Digital Health: A Live Healthcare Console for Public Health in Gauteng, South Africa

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Declaration

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I declare that the thesis is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis to originality-checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

Wesley Moonsamy 14 October 2024

Signature Date

Abstract

Access to quality, real-time information can enable a healthcare system to achieve tactical objectives, such as providing quality patient care, and strategic objectives, such as allocating scarce resources. Digital health systems can be used to connect disparate information-rich sources, combine appropriate information, and communicate information to key decision-makers. Even though digital health interventions, such as Gauteng's new health information system, have been implemented, stakeholders like hospital managers and emergency medical services do not have access to shared real-time information. A Live Healthcare Console was conceptualised during this research as a system that could be used to combine appropriate information and make it available to healthcare stakeholders. New digital health systems must first be designed based on the objectives of the healthcare system to achieve this concept. Therefore, this research aims to propose a new practical design model along with a supporting theoretical model to design the Live Healthcare Console.

A literature review was conducted in three phases using elements of a systematic literature review. The merits and constraints of the public healthcare system were first determined, which led to an understanding that digital health interventions could support the Department of Health's objectives. The second phase established that the public healthcare technology architecture does not adequately accommodate combining and communicating information to key stakeholders. This resulted in a need to identify a model that could be used to design the Live Healthcare Console. The third phase of the literature review established that none of the five evaluated digital health design models were contextually relevant to the South African public healthcare system. This resulted in the construction of the Design Model for a Live Healthcare Console version 0.1.

The researcher conducted thirty-one semi-structured interviews with participants, such as technology managers, hospital managers and emergency department personnel from the public healthcare system. The interviews were qualitatively analysed using an interpretive approach comprising three cycles of coding. Codes were associated with each other to form networks, which led to the identification of six themes (Combine Information, Connect Systems, Communicate with People, Contain Threats, Collaborate with Healthcare Teams, and Cooperate to Achieve Strategic Objectives). This process fuelled the creation of the Design Model for a Live Healthcare Console version 0.2. Version 0.2 was then tested with a subset of the original participant group to formulate version 1.0.

This research contributes a practical design model which could be used or further refined by the Department of Health to implement a Live Healthcare Console to assist with the management of scarce healthcare resources. This research also produced a theoretical conjecture supported by a theoretical model, which describes how the six themes could leverage existing technology resources to optimise public healthcare system management.

Key Terms

Digital health; digital healthcare design model; public healthcare system; National Health Insurance (NHI); Live Healthcare Console; Design Model for a Live Healthcare Console; public health management; connecting people to information; real-time digital health information; communication among healthcare workers; cooperation among healthcare workers; leveraging real-time healthcare information; eHealth in South Africa; healthcare team collaboration

Dedication

To my loving wife, Prelini and my precious daughters, Kayla and Mirelle.

Outputs Arising From This Research

Moonsamy, W., & Singh, S. (2024). Digital health model for South Africa's National Health Insurance: addressing hospital occupancy and emergency care. *Journal of Health Informatics in Africa*, *10*(2), 10–14. https://jhia-online.org/index.php/jhia/article/view/395

Moonsamy, W., & Singh, S. (2024). Digital healthcare champion: A new healthcare professional role leveraging 4IR to promote sustainable healthcare in South Africa. In *Research in Southern African Digital Business Vol II* (Vol. 2, pp. 62–87).

Moonsamy, W., & Singh, S. (2024). Navigating Digital Health Research Ethics: Insights from a South African Context. *Proceedings of the 2024 Conference Society 5.0 - Innovation for Sustainable and Inclusive Social Good, Volume 2*, 145–157. https://zenodo.org/records/11612759.

Moonsamy, W., & Singh, S. (2024). Towards a Live Healthcare Console: An evaluation of existing digital healthcare design models, a South African perspective. *South African Journal of Information Management*, *26*(1), 1–15. https://doi.org/10.4102/sajim.v26i1.1798

Part of this research was presented at the Health Informatics in Africa (HELINA) 2023 conference in Cape Town, South Africa on 03 November 2023. The title of the presentation was "Digital Health Model for South Africa's National Health Insurance: Addressing Hospital Occupancy and Emergency Care". The associated research was published as a journal article, as noted above.

This research was displayed as an electronic poster at the 2024 Geneva Health Day conference held on 30 May 2024.

Part of this research was presented at the Society 5.0 - Innovation for Sustainable and Inclusive Social Good conference in Balaclava, Mauritius on 27 June 2024. The title of the presentation was "Navigating Digital Health Research Ethics - Insights from a South African Context". The associated research was published as a conference proceeding, as noted above.

The research results were presented at the Johannesburg Primary Healthcare Conference in Johannesburg, South Africa on 28 August 2024. The title of the presentation was "Digital Health: A Live Healthcare Console for Public Health in Gauteng, South Africa". The researcher was awarded the "Best presentation" award for this research.

Acknowledgements

- I would like to express my gratitude to my research supervisor, Prof Shawren Singh, for his guidance during this research. His inspiration also led me to publish related research and approach opportunities from unique perspectives.
- Thank you to my parents, Mr Denny Moonsamy and Mrs Prem Moonsamy, for planting the seed of education early on in my childhood and encouraging me during this research.
- Thank you to my colleagues at the School of Computing for their words of wisdom and advice whenever I needed it.
- Thank you to my friends and family for their support during this research.
- Thank you to my daughters, Kayla and Mirelle, for their patience and understanding during the long hours I spent at my laptop.
- Thank you to my wife, Prelini Moonsamy, for always believing in me and for making the sacrifices it took to support me on this journey.

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Terms and Abbreviations

Term	Abbreviation (where applicable)	Definition
Advanced Life Support	ALS	Paramedics with advanced-level training
Autonomic Network Management	ANM	A networking approach which supports cloud-based computing using software
Basic Life Support	BLS	Paramedics with basic-level training
Chief Executive Officer	CEO	The manager of a hospital
Chief Information Officer	CIO	The person responsible for the technology infrastructure and digital health systems at a hospital
College of Agriculture and Environmental Sciences	CAES	The College of Agriculture and Environmental Sciences
Context-Specific Literature Review	CSLR	The literature review conducted with academic literature relevant to this research
Deductive Coding		Identifying text within content based on pre-defined codes
Digital Health		Technology and systems related to healthcare and patient records. Sometimes referred to as eHealth
Edge computing		A technique that reduces processing strain on cloud-based systems by moving processing to nearby systems in the landscape
eHealth		Technology and systems related to healthcare and patient records. Sometimes referred to as digital health
Emergency Medical Services	EMS	Ambulance crews, dispatchers and call takers in Gauteng
Federated Health Information Architecture	FHIA	A healthcare-related technology architecture which supports the interoperability and synchronisation of data between systems
Fog computing		A technique used to reduce data packet sizes sent to a cloud using compression and other data reduction methods
Fourth Industrial Revolution	4IR	Combing digital health systems with human instinct
Fuzzy systems		Systems based on an adaptation of human logic
Google Mashups		A graphical mapping tool created by Google
Health 4.0		Digital health systems based on 4IR principles

Health Economic Evidence	HEE	Evidence related to healthcare costs and benefits
Health Information Architecture	HIA	A healthcare-related technology architecture which supports interactions between users and healthcare systems
Health Level 7	HL7	Standards framework related to healthcare systems
Human Research Ethics Committee	HREC	Research ethics committee which is allowed to approve research involving human participation
Inductive coding		Identifying codes as they appear within the text instead of using pre-defined concepts
Intermediate Life Support	ILS	Paramedics with intermediate-level training
Live Healthcare Console		A system conceptualised during this research that combines information from existing healthcare systems and makes it available to the key stakeholders
Load shedding		Electricity interruptions in South Africa
Magnetic Resonance Imaging	MRI	Medical imaging machine
National Health Insurance	NHI	The unified healthcare system the Department of Health aims to create by combining the public and private healthcare systems
National Health Research Database	NHRD	The central database which monitors healthcare-related research in South Africa
Near-Real-Time		The latest digital version of information which may differ from non-digital or paper-based information
Neural Networks		Systems that process data using artificial intelligence
Real-Time		The latest version of information
Research Ethics Committee	REC	A committee tasked with approving or declining research projects
Software Defined Networking		A networking approach which supports cloud-based computing using software
University of South Africa	UNISA	The University of South Africa

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Chapter 1: Introduction

1.1 Research Synopsis

This research can be divided into nine phases. The initial phases comprised the conceptualisation of the research idea, conducting the literature review and determining the research method. During the data handling phases of this research, the study obtained ethical clearance and the research data were collected and analysed. The concluding phases comprised the model's refinement, confirmation from participants and deriving the conclusions of this research. **Figure 1** summarises these nine phases.

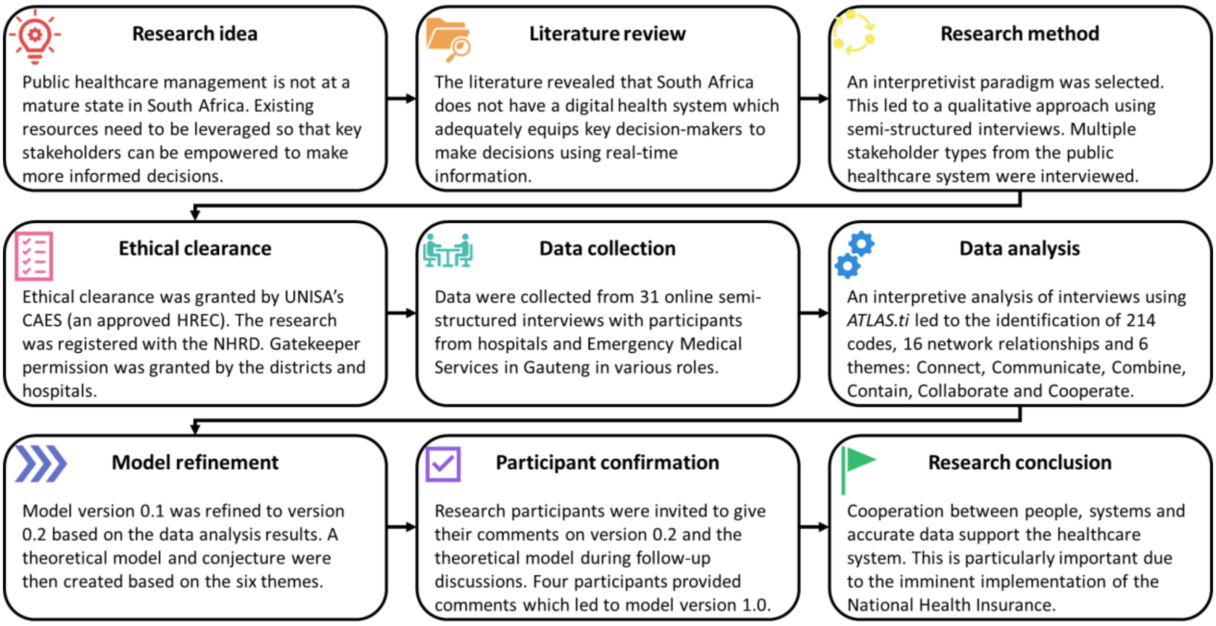


Figure 1. The research synopsis

1.2 Research Focus

The focus of my Master's degree in digital health (Moonsamy, 2021) was the collection of digital health data in the form of digital vaccination records. That research noted that digital health data could be used for reporting, advancing insights and keeping the public informed. This has led to my deep fascination with the downstream use of accurate digital health data for real-time purposes.

Digital health has become associated with patient-level health information and is a key focus area of the Department of Health (Department of Health, 2020). Health information systems (HIS) and district health information systems (DHIS) have been implemented in Gauteng (Gauteng Province Health, 2017). Recently, the Department of Health initiated the roll-out of a new HIS called the SAP HIS, intended to consolidate patient information and promote the smooth functioning of digital health processes (news24, 2023e). Though several information systems have been implemented over the years, access to accurate and informative real-time information in certain situations is still not available (Nguyen, 2023a). Key stakeholders, such as hospital CEOs, emergency medical services (EMS), provincial level managers and patients, do not have a unified view of hospital occupancy information for their specific purposes. The focus of this research is designing a model that can harness existing digital health-related data to provide real-time information to the relevant stakeholders within Gauteng, South Africa.

1.3 Problem Statement

By appropriately connecting and utilising technology in the healthcare ecosystem, scarce resources, like hospitals, hospital beds, healthcare workers, EMS and funding, can be used more effectively to deliver quality healthcare. There are four main levels of healthcare facilities in Gauteng (Gauteng Provincial Government, 2022), offering different levels of healthcare services based on, among other criteria, the severity of a patient's medical needs. A clinic would offer a basic level of healthcare, such as treatment for minor illnesses. A level 3 healthcare facility (sometimes referred to as an academic hospital or tertiary facility), such as the Donald Gordan Medical Centre, specialises in services such as medical oncology (WDGMC, 2022). **Figure 2** illustrates the four main levels of healthcare facilities.

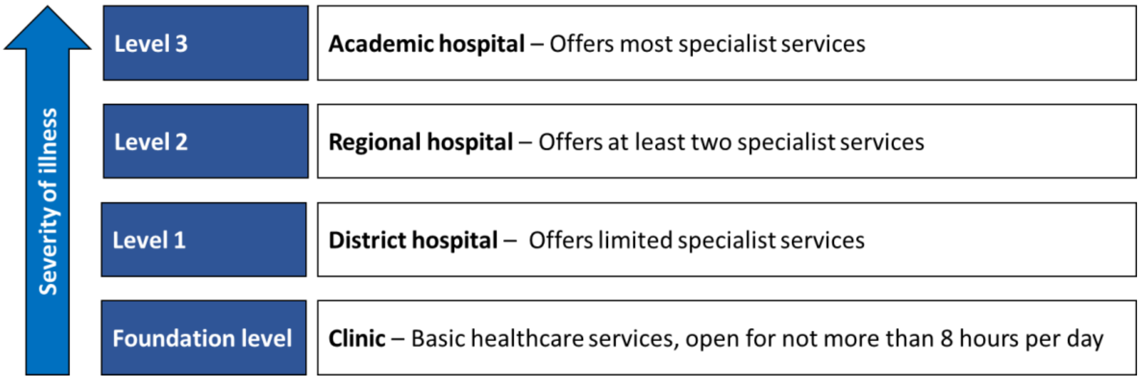


Figure 2. Healthcare facility types in Gauteng

Source: Adapted from KZN Health Department (2001) and Western Cape Government (2023)

Due to this fragmented healthcare system structure, patients do not always visit the facility appropriate for their needs (Van Straten et al., 2017). Consequently, higher-level facilities utilise resources on cases that should have been handled by lower-level facilities. This creates congestion in the system, whereby patients who need specialised medical care wait longer than necessary. In the case of patients who require stabilisation and transportation to a healthcare facility, Tiwari et al. (2021) argue that it is critical that EMS is connected to primary-level healthcare. Linking EMS and primary-level healthcare could apply to countries like South Africa. Furthermore, Mashao et al. (2021a) call for a digital bed management solution for the emergency department, along with a dedicated bed manager, thereby strengthening the case for an appropriate public healthcare management system focusing on bed management that accommodates the needs of all relevant stakeholders.

