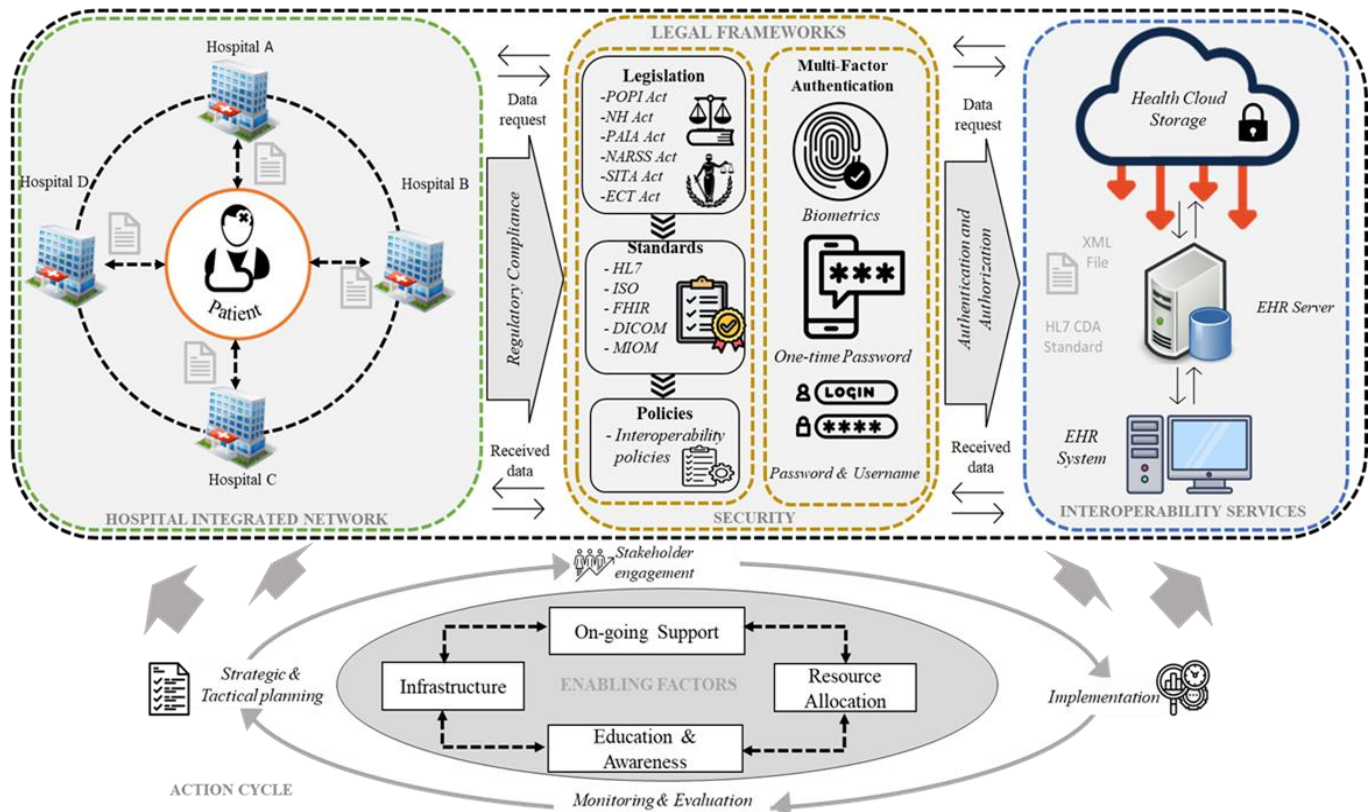


Figure 4. Proposed framework for data interoperability of health information systems in public hospitals