1.4 Scope of Research

This research was conducted within the public healthcare system in South Africa. Though not the key focus of this research, the effects of the National Health Insurance (NHI) on the overall healthcare system are discussed where relevant. Private healthcare is also briefly discussed but is not the core focus of this study. This research was conducted in the Gauteng province of South Africa, as this province contains a larger number of public healthcare hospital beds compared to the remaining eight provinces (Dell & Kahn, 2017). The research considers the storage, use and dissemination of hospital bed occupancy information within all departments but concentrates on the emergency departments. Public clinics that do not offer overnight patient treatment do not form part of this research. EMS is also included in this research as these public healthcare services interact with hospital emergency departments daily. **Section 3.3** and **Section 3.4** discuss the key stakeholder groups in detail but can be briefly described here as hospital and EMS staff with an interest in hospital bed occupancy information and patient transport processes. Patient, medicine, treatment, medical equipment and other forms of healthcare-related data are indirectly discussed as part of this research, but no details or identifiable information is shared. This research also did not examine raw hospital bed occupancy data, as its scope was determining how to connect the various departments and stakeholders. Public HISs, such as SAP HIS or other systems, were also not accessed during this study.

1.5 Research Questions

Monitoring patients within hospitals can be achieved by using healthcare monitoring systems. These systems can be enhanced to move towards smart healthcare by incorporating neural networks and fuzzy systems (El Zouka & Hosni, 2021). However, the current research takes a broader view of healthcare monitoring, i.e., from a public healthcare perspective, not from the patient viewpoint. Thus, it considers monitoring healthcare facilities in terms of the “pulse” of the individual facilities and districts. This research could also be described as monitoring the “health of the healthcare system”, which could include the use or availability of resources. The use of Google *Mashups* and Google *Maps* during the 2021 civil unrest in South Africa supplied a graphical view of the movement of the public and could provide safety advice to commuters (Kahla, 2021). An adaptation of this idea gave rise to the concept of a Live Healthcare Console, which could serve as a public healthcare management system with the possibility of being extended per the needs of the key stakeholders.

To formulate an appropriate research question, problematisation and gap-spotting techniques were considered. Problematisation can be regarded as sceptical and challenging existing theories, whereas gap-spotting relates to identifying deficits in existing literature (Gkeredakis & Constantinides, 2019; Sandberg & Alvesson, 2011). Such deficits in the existing literature regarding public healthcare system monitoring in South Africa led to the main research question.

The study utilised problematisation to identify problems in existing digital health design models, which resulted in the three sub-questions.

RQ – How can digital health interventions in the form of a Live Healthcare Console support public healthcare management?

- SQ1 – How can a Live Healthcare Console support the key stakeholders in their tactical and strategic functions?
- SQ2 – What are the key elements needed for the design of a Live Healthcare Console?
- SQ3 – What influences the effectiveness of a Live Healthcare Console within the public healthcare system?

Section 5.5 discusses and answers the main research question along with the three sub-questions.

1.6 Research Objectives

The primary objective of this research was to develop new theory on public health management in Gauteng, South Africa by using the concept of a Live Healthcare Console. This objective was accomplished by first understanding the current public healthcare situation, investigating supporting technologies and engaging with the appropriate stakeholders. The new theoretical development serves to inform decision-makers and policymakers on how to leverage the strengths of the existing systems and provide support to areas needing improvement.

The subsequent objective was to create a digital health design model to facilitate the development of a Live Healthcare Console. The design model promotes using existing systems and information to ensure minimal impact on the technological landscape. It was also created with the understanding that technology is rapidly evolving and, therefore, should incorporate elements of flexibility. Healthcare technology architects can use the design model to inform technical design decisions.

1.7 Significance of this Research

Real-time healthcare data can enable healthcare monitoring and support patient care (F. Hassan et al., 2020). Therefore, it is reasonable to assume that decisions relating to patient transport might benefit from real-time data. Patient transport from a scene to a hospital, transfer to higher- or lower-level facilities, as well as short- and long-term load-balancing[1] of scarce resources, require a mix of real-time and historical data. Currently, key stakeholders access fragmented

[1] A daily activity performed by healthcare managers to ensure healthcare resources are distributed in a manner which ensures that patients receive optimal care.

information, meaning they do not have access to the same version of the information, which can hinder their ability to distribute resources effectively.

There is a need to improve network or connected applications of digital health (Alekseeva et al., 2022). This research identified deficits in the literature, which prevents the optimisation of information sharing within the South African public healthcare system. Such deficits heightened the understanding of the current South African public healthcare situation. Combining the results of the literature review with the findings derived from the 31 semi-structured interviews resulted in the development of a new theory regarding the availability of quality healthcare-related information.

A contextualised public healthcare monitoring system can serve as an information portal for the relevant stakeholders, who need to make short- and long-term decisions. This is important because of the Department of Health's plans to unite the current fragmented health system (Department of Health, 2019a; Moonsamy & Singh, 2024b). Such a change to the healthcare system would facilitate further pooling of scarce resources. In addition to the forecasted changes in the healthcare system, South Africa has experienced unexpected changes in hospital occupancy brought about by incidents such as the recent fire at Chatsmed Hospital in Ethekwini and Charlotte Maxeke Johannesburg Academic Hospital in Parktown (IOL, 2022b; Motara et al., 2021). Such unexpected changes prompted patient transfers to neighbouring hospitals. Decision-makers should also have accurate and real-time information to avoid repeating some of the mistakes made during the Life Esidimeni tragedy (Singh, 2017).

1.8 Limitations of the Study

This research was conducted in Gauteng as this is the province with the largest population in South Africa (Stats SA, 2021) and a larger number of public healthcare hospital beds compared to the remaining eight provinces. Gauteng is also the place of residence of the researcher, making it more convenient to engage with the key stakeholders. Only hospitals (healthcare facilities that provide overnight patient care) and EMS departments were considered for this study because it focused on bed occupancy and patient transport. Further, this research only concentrated on the public healthcare system, although referencing the private healthcare system where relevant.

1.9 Research Strategy

This research considered information systems, healthcare-related business processes and the roles of healthcare stakeholders. This perspective led to a qualitative approach since that would facilitate the data collection, analysis and theoretical development processes. The researcher conducted and analysed semi-structured interviews using three cycles of coding, which led to the formulation of themes used to develop a theoretical and practical model.

1.10 Ethical Considerations

The *Turnitin* plagiarism checking tool was used to determine the originality of this research. The *Turnitin* report summary is available in **Appendix 8.1.**

This thesis document was proofread and edited by a certified editor. The editing certificate is available in **Appendix 8.2**

Digital health or eHealth research in South Africa is considered health research (Republic of South Africa, 2004; University of South Africa, 2016, 2024). Therefore, this research followed all the necessary healthcare ethical application processes. The following committees granted ethics approval:

- University of South Africa College of Agriculture and Environmental Sciences – **Appendix 8.3**
- Ekurhuleni Research District **– Appendix 8.4**
- City of Johannesburg (Joburg) Research District – **Appendix 8.5**
- Sedibeng Research District – **Appendix 8.6**
- Tshwane Research District – **Appendix 8.7**
- West Rand Research District – **Appendix 8.8**
- Emergency Medical Services Research Committee – **Appendix 8.9**
- National Health Research Database – **Appendix 8.10**

Gatekeeper permission was provided at the hospital level. The approval letters were not provided to protect the anonymity of the research participants.

1.11 Structure of the Thesis

Chapter 1 sets the scene of this research by introducing the research problem. The chapter presented the scope and objectives of this research along with the research questions, which were discussed in detail.

Chapter 2 serves as the literature review. This chapter presents the three phases of the literature review, providing summaries at the end of each phase. **Chapter 2** also introduces the construction of the practical model (Design Model for a Live Healthcare Console version 0.1).

Chapter 3 presents the research methodology in detail, including the research design, sampling method, research instrument and data collection strategy. The chapter also includes the methods used to ensure the trustworthiness of the collected data.

Chapter 4 presents the data analysis and results. The chapter discusses the ethical process that was followed in detail and describes the data analysis phase, including reaching data saturation. **Chapter 4** further details the derivation of the themes and explains the impact of the themes on the design model.

Chapter 5 introduces the theoretical development and provides an overall discussion. The chapter discusses the formulation of the Design Model for a Live Healthcare Console version 1.0, based on the identified themes, explains the evolution of the design models, and answers the overall research questions.

Chapter 6 concludes this research. This chapter describes how academic integrity was achieved through rigorous scientific research, explains the contributions of this research (theoretical and practical) and presents ideas for future research. This chapter also provides reflections on the research.

1.12 Summary of Chapter 1

The South African public healthcare system is constrained due to a lack of healthcare-related resources. This situation requires key decision-makers in various roles within the healthcare system to use the available resources optimally, which is attained through load-balancing resources by the effective allocation of resources to patients. Key decision-makers require quality information to support their decisions to accomplish this. The lack of consistent data throughout the various healthcare systems poses a threat to resource optimisation.

This chapter introduced the problem under study and set the boundaries of the research by delineating the research focus and limitations. The chapter highlighted the significance of the problem under investigation and presented the main research question and three sub-questions. **Chapter 2** maps out the research by discussing the three phases of the literature review and constructing the Design Model for a Live Healthcare Console version 0.1.

Chapter 2: Literature Review

This chapter presents the literature review, which was conducted in three phases. Each phase builds on the knowledge gained from the previous phase. The first phase sets the scene for this research, highlighting deficiencies in certain public healthcare system processes. The second phase considers the architectural landscape, which is key to understanding how technology and people blend within the healthcare ecosystem. The third phase presents the evaluation of five existing digital health design models from developed and developing countries relevant to designing a Live Healthcare Console. These models were evaluated in the South African context. Once the study had determined that these five digital health design models did not fully satisfy unique South African perspectives, a new model was constructed based on the knowledge gathered through the literature review and elements from the five evaluated models. **Figure 3** illustrates the structure of this chapter.

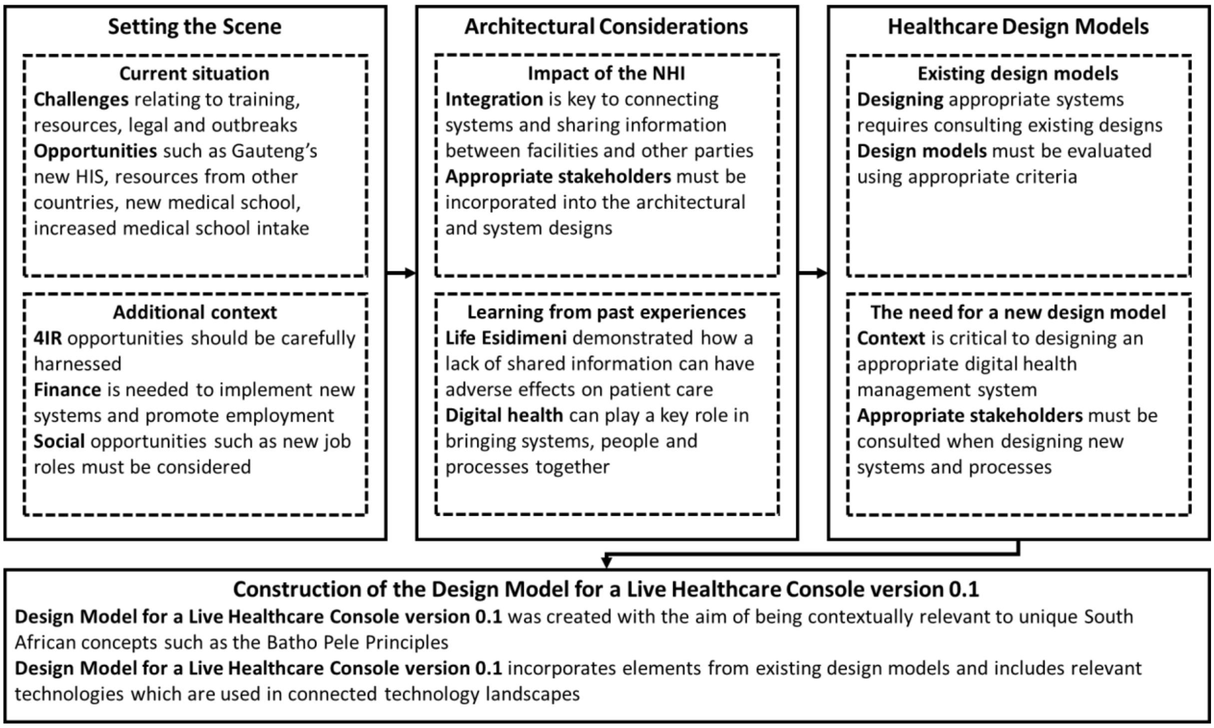


Figure 3. Structure of Chapter 2

Figure 3 demonstrates how setting the scene comprised understanding the current situation regarding the public healthcare system and provided context relating to 4IR, financial and social considerations. This understanding led to an investigation into the technology architecture germane to the implementation of the NHI, as well as lessons to be learnt from past South African events. Subsequently, it was necessary to examine healthcare design models from other countries, as South Africa did not have a contextualised model to consider for this research. The study evaluated five models and determined that they did not entirely apply to the South African context. This prompted the need to design a new model. The final step of the literature review led to the construction of the first version of the design model.

2.1 Setting the Scene

The South African public healthcare system is burdened by several challenges but also benefits from opportunities aiming to alleviate these challenges. Challenges and opportunities related to the public healthcare system are noted in academic literature and the media alike (Modisakeng et al., 2020; Moyimane et al., 2017; Mueller, 2020; news24, 2023e). This phase of the literature review aimed to identify the main challenges and opportunities related to the public healthcare system and possible improvements from a digital health perspective.

To confirm the most recent challenges and opportunities existing within the public healthcare system, the researcher undertook a situational review, which can be conducted prior to a systematic literature review (SLR) (Munn et al., 2018). The situational review followed the steps of a scoping review, an approach that considers existing as well as developing knowledge about a particular area (Mak & Thomas, 2022). By researching digital newspaper media, several existing challenges within the public healthcare system were identified. These include training (lack of training provided to healthcare workers on the use of digital systems), resources (shortage of staff at healthcare facilities) and legal (impact of the NHI). The situational review also highlighted the opportunities or attempts to mitigate the challenges associated with the public healthcare system. The most recent is a new HIS being deployed to Gauteng hospitals (news24, 2023e).

The situational review was followed by a context-specific literature review (CSLR), which utilised elements of an SLR. The objective of the CSLR was to identify healthcare challenges and opportunities, which have been documented in scholarly literature. Once the relevant documents had been retrieved through the CSLR, they were analysed using a content analysis approach. Concepts were identified from the documents using a hybrid approach (human and artificial intelligence [AI]). This was followed by three coding cycles, which condensed the identified codes into 12 code groups and then into three themes: finance, social and the 4IR. The CSLR search results were reported using the preferred reporting items for the systematic reviews and meta-analysis (PRISMA) 2020 framework.

2.1.1 Situational Review

The situational review followed a subset of the steps of a scoping review (explained in **Table 1**) and investigated the public healthcare situation through the lenses of current affairs (digital newspaper media) by searching digital newspaper articles for the latest news relating to healthcare in South Africa.

Table 1. Recommended scoping review steps and their adoption in this research.

Step #	Description	Relation to this research	Adopted in the situational review
1	Identifying the research question	The research questions discussed in **Section 1.5** were formulated for the overall research. No specific questions were designed for this phase of the literature review.	Partial
2	Identifying relevant studies	Relevant digital newspaper articles highlighting the most recent public healthcare challenges and opportunities were identified.	Yes
3	Selecting studies for inclusion in the review	Articles relevant to public healthcare challenges and opportunities were included.	Yes
4	Charting the data	This step was not extensively followed, as the main extraction criterion was the date of the article.	Partial
5	Collating, summarising and reporting the results	The results of the situational review are summarised and presented in **Table 2**.	Yes
6	Consulting stakeholders (optional)	Stakeholders were not consulted during this phase, as a content analysis approach was followed.	No

A search of digital media in the form of newspaper articles from 2022 to 2023 revealed numerous challenges experienced in the South African public healthcare sector. The challenges were then categorised as follows:

- Training – Training or refresher training is required for the relevant staff.
- Resources – Finance-, human capital-, equipment- or energy-related (electricity).
- Legal – Related to governance and policies issued by the Department of Health.

Healthcare-related events in South Africa frequently make headlines in the media. **Table 2** presents the events that constrained the public healthcare system.

Table 2. Recent events that constrained the South African public healthcare system.

Year	Event	Reference	Related category
2023	Woman wakes up in morgue after being declared dead	(IOL, 2023a)	Resources and Training
2023	Three-year-old girl dies when breathing apparatus stops working due to electricity disruptions (load shedding)	(news24, 2023c)	Resources
2023	Newborn babies placed in cardboard boxes instead of incubators	(City Press, 2023)	Resources and Training
2023	Proposed legal action against proceeding with the NHI	(Businesstech, 2023)	Legal and Resources
2023	Cholera outbreak	(news24, 2023a)	Resources
Ongoing	Exodus of doctors	(Bezuidenhout et al., 2009; BusinessTech, 2022)	Resources

Table 2 highlights six healthcare-related events that occurred in 2023. An unconscious woman was declared dead and taken to a morgue instead of being treated as an inpatient. Such an occurrence could have been the result of inadequate training or a lack of trained resources to make critical decisions. A three-year-old girl died when her breathing apparatus stopped working because of electricity disruptions (referred to as load shedding). Staff in a hospital placed newborn babies in cardboard boxes as a temporary measure due to a shortage of incubators. In such cases, the lack of resources (electricity, medical equipment) could mean the difference between life and death. The proposed legal action against the implementation of the NHI presents legal challenges to the adoption of the NHI in the public healthcare system. The cholera outbreak posed a threat to resource availability within the overall healthcare system. The ongoing challenge of qualified doctors leaving South Africa places a further resource strain on the healthcare system.

Further to general events impacting the overall public healthcare system, some events affect specific tasks such as patient transport and, by extension, emergency medical care. **Table 3** presents these events.

Table 3. Recent events related to patient transport.

Year	Event	Reference
2022	Shortage of ambulances highlighted in South Africa	(BusinessDay, 2022; IOL, 2022a)
2023	Patients turned away because of protest action at hospitals	(news24, 2023d)

2023	Excess strain on emergency medical services during the festive season	(news24, 2023b)

Effective patient transport is a mechanism used to reduce the geographical distance between a patient who requires urgent medical attention and the resources that could be used to treat that patient. A shortage of ambulances in South Africa was noted, which, consequently, necessitated further triaging or prioritising of patients requiring transport. In some cases, patients could not enter hospitals because of strike action. This resulted in patients being rerouted to other hospitals. A spike in healthcare-related incidents, such as vehicle collisions, during festive periods further constrained the healthcare system.

On the other hand, the Department of Health has taken steps to safeguard the implementation of the NHI and ease current public healthcare system constraints, as presented in **Table 4**.

Table 4. Steps taken by the Department of Health to limit the impact of the NHI and improve current healthcare service delivery.

Year	Steps taken by the Department of Health	Reference
2023	New health information system implemented in Gauteng	(news24, 2023e)
2023	Assistance provided by doctors from Cuba	(South African Government, 2023)
2023	Launch of South Africa’s 10^{th} medical school	(Nelson Mandela University, 2023)
2021	Increased medical school intake	(Department of Health, 2021b)

South Africa has implemented measures to resolve the training- and resource-related challenges constraining the healthcare system. In 2021, the Department of Health made provision to increase the number of medical students admitted into the relevant medical programs. The Nelson Mandela University’s medical school became South Africa’s 10^{th} medical school, which might result in more qualified doctors entering the healthcare system in the coming years. Assistance from Cuban doctors helped ease the resource constraints within the public healthcare system. Gauteng’s new HIS is a technological intervention aiming to optimise digital processes such as searching for patients and onboarding new patients onto the system. The system also aims to make relevant medical information available to the appropriate stakeholders, such as doctors. These interventions indirectly serve to safeguard the implementation of the NHI.

2.1.2 Context-Specific Literature Review

Following the situational review, a CSLR was conducted to delve deeper into the identification of challenges and opportunities related to the South African public healthcare system. Elements of an SLR were used to conduct this review. The Ohio State University (2023) describes an SLR as a nine-step process. These steps are presented in **Table 5**, together with an explanation of the steps followed during the CSLR.

Table 5. Recommended SLR steps and their adoption in this research.

Step #	Description	Relation to this research	Adopted into the CSLR
1	Choose the right kind of review	As discussed in **Section 2.1.1,** the situational review (using digital newspaper media) led to an elementary understanding of the challenges and opportunities related to public healthcare in South Africa. This necessitated a CSLR to provide more detail.	Yes (The appropriate review was selected, but this was not an SLR)
2	Formulate your question	As with the situational review, no new research questions were formulated since the research contained an overall research question (RQ) and three sub-questions (SQ1, SQ2 and SQ3).	Partial
3	Establish a team	The minimum recommended number of team members for an SLR is three (Phillips & Barker, 2021). The researcher enlisted the library services at the University of South Africa (UNISA) to assist with the literature search. Therefore, this step was not directly followed per the guidelines.	Partial
4	Develop a protocol	A research search protocol was created. **Table 6** discusses the databases and search terms.	Yes
5	Conduct the search	The UNISA library services team conducted the literature search.	Yes
6	Select studies	Relevant studies were selected.	Yes
7	Extract the data	The relevant data were extracted.	Yes
8	Synthesise your results	The results were analysed and synthesised.	Yes

9	Disseminate your report	The results of this phase of the literature review have been published (Moonsamy & Singh, 2024c).	Yes

Source: Adapted from The Ohio State University (2023).

The literature search terms and further context, such as suggested databases and the overall research objectives, were supplied to the UNISA library team. The search terms and their justifications are detailed in **Table 6**. The following databases and resources were searched: *Unisa Library e-Journal Finder, Google Books, ProQuest Dissertations, Theses Global, Sabinet African Journals, EBSCOhost – Academic Search Ultimate, Africa-Wide Information, APA PsycArticles, APA PsycInfo, Business Source Ultimate, Communication Source, EconLit with Full Text, Global Health, Health Source – Consumer Edition, Health Source: Nursing/Academic Edition, Humanities Source, Legal Source, Library & Information Science Source, Library, Information Science & Technology Abstracts, MasterFILE Premier, Political Science Complete, SocINDEX with Full Text*.

Table 6. A subset of the literature search terms and their justification for this research.

Search term #	Search term	Reason for inclusion in this research
1	Issues with patient transfer	There is a financial and staff resource cost associated with patient transport and transfer. The costs start from R 461.00 for using the services of an ambulance, excluding the cost of the paramedic, which can range from R 1 250.00 to R 2 800.00 (Sanlam Reality, 2022). More detailed costs have been documented by The Department of Transport (2021). Therefore, unnecessary patient transfers cause increased financial constraints on the public healthcare system.
2	Issues with patient transfer in ambulance	Refer to #1
3	Shortage of doctors in facilities	A shortage of doctors in public healthcare facilities could lead to delays in patient care, which could place further strain on the overall public healthcare system.
4	Shortage of nurses in facilities	Refer to #3 in the context of a shortage of nurses.
5	Shortage of ambulances	Refer to #1 and #2

6	Shortage of medicines	A shortage of medicines results in sub-optimal patient care, placing further burdens on the public healthcare system.
7	Shortage of beds	A shortage of beds in a particular facility could cause patients to be turned away, which can bring about issues similar to #6. A shortage of beds can also precipitate unnecessary patient transfers, which add financial and staff resource strains.
8	Strikes and protests	This results in staff shortages: refer to #3 and #4.
9	Impact of the National Health Insurance (NHI)	It is useful to understand the potential effects of the NHI on the public healthcare system and the impact on related systems and processes.
10	Outbreaks such as measles and cholera	Outbreaks place a sudden burden on the already constrained healthcare system.

Table 6 outlines some of the search criteria used in the database searches. The following exclusion criteria or limitations were placed on the searches:

- The research papers should have been published within the past ten years.
- Challenges should not be related to a specific disease or pandemic, such as HIV or COVID-19.

Once the relevant documents had been retrieved, they were analysed through qualitative content analysis. By using this approach, a researcher can deduce meaning from the retrieved data or content (Bengtsson, 2016). The study applied a hybrid approach, namely human (computer-assisted) and AI, to analyse the content. The software used was *ATLAS.ti* version 23.2.3.27778 (beta version). The beta version includes integration with OpenAI, an AI-focused organisation (OpenAI, 2023), which performs certain functions such as coding and determining concepts using AI (ATLAS.ti, 2023b).

The top two concepts from each document were first derived using AI and then grouped and retained for later use. Thereafter, the content was coded using three cycles of coding. The first cycle incorporated a hybrid approach, using inductive coding, which considers the terminology used within the documents. This approach can be considered favourable when the researcher wants to limit bias arising from their existing knowledge and the angle of the research (Skjott Linneberg & Korsgaard, 2019). However, inductive coding can result in a large number of codes (Cascio et al., 2019), which need to be reduced to code groups. Code groups were derived during the second coding cycle. During the third coding cycle, the code groups were merged and analysed in conjunction with the concept groups uncovered using AI, resulting in the formulation of three themes. **Figure 4** illustrates the approach followed during this literature review phase.

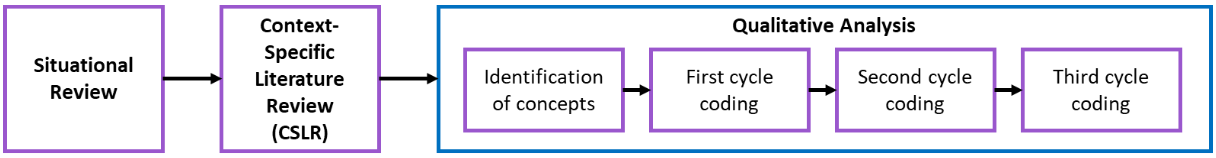


Figure 4. The research approach for setting the scene.

The CSLR returned 1,297 documents based on the search protocol. Twenty-one of these documents were relevant and accessible. By using AI, the study determined that these documents comprised concepts related to healthcare (patient care and procedures), healthcare guidelines (governance and protocols) and human involvement (patients, community and healthcare professionals). The documents also presented views on the challenges in the public healthcare system as well as the opportunities that could improve the current system. Future changes to the overall healthcare system, such as the NHI, were also featured in these documents.

An adaptation of the PRISMA 2020 flow diagram was used to present the identification and screening and included reports of the literature review (Rethlefsen & Page, 2021). **Figure 5** illustrates this adapted layout.

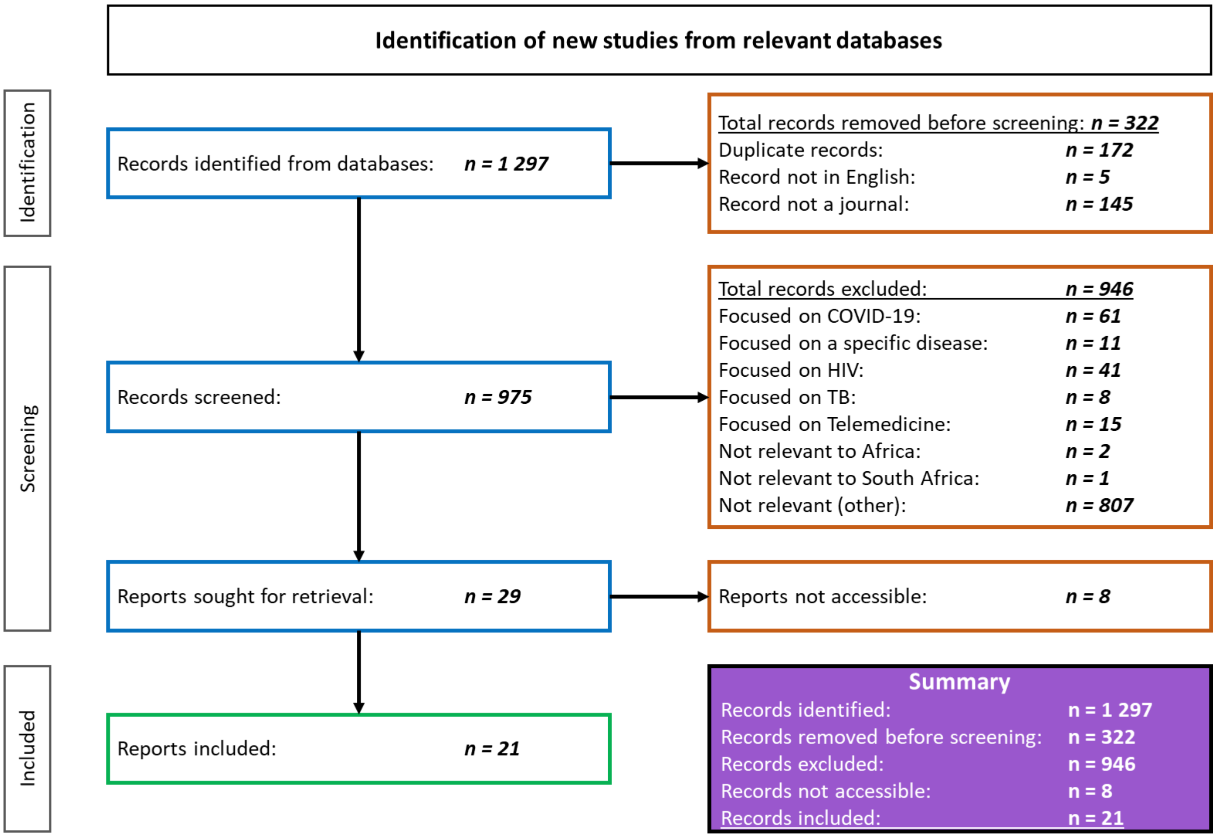


Figure 5. Literature review identification, screening and reports included a diagram presented in an adapted version of the PRISMA 2020 layout.