As illustrated in Figure 4, the proposed framework comprises six interrelated dimensions. These dimensions are derived from quantitative insights (i.e., calls for clear implementation roadmaps, security protocols, infrastructure specifications), qualitative perspectives (i.e., stakeholder engagement and regulatory compliance) as well as alignment with gaps in national frameworks as they lack actionable implementation guidelines. Despite existing national interoperability frameworks remain focus on policy level, the six dimensions incorporated in this framework are operationalised for the hospital context. For instance, hospital integrated network is framed as legally binding agreement between two or more public hospitals, aimed at working together to seamlessly share data across various systems; regulatory compliance is tied to legislation and technical standards for data interoperability; security focuses on data protection through defensive mechanisms for hospitals; action cycles provide step by step implementation processes to be followed. As a result of this operationalisation, the proposed framework differs from existing national frameworks by translating high-level goals into actionable strategies relevant to South African public hospitals. These dimensions are discussed in detail as follows:

6.1 Hospital integrated network

A hospital integrated network consists of aligned public hospitals collaborating to deliver efficient, coordinated, and patient-centred care. This dimension of the framework promotes legally binding agreements among participating hospitals to enable the secure sharing, access, and exchange of patient health information. Centralised data systems facilitate continuity of care across multiple locations, strengthen inter-facility collaboration, and enhance patient outcomes. Hospitals in South Africa are particularly encouraged to adopt this networked model to improve care quality and operational efficiency.

6.2 Regulatory compliance

Regulatory compliance is foundational to establishing trust and legitimacy in interoperability initiatives. The framework requires public hospitals to adhere strictly to relevant legislation, including the POPIA, the PAIA, the NHA, the NARSSA, SITA, and ECTA. Compliance with technical standards such as HL7, ISO, FHIR, DICOM, and MIOM is also essential to ensure uniformity and interoperability. The National Department of Health and regulatory authorities must mandate adherence to these legal and technical frameworks. Furthermore, public hospitals should develop internal policies and monitoring mechanisms aligned with national digital health strategies to ensure sustained regulatory compliance. Failure to implement such governance structures may significantly hinder data interoperability efforts.

6.3 Security

Data security is a critical enabler of data interoperability. Public hospitals must implement robust security protocols to control access and ensure the confidentiality and integrity of health data, particularly when stored or transmitted via cloud platforms. The framework recommends the use of Multi-Factor Authentication (MFA), including biometric systems, passwords, and one-time passwords (OTPs), to authenticate users securely across hospitals. A layered authentication model will safeguard sensitive health information from unauthorised access and cybersecurity threats, attacks and data breaches.

6.4 Interoperability services

Interoperability services within the framework are supported by cloud storage, hospital servers, and EHR systems. These technologies enable seamless communication across institutions, providing authorised users with real-time access to patient records, even across disparate systems. For example, the HL7 CDA standard enables structured data exchange, allowing EHRs and HISs to connect and share patient information effectively. Hospitals are encouraged to create XML files conforming to HL7 CDA to standardise communication between systems. This ensures system compatibility and supports continuity of care across facilities.

6.5 Action cycle

The action cycle encompasses a series of sequential steps required to implement data interoperability effectively. Public hospitals must develop a strategic implementation plan outlining timeline, responsibilities, resource allocations, and technology requirements. Crucially, stakeholder engagement is embedded within this cycle, involving collaboration with government agencies, clinicians, IT vendors, regulatory bodies, and other key actors. Active participation from stakeholders ensures alignment with institutional goals and facilitates shared ownership of the initiative. Continuous project review meetings, performance tracking, and timely resolution of implementation challenges are essential. Monitoring and Evaluation (M&E) mechanisms must be in place to assess whether interoperability objectives are being achieved and to inform ongoing improvements.

6.6 Enabling factors

The final dimension emphasises the critical enablers that support the successful implementation and long-term sustainability of data interoperability. These include (a) government support and leadership commitment; (b) allocation of human, technical, and financial resources; (c) capacity building, staff training, and education; and (d) investment in digital infrastructure, including hardware, software, and secure, high-speed internet. The study identifies inadequate funding and infrastructure as major barriers. The government should allocate sufficient budget to enable public hospitals to upgrade their systems and networks to meet data interoperability demands. Collaboration between the National Department of Health, provincial authorities, IT personnel, policymakers, and health officials is essential to ensure adequate infrastructure, enforce standards, and promote workforce readiness.