Following the adapted PRISMA 2020 layout presented in **Figure 5**, 21 documents were found appropriate and accessible for analysis. A high-level analysis was conducted using *ATLAS.ti*. before the detailed qualitative analysis of the 21 documents. During this phase, concepts defined by ATLAS.ti (2023a) as “significant noun phrases” were first identified. These concepts provided an introductory idea of the significant content in each of the documents. **Table 7** presents the top two concepts identified from each document. These concepts were later incorporated into the qualitative analysis to identify the main themes in the literature.

Table 7. Concept identification from the retrieved documents.

Reference	Main concept	One sentence summary of the document
(Zuma, 2022)	(1) Medicine (2) Stock	Medicine stock-outs within the public healthcare system present challenges to patient care.
(Mtotywa et al., 2022)	(1) Country (2) Opportunity	The Fourth Industrial Revolution (4IR) presents opportunities; however, there are challenges associated with leveraging them within the South African context.
(Mantzaris, 2022)	(1) Scheme (medical) (2) Member	The mismanagement of resources is highlighted in this research.
(Makoni, 2023)	(1) Power (2) Hospital	Power cuts have a discontinuous and disruptive effect on patient care at hospitals.
(Coetzee et al., 2013)	(1) Nurse (2) Hospital	The perceptions of nurses from public and private healthcare hospitals are presented in this research.
(Jinabhai et al., 2021)	(1) Data (2) Health	DHIS call out the need for (digital) data within the public healthcare system.
(Mashao et al., 2021b)	(1) Patient (2) Emergency Department	Suboptimal processes can compromise patient care in the emergency department.
(Katuu & Van der Walt, 2016)	(1) Health (2) Record	The need for a national legislative and regulatory framework for healthcare records is highlighted.
(Rikwe & Gie, 2019)	(1) Service (2) Strike	Public healthcare worker strikes impact service delivery (patient care) negatively.
(Troyer & Brady, 2020)	(1) Handover (2) Study	This research paper was not directly related to the South African healthcare system but contained elements relevant to South Africa. Patient hand-over in the emergency department is a critical time for patient care.

(Laatz et al., 2019)	(1) Helicopter Emergency Medical Services (HEMS) (2) Patient	HEMS can impact patient care positively; however, further research is needed.
(Osman, 2018)	(1) Health (2) Service	The NHI aims to unify the South African healthcare systems; however, some concerns need to be addressed before its implementation.
(Park & Yu, 2019)	(1) Nurse (2) Policy	Policies are needed to support the adequate supply of nurses within the public healthcare system.
(Van Hoving et al., 2015)	(1) Emergency (2) Care	Top research priorities relating to emergency care have been presented.
(Moyimane et al., 2017)	(1) Equipment (2) Nurse	Inadequate supply of medical equipment and medical equipment not being serviced affect patient care negatively.
(Passchier, 2017)	(1) Health (2) System	Similar to Rikwe and Gie (2019).
(Wilkinson et al., 2021)	(1) Health Economic Evidence (2) Clinical Practice Guidelines	Health economic evidence is an aspect of patient care and financial management that should be considered in clinical practice guidelines.
(Nhede et al., 2022)	(1) Service (2) Technology	The 4IR can impact service delivery within the public healthcare system positively but should consider the social implications of using technology.
(Mantell et al., 2022)	(1) Community (2) Health	Programmes promoting better patient care and job satisfaction should be considered within the public healthcare system.
(Modisakeng et al., 2020)	(1) Medicine (2) Hospital	The impact of and potential solutions to medicine shortage in the public healthcare system are presented.
(Mukwena & Manyisa, 2022)	(1) Hospital (2) Participant	Factors relating to the implementation of the NHI are discussed in relation to hospital preparedness.

Table 7 demonstrates that healthcare in South Africa is influenced by patient care, healthcare guidelines, digital health systems, community involvement and healthcare professionals. The concepts identified during the high-level analysis were then grouped and are described in **Table 8**.

2.1.2.1 Concept Identification Grouping

The two most prominent concepts from each of the documents were identified using *ATLAS.ti* and are presented in **Table 7**. Thereafter, duplicate concepts were removed, and the remaining concepts were classified into ten concept groups, as described in **Table 8**.

Table 8. Description of the ten identified concept groups.

Concept group	Description
Finance	Financial considerations, such as budgets and the cost of patient care at healthcare facilities, influence public healthcare. Some costs are also incurred by patients when collecting chronic medication, as well as the cost of returning to the facility when a prescription cannot be dispensed in full.
Governance and policies	Governance and policies created by the Department of Health influence the overall healthcare system, including healthcare facilities.
Healthcare challenges	These challenges include finance, social implications, technology, electricity shortages, high staff turnover and medicine shortages.
Healthcare workers	These are doctors, nurses and paramedics and can broadly include healthcare facility managers and operations staff.
Opportunities	Opportunities include governance and policy changes positively affecting the public healthcare system. South Africa’s highly skilled healthcare professionals also benefit the public healthcare system. Future opportunities are represented by the potential benefits of the 4IR as well as new information systems being implemented.
Patient	People seeking medical attention.
Patient care	The ability to provide quality care to people seeking medical attention. Patient care is influenced by finance, governance and policies, challenges and opportunities.
Social	Some social considerations are influenced by finance, challenges, and opportunities in the public healthcare system. For example, 4IR opportunities, which automate tasks, could have a negative social impact in terms of employment.
Stakeholder	People with an interest in healthcare. They can include patients, healthcare workers, policymakers and people involved in healthcare research.
Technology	This includes digital health systems, infrastructure and communication devices.

Once the ten concept groups had been formulated, the first cycle of coding was initiated. The documents were then coded using the inductive approach, and is discussed in **Section 2.1.2.2**.

2.1.2.2 Three Cycles of Coding

The researcher selected inductive instead of deductive coding to limit bias when identifying codes (Skjott Linneberg & Korsgaard, 2019). This approach allowed for codes to be revealed as the documents were analysed. **Section 2.1.2** indicated that a hybrid approach was used during the first cycle of coding. During the human-centred approach, 201 codes were identified. The AI-supported approach revealed 160 codes. Both sets of codes were then grouped. The first group contained 11 code groups, and the second group contained 12 code groups, with 11 in common between the first and second groups. The code groups are described in **Table 9**.

Table 9. Description of the 12 code groups identified as part of the human-centred approach during the second coding cycle.

Code group	Description
4IR challenges	The advantages of the 4IR, such as intelligent automation, can impact South Africa's workforce negatively.
4IR opportunities	The automation of certain tasks and the promotion of synergy between humans and computers afforded by the 4IR can have advantages, such as quality data and efficiency.
Collaboration	Collaboration among staff in healthcare facilities (healthcare workers and other related functions) promotes positive outcomes.
Financial considerations	District and healthcare facility-level budgets must be considered when making decisions related to patient care, medical equipment maintenance and medicine management.
Governance and policies	These can refer to the management of healthcare facilities as well as healthcare practice guidelines.
Healthcare challenges	Challenges include staff shortages, medicine shortages and malfunctioning medical equipment. Future initiatives such as the NHI also contribute to these challenges as there are still unknown variables relating to its implementation.
Healthcare operations	Refer to the daily functioning of healthcare facilities, including patient care and maintenance.
Healthcare opportunities	Refer to solutions (such as new technology, highly skilled personnel, etc.) that can impact healthcare operations positively.
Social considerations	Influences on the welfare of patients and healthcare workers.
Technology considerations	These include infrastructure, electricity supply, training staff, etc.
Technology in use	The current use of technology within healthcare facilities at different levels, such as for patient care, administration, medicine management, etc.
Technology obstacles	Influences such as electricity shortages obstruct the use or implementation of technology initiatives.

Once the code groups had been formulated, the third cycle of coding was performed to determine the relationships between the 12 code groups. Sixty-six relationships were identified, with 20 being unique. **Table 10** presents the relationships between the code groups.

Table 10. Relationships between the identified code groups.

Code groups	4IR opportunities	Collaboration	Financial considerations	Governance and policies	Healthcare challenges	Healthcare operations	Healthcare opportunities	Social considerations	Technology considerations	Technology in use	Technology obstacles
4IR challenges	can hinder	should be reduced by	are associated with	are affected by	can result in	can impede	can stifle	are associated with	are associated with	are associated with	are related to
4IR opportunities		require	are associated with	should consider	should reduce	should assist with	should be aligned with	should consider	should consider	should utilise	can be impeded by
Collaboration			should inform	should inform	should reduce	should assist with	should inform	should inform	should inform	should promote	should reduce
Financial considerations				are associated with	are associated with	are associated with	are associated with	are associated with	are associated with	are associated with	are associated with
Governance and policies					should reduce	should assist with	should support	should consider	should consider	should consider	should reduce
Healthcare challenges						can impede	can stifle	are associated with	should consider	should consider	can be caused by
Healthcare operations							can inform	should consider	are associated with	are associated with	can be impeded by
Healthcare opportunities								should consider	should consider	are associated with	can be impeded by
Social considerations									should consider	should consider	can be influenced by
Technology considerations										can be influenced by	can be impeded by
Technology in use											can be impeded by

Table 10 highlights the relationships between the 12 code groups. These relationships demonstrate that key decisions within healthcare cannot be made in isolation, as some aspects, such as changes in governance and policies, can either burden other areas or impact the healthcare system positively. **Figure 6** illustrates a summary of the analysis.

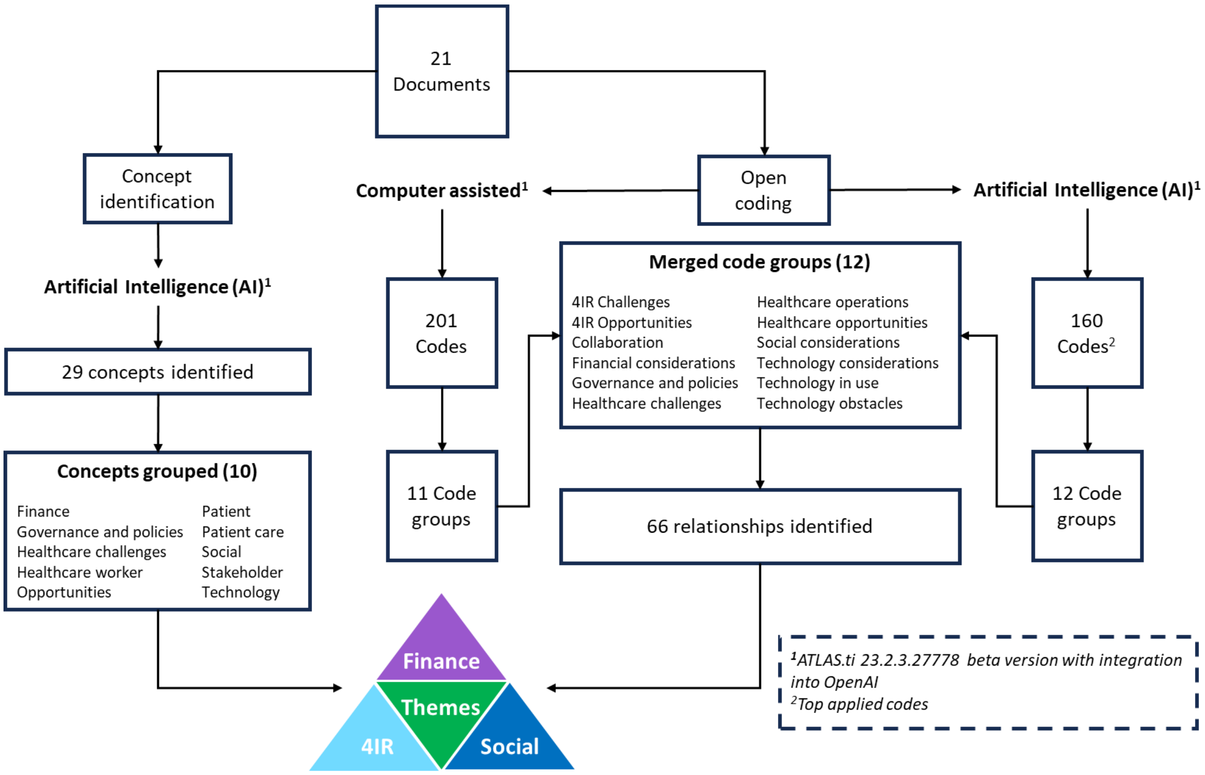


Figure 6. Summary of the data analysis steps and results.

Figure 6 illustrates how the 21 documents were analysed qualitatively. Concepts were identified using the AI functionality of *ATLAS.ti*, leading to the identification of 29 concepts, which were then classified into ten concept groups. The documents were also coded using two approaches, namely computer-assisted (human coding) and AI-driven (using *ATLAS.ti*). The computer-assisted coding resulted in 201 codes, which were classified into 11 code groups. The AI coding led to 160 codes, which were classified into 12 code groups. The code groups were merged to form 12 overall code groups; these code groups were associated with each other, forming 66 relationships. This led to the identification of three main themes: finance, social and 4IR, as illustrated in **Figure 7**.

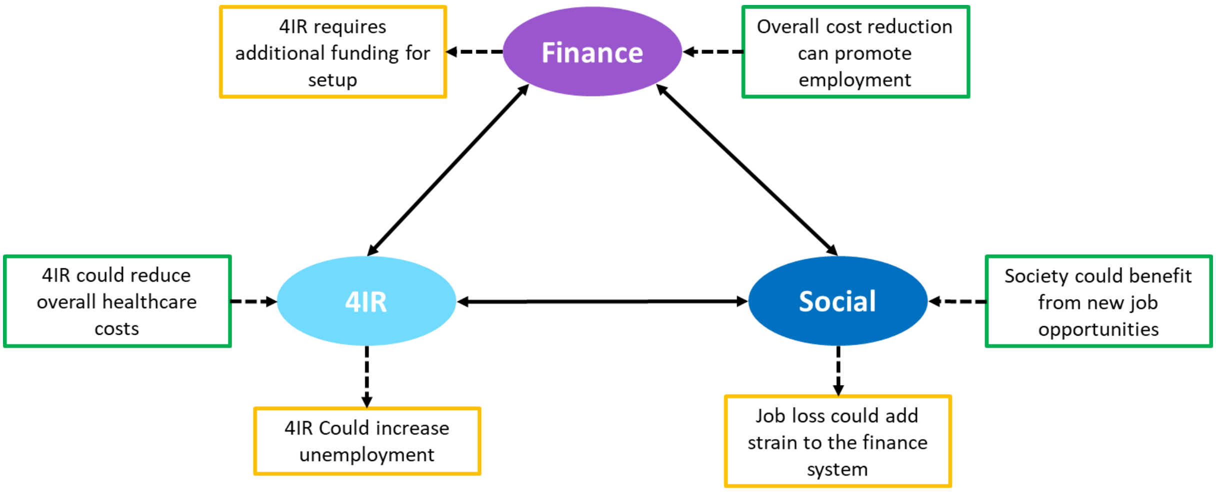


Figure 7. Summary of the three themes and their relationships.

Figure 7 illustrates the three themes from a cost-benefit perspective. The advancements offered by the 4IR require funding (finance), but once implemented, can promote employment in the public healthcare sector. Society (social) can be negatively impacted by the 4IR if certain jobs are automated; however, new employment opportunities can affect society positively. The 4IR can also be used to improve healthcare services and reduce costs (finance).

One of the concerns raised by healthcare professionals is the burden of using new digital health systems because this increases their workload. Furthermore, some are not adequately trained in using new digital health systems. These scenarios relate to the training, resource and legal challenges identified during the situational review. In a study conducted in the USA, a healthcare worker stated the following regarding digital health systems:

> *I don't have time to enter all that [PCR[2]] information. If I have a choice between stopping profuse bleeding and messing around with a laptop, the choice is pretty obvious.* (Troyer & Brady, 2020)

A study in South Africa pointed out the following:

> *Hence, the need for data capturers delegated with the responsibility of data capturing will be highly beneficial to avoid overworking and burnout, which could jeopardise the quality of the data captured.* (Jinabhai et al., 2021)

Therefore, one could deduce from these sentiments that “Doctors want to doctor, and nurses want to nurse”. Healthcare workers should be allowed to perform their primary function with limited disturbance to promote the success of the healthcare system. This outcome must be considered in conjunction with South Africa’s rising unemployment rate (IOL, 2023b).

[2] Patient Care Report

Clinical practice guidelines assist healthcare professionals in making decisions regarding patient care (Wilkinson et al., 2021). These guidelines are intended to promote patient care while simultaneously managing costs. The South African Helicopter Emergency Medical Service Activation Screen (SAHAS) supports similar objectives (Laatz et al., 2019). Other areas of patient care, such as medicine and bed management, have been identified as not yet fully optimised. Decentralised and not fully digitised medicine management systems result in partially filled chronic prescriptions, which compromises patient care (current and future). When prescriptions are partially filled, patients must return to the healthcare facility to collect the rest of their medication, incurring unnecessary transport costs as well as having to take additional time off from work. Bed management that does not produce real-time information causes increased waiting times in the emergency room or delayed admissions, which further compromise patient care. Some of these challenges are intended to be addressed by Gauteng's new HIS; however, it is not yet clear whether all healthcare facilities in the province have been incorporated into the system. The following sentiment regarding the relationship between the emergency department and the wards reveals opportunities that should be considered:

> *Improving coordination and capacity of the hospital bed management by using a computerised bed management system coupled with a dedicated bed manager in the ED who should facilitate the process of inpatient admission.* (Mashao et al., 2021b)

Modisakeng et al. (2020) highlight issues with medicine inventory management. These issues relating to incorrect inventory are apparent even with the use of a digital system. An additional challenge to the healthcare system that could have a negative financial impact relates to medical equipment. Malfunctioning medical equipment can be due to its maintenance not happening at the recommended intervals (Moyimane et al., 2017) or not having the budget to do so. This issue could also be due to a lack of stakeholder involvement.

2.1.3 Summary of Setting the Scene

Fourth Industrial Revolution principles suggest that there should be synergy between humans and technology. One might argue that human instinct combined with quality information could lead to better decision-making. In the case of the woman who woke up in a morgue (**Table 2**), one could reasonably assume that better training combined with adequate governance procedures could have prevented this situation. The section also highlighted that in high-pressure situations, healthcare professionals do not want to use technology; they prefer being hands-on and treating patients. Calls for better bed and medicine management, the prevention of patients being turned away from hospitals, and other incidents caused by a lack of resources emphasise the need for better decision-making at various levels.

Gauteng's new HIS promotes access to good quality information. Since systems rarely exist in isolation, one could assume that information might exist disjointedly and with equally disjointed access to the information. This research pertains to making the right information available to the right people; consequently, an investigation of the public healthcare system's overall technology architecture was necessary. This investigation was the focus of the next literature review phase.

2.2 Technology Architecture Development

The situational review and CSLR uncovered challenges and opportunities related to the public healthcare system first by exploring digital newspaper media and then analysing scholarly literature. Hospital bed capacity and occupancy and medicine management were specifically mentioned. The study notes that the Department of Health has begun rolling out a new HIS, but its capabilities from an overall hospital management perspective have not yet been adequately documented. The relationship between technology and humans (healthcare professionals) within the 4IR, finance and social contexts were also discussed. Thereafter, the impact of the NHI was introduced. Once the groundwork had been laid, it was necessary to understand (from a technology architecture perspective) what measures the Department of Health had taken to reduce the challenges it faces with "as is" and "to be" systems once the NHI is implemented.

Through an in-depth investigation of the Federated Health Information Architecture (Department of Health, 2022), the second phase of the literature review determined that a conceptual digital health model needs to be developed to support the existing architecture. The model must be contextually relevant to current challenges and should support future initiatives such as the NHI.

2.2.1 The South African Healthcare Technology Architecture Context

Real-time hospital occupancy information across relevant healthcare-related facilities in Gauteng is not yet available. Consequently, paramedics might unknowingly transport a patient to an emergency department that has reached capacity. In conjunction with addressing these types of scenarios, the Department of Health aims to migrate South Africa from the current fragmented healthcare system (public and private) to the NHI (Department of Health, 2021b). The NHI aims to unify the healthcare system to benefit all South Africans. This objective requires substantial digital health transformation as existing information systems must be interconnected to provide a seamless experience to healthcare professionals and patients.

This phase of the literature review considered the Federated Health Information Architecture proposed by the Department of Health (Department of Health, 2022) as well as literature published in other countries. Since research and associated scenarios must be contextually relevant (Davison & Martinsons, 2016), the Life Esidimeni tragedy of 2016 (introduced in **Section 1.7**) which was closely linked with patient care and, therefore, patient transfers was considered in assessing the future readiness of the Federated Health Information Architecture.

2.2.2 The National Health Insurance

Globally, healthcare systems are constrained by factors such as ageing populations with chronic conditions (Gibbings & Wickramasinghe, 2021). However, South Africa has an increased burden on emergency services arising from violent crimes (Martin et al., 2017). Health 4.0 poses opportunities for optimising healthcare delivery by incorporating technologies such as cloud computing, fog computing, the Internet of Things and the Internet of Medical Things (Karatas et al., 2022). To realise the benefits of Health 4.0, an all-encompassing health information systems architecture needs to be designed. The proposal of the NHI has necessitated devising an implementation plan and designing a future-state architecture.

The NHI will be implemented in six phases (Department of Health, 2022): (1) Identify national interoperability use cases, (2) Evaluate, validate, refine and prioritise national interoperability use cases, (3) Identify insufficiencies in the health normative standards framework and address them, (4) Articulate related national interoperability specifications, (5) Implement and informally assess national interoperability specifications, and (6) Introduce formal conformance assessment and conformance certification.

Currently, in Phase 2 (2022 to 2026) of the implementation plan, the healthcare delivery mechanisms are being reinforced with more resources and by integrating selected private healthcare services (Department of Health, 2019b). The future-state architecture, focusing on the NHI, has been designed and is based on the Federated Health Information Architecture and is described in **Section 2.2.3**.

2.2.3 Federated Health Information Architecture

Under Step 3 of the NHI implementation plan, the proposed Federated Health Information Architecture was assessed, and potential insufficiencies were highlighted. The “Magnifying the Problem” approach was then employed to identify such architectural insufficiencies (Luse et al., 2023). Health information architecture encourages interactions between users (healthcare workers and patients) and healthcare systems. Federated Architectures promote the interoperability and synchronisation of data between different systems (Damián Segrelles Quilis et al., 2023). Blending the principles of a Federated Architecture with an existing health information architecture result in a Federated Health Information Architecture which affords the interoperability and data synchronisation capabilities onto an architecture that already supports interaction between users and systems. **Figure 8** presents the Federated Health Information Architecture designed for the NHI. The Federated Health Information Architecture proposed by the Department of Health focuses on ensuring interoperability. Interoperability, a key mission of Health Level 7 (HL7) (HL7 International, 2024), supports the idea that synchronising data is preferred to integration, which focuses on the translation of data between heterogeneous systems (Mudaly et al., 2013). The health information exchange in this architecture is responsible for

Orchestration: management of workflows, Messaging: data flow of shared information, and Terminology Service: Data transformation. Notably, the synchronisation of data between clinical systems and emergency services received minimal emphasis.

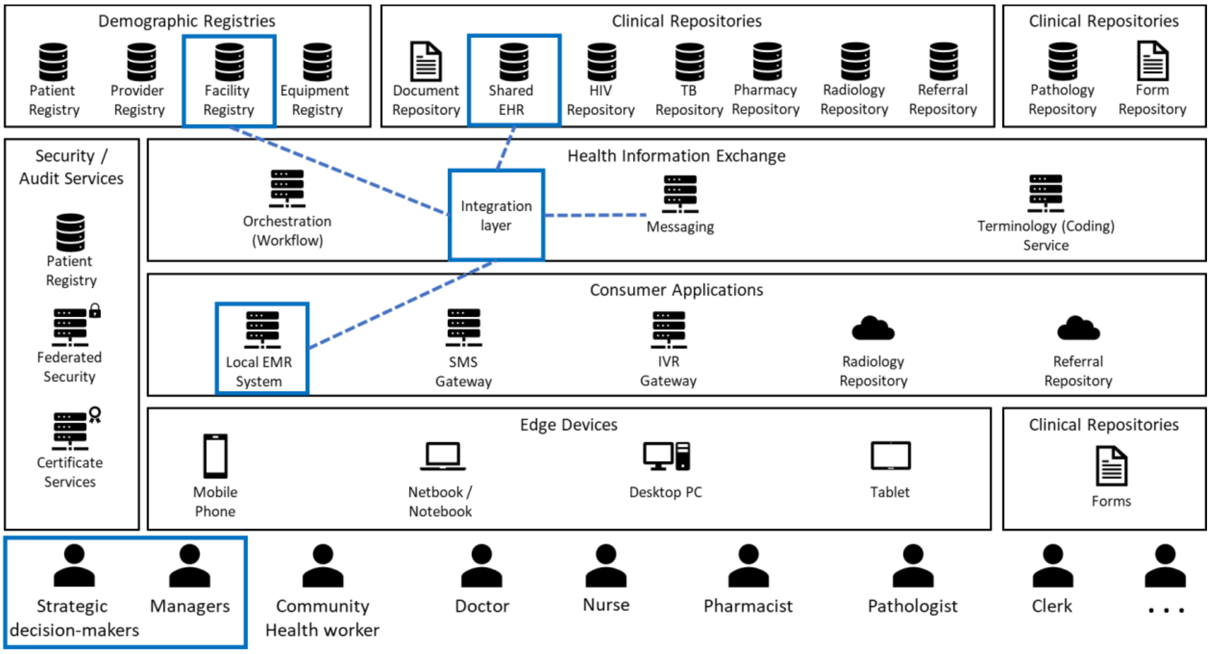


Figure 8. Federated Health Information Architecture with highlighted focus areas based on this research.

Source (adapted): (Department of Health, 2022)

Medical records are depicted as a shared repository within the clinical repository. This layout implies a consolidation of records (Boczar et al., 2023). Based on this understanding, the patient records and, by extension, the data subsets describing the overall state of the healthcare system will reside physically in a central location. Though there are merits to a central repository, such as a single version of the data, this would require all facilities to change to the same HIS to become fully interoperable. No less than five hospital groups operate within the South African private healthcare system: Life Healthcare, Mediclinic, Netcare, Joint Medical Holdings and Lenmed (Hospital Association South Africa, 2023), excluding the thousands of smaller private medical facilities. It is reasonable to assume that hospitals in the private and public healthcare systems do not run on the same HIS or, at the very least, have customised their systems to an extent such that it would require significant effort to consolidate them into a single platform.

Private medical aid schemes, emergency services and healthcare facilities will still feature in some aspects of the NHI. However, these components are not adequately accommodated within the Federated Health Information Architecture. When considering the inevitable heterogeneous landscape, an integration layer, as suggested in **Figure 8**, could support the messaging layer. This would be useful in scenarios such as emergency medical care, patient transportation and inter-facility patient transfers, as EMS systems run on a different platform.

The proposed architecture in **Figure 8** does not contain an overall healthcare monitoring system to be used by strategic healthcare managers for critical decision-making. The proposed Live Healthcare Console could connect systems and combine information in real-time from disparate sources, ensuring a single version of the data. This could be achieved by using an existing or bespoke integration platform.

The Life Esidimeni tragedy of 2016 report (Section27, 2023a) highlights the factors presented in **Table 11**. Considering these factors, it is noteworthy that a lack of real-time access to shared information (paper-based or digital) can have detrimental consequences.

Table 11. Information-related factors that contributed to the Life Esidimeni tragedy of 2016.

Contributing factors related to information processing	**Comments**
Lack of medical authorisation for patient transfer	Insufficient digital records existed for several patient transfers between the origin and destination healthcare facilities.
Lack of clinical assessment evidence	Insufficient digital records of clinical assessments performed on the patients prior to being transferred. The follow-on effect resulted in a lack of available future or chronic medical records.
Lack of patient monitoring	Insufficient digital records existed for monitoring the patients' conditions during the transfer process.
Receiving staff were unable to interpret the incomplete medical records in cases where they were received	Receiving staff were not trained or did not know how to interpret the medical records received and were thus unable to provide the necessary medical care.
Insufficient handover and control of medical supplies received	Insufficient digital records were available to support the control of medical supplies received, thus leading to deficient patient care.

Source (adapted): (Health Ombud, 2022)

At this point, it might be useful to consider the "poka-yoke[3]" principle of ensuring that systems and processes are mistake-proof (Saurin et al., 2012). Consequently, the recommendations in **Section 2.2.4** have been created to support the proposed NHI technology architecture and to minimise information inconsistencies.

2.2.4 Recommendations Related to the NHI Technology Architecture

The identification of insufficiencies is a key element of enterprise architecture. Step 3 of the NHI implementation plan refers to the identification of insufficiencies in the health normative standards

[3] Japanese term meaning to avoid unexpected surprises, poka-yoke is a safeguard that prevents a process from proceeding to the next step until the proper conditions have been satisfied and accepted.

framework. The insufficiencies and recommendations in **Table 12** refer to the Federated Health Information Architecture proposed by the Department of Health.

Table 12. Insufficiencies and recommendations relating to the Federated Health Information Architecture.