Conclusion and future studies

This study aimed to propose a framework for incorporating data interoperability of health information systems in public hospitals in the Gauteng Province of South Africa. It is hoped that the proposed framework will help promote a cohesive, efficient, and patient-centred health environment. Findings from both qualitative and quantitative data revealed a consistent consensus that national digital health policies and strategies, despite their intentions, are inadequate in guiding public hospitals towards achieving data interoperability across systems. Key limitations identified include insufficient stakeholder engagement, inadequate technical guidelines, weak alignment with existing policy and legal frameworks, and the absence of clear infrastructure specifications. This framework addresses these shortcomings by incorporating six interconnected dimensions: hospital integrated networks, regulatory compliance, security, interoperability services, action cycles, and enabling factors, all aimed at promoting a patient-centred digital health environment. The framework provides technical guidelines designed to assist healthcare stakeholders in addressing fragmentation within the public health sector. The framework further builds upon existing frameworks such as the OpenHIE, the National eHealth Interoperability Framework and Interoperability Framework of the African Union. Although these initiatives set policy principles and technical standards, they remain limited in providing operational guidance at the hospital level. The proposed framework addresses this gap by offering actionable guidelines like implementation phases, infrastructure requirements, and regulatory compliance

A major limitation of this study is that the proposed framework has not been tested or validated in practice. It is therefore recommended that future research be conducted to assess its applicability and effectiveness across different provinces in South Africa, as well as in other countries with varying governance structures and levels of infrastructural capacity. The study concludes that the pursuit of interoperable health systems requires more than the establishment of robust frameworks; it also demands meaningful stakeholder engagement, sustained political commitment, and strategic investment in infrastructure to ensure effective and sustainable implementation. The novelty for this lies in its two-fold contribution. From the methodological perspective, the study employed a convergence parallel design across six public hospitals which allowed to capture both experiential and systematic perspectives. Moreover, the study proposed that framework that bridges the gap between policy and operational hospital level. As opposed to existing frameworks which place an emphasis on policy alignment in isolation, the proposed framework incorporates stakeholder engagement, regulatory compliance and infrastructure preparedness, thereby providing practical blueprint for data interoperability, particularly for healthcare systems that are resource-constrained.

From our perspective as researchers, the long-term vision for South African health information ecosystem should be the establishment of a nationally integrated system that bridges the gap between high-level digital health policies and hospital-level implementation. Such a system could address fragmentation within the public sector and ensure equitable, efficient, and patient-centred care. At the same time, we contend that this national system should be designed for regional compatibility, in line with African Union initiatives on interoperability and digital identity. This dual approach national leadership with regional alignment, could allow South Africa not only to strengthen its internal digital health landscape but also to contribute to continental efforts aimed at enabling cross-border healthcare data exchange and advancing universal health coverage in Africa.

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Data availability: The data that support the findings of this study are available from the corresponding author, KG Chuma upon reasonable request.

Kabelo Given CHUMA holds a Ph.D. in Information Science from the University of South Africa (UNISA) and currently serves as a Senior Lecturer in the Department of Information Science within the College of Human Sciences. With a strong academic and professional foundation, Dr Chuma's research focuses on a wide range of critical and emerging issues in the digital information landscape. His core areas of expertise include Big Data and Analytics, Data Cybersecurity, Information Security, Health Information Security, Data and Network Security, and Health Information Governance.

ORCID ID: <https://doi.org/0000-0002-5817-6063>

Mpho NGOEPE is a Professor and Executive Director of Library and Information Services at the University of South Africa (UNISA). His research interests include libraries, archives, records management, authentication, oral history, literature, and archival theories. His research has been published in various journals including Journal of Infrastructure Policy and Development, Library Management, Information Development, Collection and Curation and Global Knowledge Memory and Communication. He is a C2 NRF rated researcher (2022-2027).

ORCID ID: <https://doi.org/0000-0002-6241-161X>

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