Possible Insufficiency	Recommendation
The shared electronic health record is depicted as a single, shared repository. This is an oversimplified view which assumes that the existing and future systems will be interoperable.	An integration layer needs to be considered to ensure that heterogeneous systems can share and transmit patient records to healthcare providers at the point of patient care, which is an aim of the Department of Health (Moonsamy & Singh, 2019). Access to accurate patient records can support the allocation of resources based on individual patient needs.
The stakeholder list in the Federated Health Information Architecture has omitted key decision-makers.	The stakeholder list should include strategic decision-makers who require selected data subsets to make important decisions. Managers (which can include EMS managers) who require other levels of information and processing should also be included. These additional stakeholder types will assist in revealing related use cases per Steps 1 and 2 of the NHI implementation plan.
Emergency care and patient routing are not adequately depicted.	The health information exchange should include integration to translate messages between heterogeneous electronic medical record systems and healthcare facilities (private and public).
Medical aid schemes are not represented in the architecture	Medical aid schemes will still exist after the NHI has been implemented. These organisations require access to certain electronic health records and, therefore, should be included in the architecture.
Architectural standards are not yet as mature as the UK's National Health Service.	The UK's National Health Service architecture principles should be consulted when creating the frameworks for the NHI (NHS75, 2020).

The recommendations presented in **Table 12** are important because of the scale of the NHI implementation. The heterogeneous landscape will require a large amount of integration between different systems. The impact of third parties, such as medical aid schemes, must also be considered.

2.2.5 Summary of Technology Architecture Development

Section 2.2 highlighted that poor quality, disjointed or inconsistent health information can have negative consequences, particularly during patient transfers, emergency care and facility management. During this literature review phase, the lessons learnt from the recent Life Esidimeni tragedy were considered in assessing the Federated Health Information Architecture proposed by the Department of Health. This led to recommendations that could ease some of the inevitable challenges during a large HIS project. One of the key recommendations is the need for an integration layer that can translate and share information between healthcare facilities as well as parties such as EMS, whose technology landscape is not directly linked to healthcare facilities. It is recognised that health information exchange layers such as OpenHIE and Fast Healthcare Interoperability Resources (also referred to as FHIR, pronounced as "fire") aim to connect disparate digital health systems and to make patient records accessible via different platforms (OpenHIE, 2024; Outcome Healthcare, 2024). The Federated Health Information Architecture proposed by the Department of Health suggests the use of a health information exchange layer. However, the purpose of the proposed integration layer is to connect high-level information, such as hospital bed occupancy, and not patient-level information, between healthcare facilities (including EMS) and other third parties. The aim is for the integration layer to serve as the core of the Live Healthcare Console by housing the connected high-level information and not just translating such information for exchange.

The present study needed to search academic literature to determine whether an existing digital health model that meets the uniquely South African public healthcare system requirements already exists to avoid recreating an existing and appropriate design model for the Live Healthcare Console. During the next phase of the literature review, relevant academic literature was searched to find and evaluate digital health models to determine their suitability to the South African context.

2.3 Existing Healthcare Design Models

Gauteng's new HIS, together with district health information systems, have been implemented to support the public healthcare system (Gauteng Province Health, 2017; news24, 2023e). Related to these systems is the National Indicator Data Set, which includes indicators such as inpatient management (Day & Gray, 2017). However, the National Indicator Data Set is based on historical data and is available monthly, not in real-time. The historical rather than real-time availability of the data could be a result of the disjointed nature of information systems implemented in developing countries (Nguyen, 2023b), including South Africa.

It was noted during the technology architecture development phase of the literature review that an integration layer (residing within the health information exchange in **Figure 8**) could serve to provide a single view of high-level information for key stakeholders. The system initially introduced in **Section 1.1** as a Live Healthcare Console would, however, first need to be designed and modelled.

Hence, the purpose of this literature review phase was first to identify existing digital health design models and second to evaluate them to determine their suitability within the South African context. Reusability is a commonly accepted principle in information systems. Therefore, it is reasonable to assume that this includes the reuse of digital health design models.

A graphical design model was selected for this research as models can be used to describe a problem and suggest new ideas by describing the necessary components and stripping away those that are unnecessary (Olivier, 2004). Eslami Andargoli et al. (2017) argue that the identification, evaluation, and interpretation of the available resources related to a subject are fundamental components of a literature review. During this phase of the literature review, relevant digital health graphical design models were identified, evaluated and discussed.

Five digital health models were identified and evaluated using a custom evaluation framework. The digital health models were evaluated within the South African context, emphasising local principles to determine whether or not they applied to the South African public healthcare system. A public healthcare management view, from a district or provincial level, was considered during this phase. The study determined that none of the evaluated models were a perfect fit for the unique South African context.

The researcher implemented elements of a systematic literature review, such as a systematic search strategy (Snyder, 2019) and screening of existing literature (Moonsamy, 2021) during this literature review. One of the aims of the literature review was to investigate and evaluate existing digital health design models. The *ScienceDirect* database, which houses scientific and medical research journals (ScienceDirect, 2023), was primarily used to search for relevant material. Over 100 search terms related to eHealth and information systems models were used for six months. **Appendix 8.11** indicates the search terms that yielded the top ten number of results. The search terms were categorised as follows:

- eHealth – Domain-specific related to eHealth
- General – General terms related to the topic
- Information Systems – General information systems-related terms

A total of 82 articles published from 2000 to 2023 were deemed relevant based on their abstracts, models, figures and results. These articles were studied, and their insights were incorporated into this research. The literature search results related to digital health models were retained. The models from these articles formed the core of the digital health model evaluation. The evaluation criteria are explained in **Section 2.3.2**. The study considered the principles to guide the development of a Live Healthcare Console before evaluating the digital health models. These are discussed in **Section 2.3.1**.

2.3.1 Guiding Principles of Developing a Live Healthcare Console

Carr, Christ, and Ferro (2023) state that the intersection of appropriately implemented technology and human participation within digital health systems produces outcomes exceeding that of isolated human involvement. Tully et al. (2013) argue that the Data-Information-Knowledge-Wisdom (DIKW) pyramid is an appropriate apparatus to use when investigating digital health system components. The DIKW pyramid is rearranged as a sequence in **Figure 9** to illustrate the steps that could lead from eHealth data to wisdom.

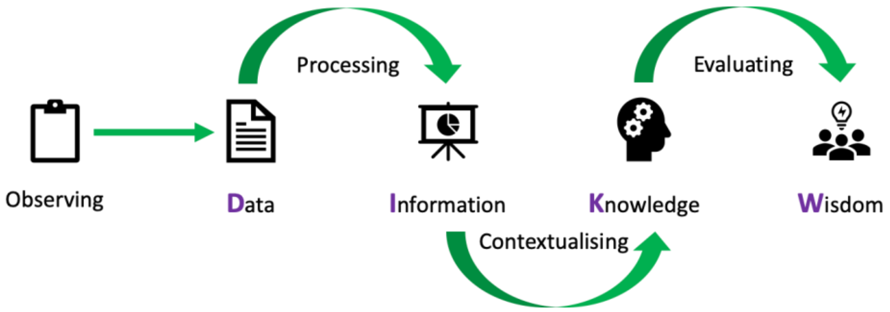


Figure 9. Steps needed to move from eHealth data to wisdom.

Source (adapted): (Tully et al., 2013)

Figure 9 highlights three steps: Processing, Contextualising and Evaluating. These steps can be understood as follows:

- Processing – Hospital occupancy data are combined with healthcare department information.
- Contextualising – Grouping data by region or province to discover patterns.
- Evaluating – Using the contextualised information to inform decision-making.

The level of risk in making decisions decreases as data moves to wisdom (Hussain et al., 2021). Thus, minimising risk and uncertainty within the healthcare ecosystem can lead to better decisions at the appropriate levels. **Figure 10** illustrates the clinical and operational organisational structure of the healthcare ecosystem in Gauteng. The organisational structure also depicts decision-making at various levels, which can be supported with live hospital occupancy information.

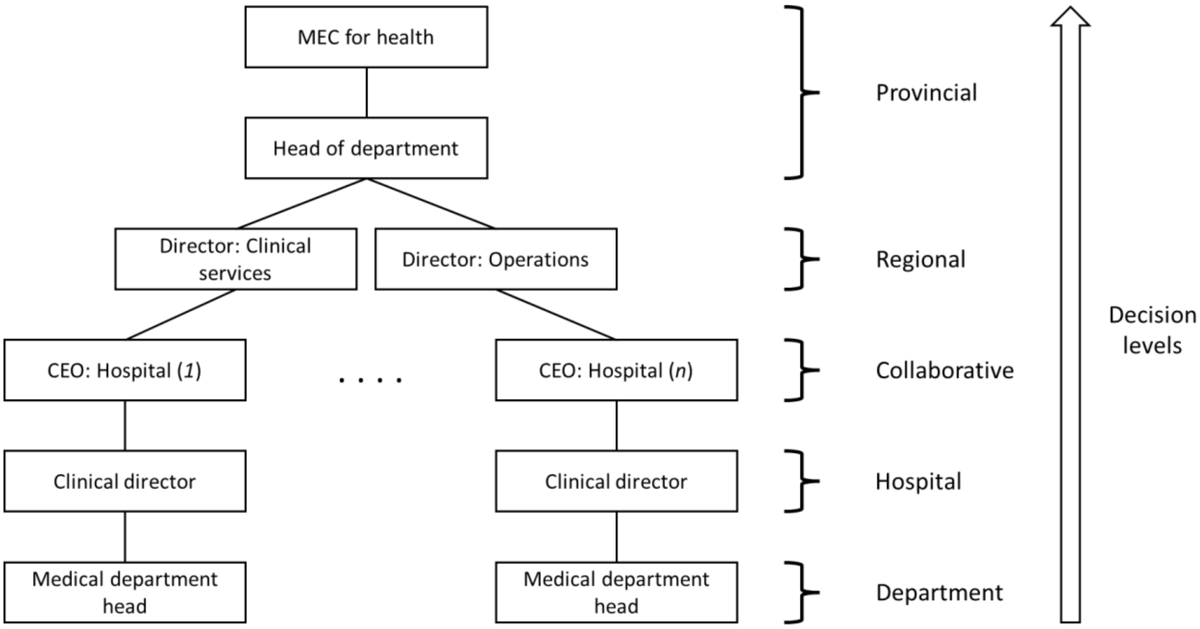


Figure 10. Organisational structure of the Gauteng healthcare ecosystem.

Source (adapted): (Department of Health, 2021a)

The Batho Pele Principles (may be referred to as the BPP) initiated in 1997 (Luthuli & Kalusopa, 2018) were created by the South African Government to promote service delivery (Joel, 2022), which includes healthcare services (Khoza & Du Toit, 2011). The organisational structure illustrated in **Figure 10** can support some Batho Pele Principles, such as resolving complaints, providing information and ensuring adequate service standards. The Batho Pele Principles are evolving and currently include nine principles (sometimes referred to as guidelines), described in **Appendix 8.12**. These principles can be supported by the DIKW pyramid, allowing for informed decisions from the point of patient care to strategic levels.

The Batho Pele Principles described in **Appendix 8.12** were incorporated into the evaluation criteria of the existing digital health models. During this literature review phase, graphical models describing solutions or ideas related to eHealth were investigated to determine their merits and limitations. The researcher visually inspected and evaluated the models by using the evaluation criteria described in **Section 2.3.2**.

2.3.2 Evaluation Criteria Defined

Odhiambo-Otieno (2005) identified a set of evaluation criteria for the three phases of information systems implementation for the District Health Management Information Systems in Kenya. These phases are Pre-Implementation, Concurrent and Post-Operational. Since this research focuses on a design model, only the first phase (Pre-Implementation) was considered. These criteria are described in **Appendix 8.13**.

The human, organisation and technology-fit factors (HOT-fit) is a framework aimed at HIS evaluation (Yusof et al., 2008). The themes and dimensions that form part of this framework are described in **Appendix 8.14**.

The four main aims of a digital health model were conceptualised with the intention that they would contribute to the critical success factors (CSFs) of a digital health system. The digital health model aims for the Live Healthcare Console are to combine healthcare information from existing sources (combine), communicate information with key stakeholders (communicate), support collaboration with key stakeholders (collaborate) and connect existing systems (connect). These CSFs can include customer acceptance (which can include patients), interoperability and stakeholder collaboration (Kumar et al., 2023). Of note is that even though interoperability has been identified, integration can also be considered in cases with heterogeneous systems. The four main digital health model aims are described in **Appendix 8.15**.

Forming a relationship between real-time hospital capacities across the various hospitals in Gauteng requires the aims described above to be considered when establishing a set of evaluation criteria. The themes, dimensions and investigated evaluation criteria were then combined into the final evaluation criteria. These criteria and their relationship with the Batho Pele Principles are defined in **Appendix 8.16**.

Each of the five selected digital health models was scored based on the evaluation criteria, which produced a score out of 25. The scores were then grouped according to the digital health model aims. They were scored as follows: combine (score out of six), communicate (score out of four), collaborate (score out of nine) and connect (score out of six).

The aims and evaluation criteria were then matched. They were assigned a score of one (1) if the model provided for the evaluation criterion and nil (0) if it did not. The Batho Pele Principles were categorised by the evaluation criteria and scored out of 33 based on the scoring matrix as presented in **Table 13**. Weighted scoring was not applied to the criteria as an equal weighting was assumed. Scoring was applied only for the relevant aims.

Table 13. Evaluation scoring matrix

Evaluation criteria	Aims of the model				
	Combine	Communicate	Collaborate	Connect	Total
Adequacy	1	1	1	1	4
Compatibility	1			1	2
Data handling	1	1		1	3
Effectiveness			1		1
Environment				1	1
Information quality	1	1		1	3

Information systems standards			1		1
Security	1		1	1	3
Service quality			1		1
Structure			1		1
System quality	1	1	1		3
System use			1		1
User satisfaction			1		1
Total	**6**	**4**	**9**	**6**	**25**

Principle name	Batho Pele Principle				
	Combine	Communicate	Collaborate	Connect	Total
Best value	1	1	1	1	4
Information	3	1	2	2	8
Courtesy	2	1	1	2	6
Openness and transparency	1	1		1	3
Service standards	1	1	4	1	7
Customer impact			1	1	2
Access			1		1
Redress			1		1
Consultation			1		1
Total	**8**	**5**	**12**	**8**	**33**

2.3.3 Digital Health Model Evaluation Results

The study selected five digital health models from the 82 relevant articles to be investigated in this research. Their selection was due to their relevance to certain Batho Pele Principles as well as the four aims of a digital health model.

Model 1: Holistic eHealth model (Al-Sharhan et al., 2019)

Model 1 is based on the Kuwaiti healthcare system and intends to address issues such as healthcare environment complexity, copious amounts of information and the lack of a consolidated eHealth view. In addition, the large number of systems, rules, procedures and stakeholders within the eHealth domains pose significant obstacles. Therefore, the model aims to address these concerns. The scores for Model 1 are presented below:

Evaluation criteria: 76%

BPP: 82%

Aims: 75%

The model illustration and detailed evaluation scores are presented in **Appendix 8.17**.

Model 2: The computing ecosystem suitable for modern and future medical applications (Alekseeva et al., 2022)

Model 2 illustrates the use of cloud computing for storing and sharing large amounts of health-related data, which was influenced by Finland's healthcare system. The recent influx of wearable devices that use cloud-based services has made a significant contribution to the amount of eHealth data being generated. This refers to patient data and not necessarily hospital occupancy data; however, the overall model does contain various aspects useful to this scenario. The scores for Model 2 are presented below:

Evaluation criteria: 40%

BPP: 42%

Aims: 50%

The model illustration and detailed evaluation scores are presented in **Appendix 8.18**.

Model 3: Experimental environment setup (Da Silva et al., 2019)

The main scenario of Model 3 is based on the Brazilian perspective and pertains to assisted living for patients who require constant monitoring. Information from wearables and other devices is shared in real-time with healthcare services. The increasing number of wearable devices that constantly generate and share information might introduce additional strain to a cloud-based system. Thus, new technologies, such as Software Defined Networking[4] and Autonomic Network Management,[5] play a role in this model. The scores for Model 3 are presented below:

Evaluation criteria: 76%

BPP: 82%

Aims: 75%

The model illustration and detailed evaluation scores are presented in **Appendix 8.19**.

Model 4: Elements of the IoT for enabling sustainable smart environments (Deebak et al., 2022)

Some of the challenges associated with modern urban cities can be alleviated by using smart city services (Kim, 2022). Model 4 emphasises improved healthcare by using IoT devices. A distributed approach can offer advantages to existing cloud-based infrastructure as it can reduce network traffic and intensive data processing needs. The scores for Model 4 are presented below:

Evaluation criteria: 76%

[4] A networking approach which supports cloud-based computing through the use of software.
[5] A self-managing networking approach.

BPP: 82%

Aims: 75%

The model illustration and detailed evaluation scores are presented in **Appendix 8.20**.

Model 5: Design of smart ambulance system (Dumka & Sah, 2019)

Model 5 has influences from the Indian healthcare system and illustrates that when coupled with remote mobile health systems, eHealth services can be enhanced. During an emergency, real-time patient data (raw data) from an incoming ambulance can be shared with doctors and other healthcare professionals waiting for the patient to arrive. This information could improve the doctors' ability to assist the patient. The scores for Model 5 are presented below:

Evaluation criteria: 76%

BPP: 82%

Aims: 75%

The model illustration and detailed evaluation scores are presented in **Appendix 8.21**.

Models 1, 3, 4 and 5 shared the same overall scores, although Model 2 scored lower overall. This is because it did not represent a consolidated repository and inadequately represented the relevant stakeholders. The scores of all five models were simplified and averaged based on the digital health model aims and expressed as a percentage. If an aim was provided for in a model, then a score of one (1) was assigned; if not, no score was assigned. The summary of the scores is represented in **Table 14**. The detailed model evaluation calculation is presented in **Appendix 8.22**.

Table 14. Summary of model scores based on the four digital health model aims.

Model	Combine	Communicate	Collaborate	Connect
Model 1		1	1	1
Model 2		1		1
Model 3		1	1	1
Model 4	1	1	1	
Model 5	1	1	1	

The average score for the five models was 70%, as illustrated in **Figure 11**.

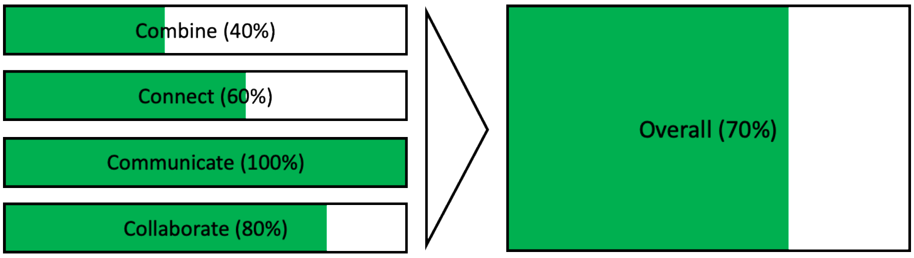


Figure 11. The combined evaluation results for all five models.

The five investigated models were evaluated against the aims of a digital health model underpinned by the Batho Pele Principles specific to South Africa. The investigated models, with roots in Brazil, Finland, India and Kuwait, were created from their distinctive perspectives. Specific contexts can influence analyses (Davison & Martinsons, 2016), which could explain why none of the models scored 100% for all the digital health model aims. Accordingly, in the South African context, a model encompassing local factors would be more appropriate. However, this model should also embody elements of generalisability (Cheng et al., 2016) for it to be valuable in similar settings, such as other African and developing countries.

The Life Esidimeni tragedy demonstrated the need for better information, which could inform better decisions, resulting in more desirable outcomes. Therefore, when targeting these benefits, digital health models should promote more than just big data collection. The data should eventually lead to wisdom that could inform immediate and future healthcare objectives. Thus, a model supporting the four aims identified in this research and addressing the South African context does not yet exist.

2.3.4 Summary of Existing Healthcare Design Models

From the 82 pertinent articles, five played a pivotal role in this phase of the literature review, as they contributed to the five digital health models that were evaluated. The overall score of 70% showed that the models encompassed most of the digital health model aims, but no single model provided for all the digital health model aims or the Batho Pele Principles. Though these models did not individually provide for all the aims, together, they contributed valuable insights.

Healthcare information and supporting systems exist, yet do not always support positive outcomes. The Life Esidimeni Section27 report stated that during the interfacility transfers, patient records were lost, and, in some cases, the whereabouts of the patients themselves were unknown (Section27, 2023b). Hence, some facets of the healthcare system, such as real-time hospital occupancy information, must be suitably designed. A new model incorporating the merits of the five investigated models as well as emerging technologies would need to be created to accomplish the four digital health model aims identified in this phase of the literature review targeting the uniting and disseminating of real-time eHealth data. **Section 2.4** discusses the initial design of the new model.

2.4 Construction of the Design Model for a Live Healthcare Console Version 0.1

The first literature review phase led to an understanding that some of the challenges within the South African public healthcare system could be alleviated using real-time information furnished to the right stakeholders at the right time. The second phase identified insufficiencies in the Department of Health's proposed future-state architecture. This led to recommendations, one of which was incorporating a specialised layer within the health information exchange to communicate and house high-level healthcare-related information. The third phase sought to determine whether an existing digital health graphical design model would fit the South African context and provide the anticipated benefits to limit rework. It was concluded that a specialised and contextual design model does not yet exist, giving rise to the need for creating a new model. Such a model should be contextually relevant to the South African public healthcare system and should also incorporate knowledge from other tried and tested models.

This section discusses the construction of the initial version of the design model, termed Design Model for a Live Healthcare Console version 0.1. The construction of the model was centred around the four main aims of the Live Healthcare Console, namely to combine, communicate, collaborate and connect information with key stakeholders. Sub-models were initially created and then fused to formulate the initial model. The model was also created while considering existing supporting technologies and is discussed in the upcoming sections.

2.4.1 Promoting the Broadcasting of Hospital Occupancy information in Gauteng

Improved infrastructure like information and communications technology (ICT) plays a crucial role in enabling Africans to access healthcare (Arimah, 2017). Such technological interventions can also contribute towards the concept of a smart city, which has been a global phenomenon for over two decades (Söderström et al., 2021) and is part of the "Johannesburg 2040 Growth and Development Strategy" (Bwalya, 2019). The Internet of Things (IoT) has also contributed towards healthcare possibilities and thereby improved quality of life (Rathi et al., 2021).

Electronic health record research focuses on patient-level details. In addition, other levels of data, such as those that can be reported at the facility, regional and provincial levels, are also considered. A 2019 study by Qehaja, Abazi, and Hajrizi observed that higher-order data, such as facility-level information, can be used in decision support systems. The eHealth aims at these levels should influence the HIS being developed (Cloutier & Brendle-Moczuk, 2020). **Figure 12** summarises the eHealth trends.

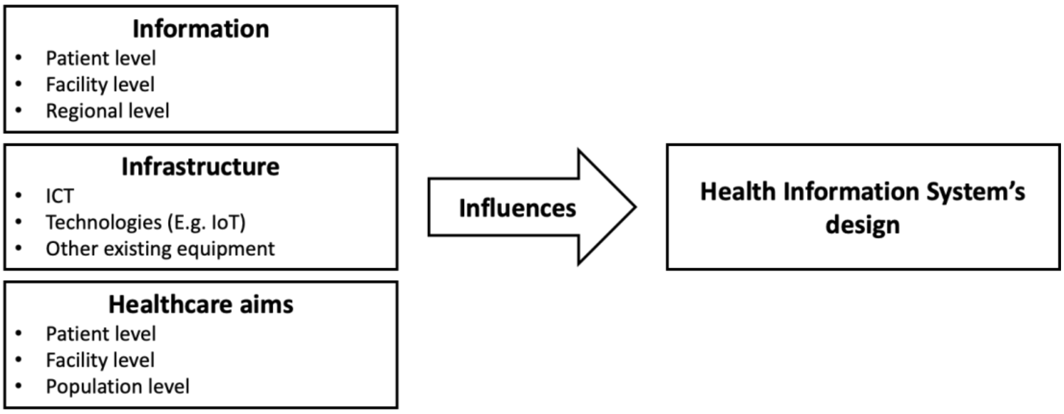


Figure 12. Health information system design influences.

Figure 12 indicates that three key factors influence the design of an HIS, with the assumption that the information or data are in a digital format that can be easily transferred and consumed by an HIS. Infrastructure includes ICT and related technologies. Again, the assumption is that equipment like laptops, screens, cables, and others are in place to support the HIS. Healthcare aims consider individual patients, challenges to overcome at the facility level as well as overall population-level aims. Another important dimension considered in the literature but perhaps understated in HIS design is stakeholders, who, in this case, can include users (those who create and use digital data at the patient level) as well as those interested in high-level data often reported at the facility or regional level.

The Freeway Management System (FMS) was launched by The South African Roads Agency Limited (SANRAL) in October 2006. One of the aims of this initiative was to inform road users by keeping them up-to-date with accurate information. The FMS is related to intelligent transport systems (ITS), which are supported by technology to promote an effective transport system (Bester, 2009). ITS have several applications, including route optimisation from a road user's current locale to services like hospitals (Sharma & Shabaz, 2022).

The ITS network in Gauteng started at 185 km in Phase 1 and consisted of 60 variable message signs (VMS) (Bester, 2009). VMS are digital boards mounted on the roadside that provide drivers with real-time information (Hernando et al., 2022). Though no implicit applications relating to the use of ITS and VMS have been observed in the South African healthcare system, the VMS operations process below demonstrates a generalised approach to displaying a variable message, as illustrated in **Figure 13**.

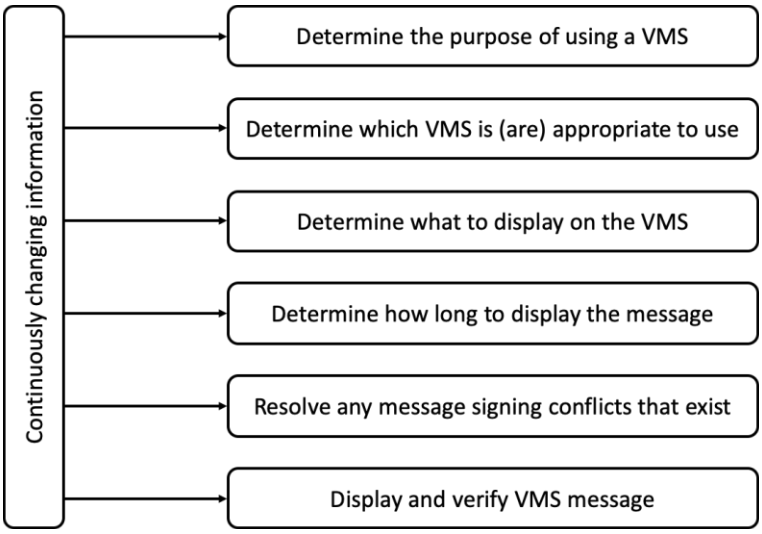


Figure 13. VMS operations process in Gauteng.

Source: (The South African National Roads Agency Limited, 2010)

A Live Healthcare Console could utilise the existing ITS infrastructure as a medium through which to share healthcare-related data with road users, EMS and patients. Information could be collected from multiple sources, funnelled through an integration layer and shared with relevant signboards. **Appendix 8.23** illustrates the current use of VMS and also demonstrates how healthcare information could be shared with road users.

This section noted the existing technologies and infrastructure in Gauteng, which could be of potential benefit to the Live Healthcare Console either directly or as a downstream application. **Section 2.4.2** contains a discussion of existing and emerging trends making an impact on digital healthcare systems.

2.4.2 Supporting Technologies

Cloud computing applications have become more useful and widespread. Cloud computing turns a database into a virtual form that is accessible remotely (A. Hassan et al., 2022). Edge computing, which has been in use for over a decade, addresses some of the challenges associated with cloud computing (processing and storage) by relocating the processing and storage closer to the storage layer. As a result of this, edge computing can provide healthcare applications (Sahni et al., 2022). Fog computing is a technology that can ease some of the constraints related to cloud computing, such as large data packet sizes; it uses techniques like compression to reduce the data packet sizes, which eases the burden on the cloud (Sadri et al., 2022).

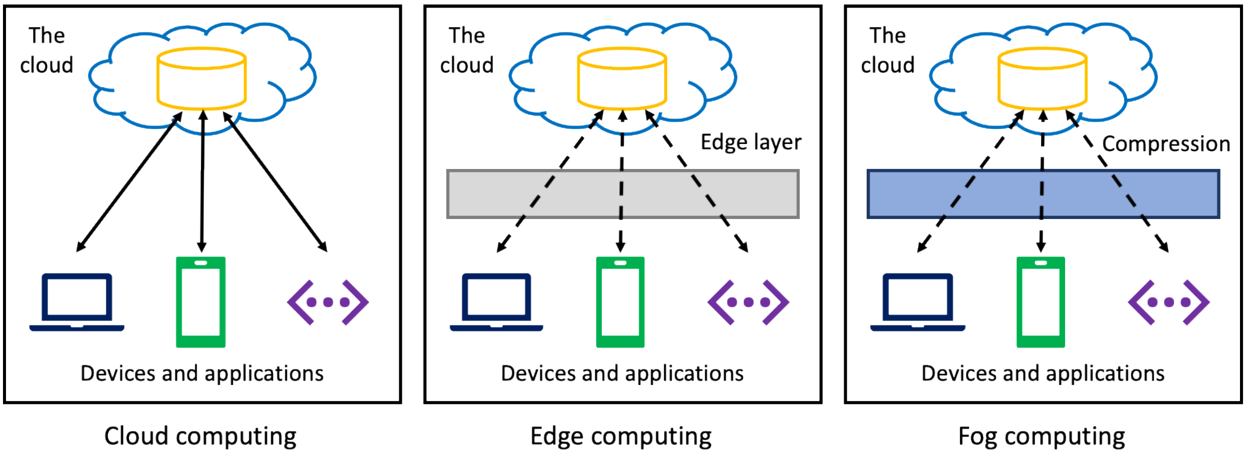


Figure 14. Illustration of cloud, edge, and fog computing

Source (adapted): (Liang et al., 2022)

Figure 14 provides a modest view of these three powerful technologies. Nevertheless, this view indeed incorporates the salient aspects considered in the development of the Design Model for a Live Healthcare Console version 0.1. A centralised system can be enhanced by utilising an edge layer to ensure that selected processing can occur away from the cloud, thereby freeing up its resources. A fog layer in the form of compression techniques can reduce the data packet size, further optimising the resources used by the cloud.

The use of cloud computing, edge computing and fog computing within healthcare and other cloud-based applications were introduced in the preceding section, also noting benefits such as reduced processing times. The upcoming sections introduce the components of the Live Healthcare Console's design model. Existing infrastructure, as well as emerging technologies, are incorporated into these components where appropriate.

2.4.3 Combine → Combining Information from Various Sources and Making it Available to the Right Stakeholders

The Combine aim, identified in **Section 2.4**, relates to storing high-level healthcare data in a centralised repository, which can be created by the providing systems like healthcare facilities and consumed by other systems and stakeholders. A centralised design depicted in **Figure 15** reduces data traffic, as the consuming systems communicate with the centralised system and not with the individual systems.

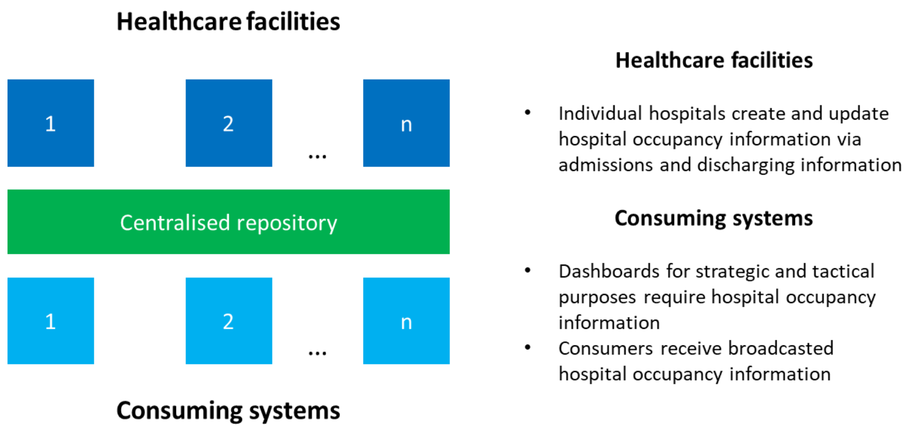


Figure 15. Sub-model illustration of the centralised repository

Figure 15 illustrates the placement of the centralised system within a simplified landscape. **Section 2.4.4** discusses the communication between the systems and the sharing of data.

2.4.4 Communicate → Communicating Information with Stakeholders and Systems

Communication was another aim uncovered during the literature review. **Figure 16** illustrates the communication of healthcare data by applying unidirectional and bidirectional arrows. The researcher observes that data can be created by the providing systems such as healthcare facilities. Such data can be uploaded into the centralised repository. Data stored in the centralised repository can then be requested by the consuming systems. This flow of data is illustrated by the bidirectional arrows.

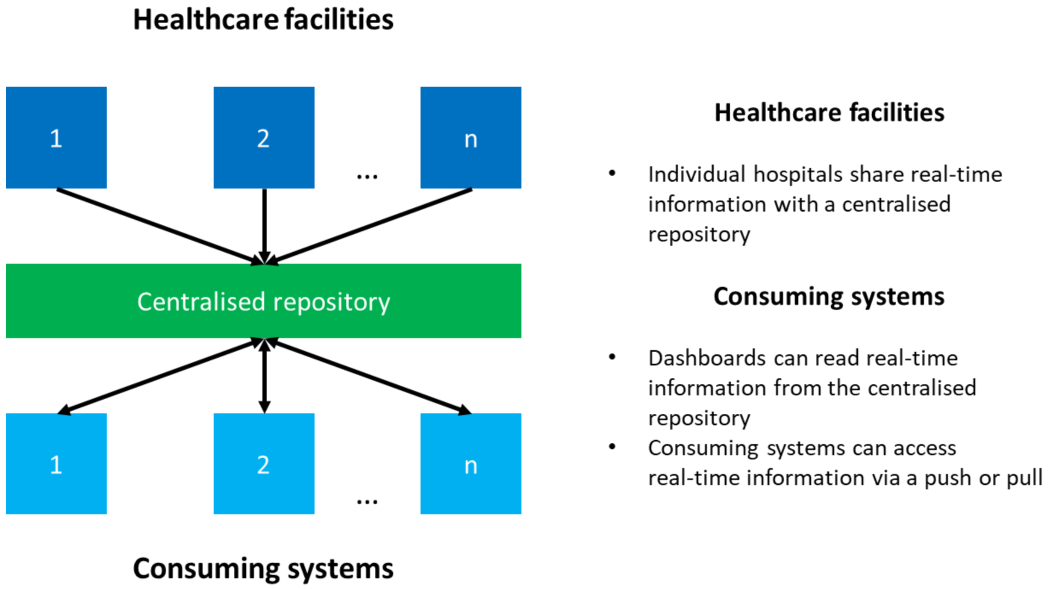


Figure 16. Sub-model illustration of communication.

Figure 16 also highlights an unknown number of providing and consuming systems. This intentional design element demonstrates that providing and consuming systems could be added or removed from the landscape with minimal impact on other providing and consuming systems. Communication between systems and stakeholders promotes collaboration, as discussed in **Section 2.4.5**.

2.4.5 Collaborate → Enabling Collaboration among Key Stakeholders

Stakeholder involvement, as well as communicating with stakeholders (bidirectional and broadcast), were identified as key elements that can promote positive outcomes in the public healthcare system. The sub-model illustrated in **Figure 17** describes four stakeholder groups, from the public to provincial managers. Healthcare information can be shared by using governance procedures to limit access to sensitive information. Therefore, information can be furnished to stakeholders based on their categories.

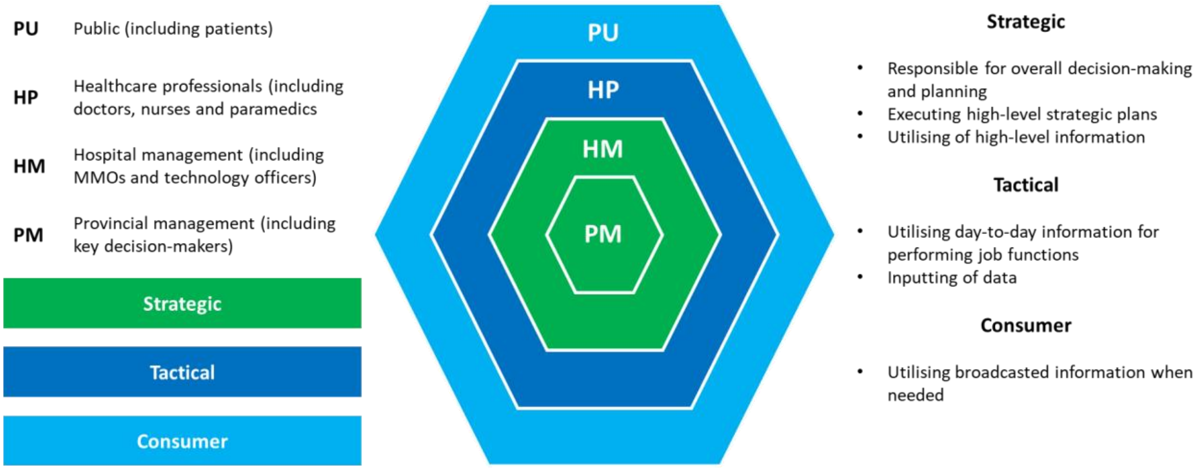


Figure 17. Sub-model illustration of collaboration

Figure 17 describes three stakeholder categories: Strategic, Tactical and Consumer. Each category can act as a “wrapper” to protect various information levels. These categories could also be applied to consuming systems. **Section 2.4.6** discusses the connectivity of systems.

2.4.6 Connect → Connecting Systems and Information with Key Stakeholders

The centralised repository has been positioned at the centre of the connect sub-model to illustrate that external systems (provider and consumer) must go through another level or system to access or input data.

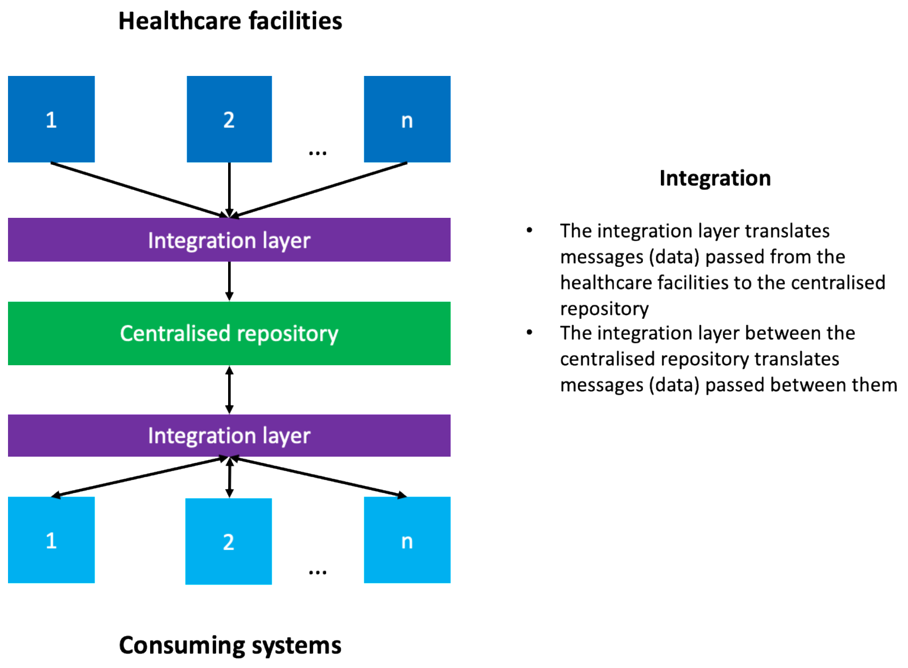


Figure 18. Sub-model illustrating connecting systems.

Figure 18 illustrates how an integration layer can be used to ensure that all the systems do not read or write directly to the central repository. This could serve to preserve the integrity of the data. New systems can also be integrated into the environment by connecting to the integration layer. Edge and fog functionalities introduced in **Section 2.4.2**, such as distributed processing and compression, can also be supported by this layer.

2.4.7 Design Model for a Live Healthcare Console version 0.1

The four sub-models introduced in **Sections 2.4.3** to **2.4.6** were fused into a single model to unite the four model aims (combine, communicate, collaborate and connect). **Figure 19** illustrates the Design Model for a Live Healthcare Console version 0.1.

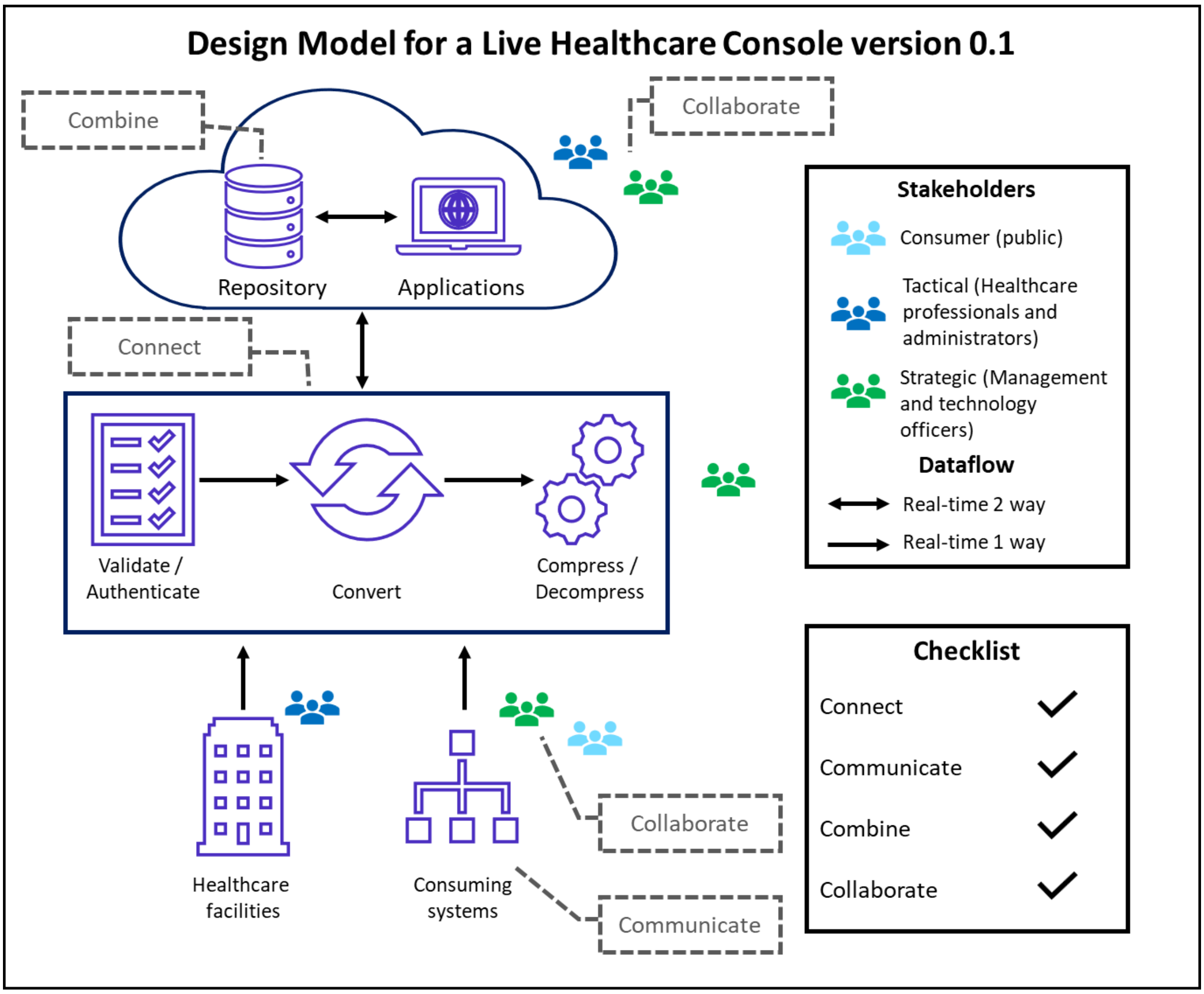


Figure 19. Design Model for a Live Healthcare Console version 0.1

All four aims have been incorporated into the Design Model for a Live Healthcare Console version 0.1, but the aims are positioned differently. The centralised repository is illustrated within a cloud hosting the data as well as the applications. The integration layer incorporates supporting technology elements. Data validation, translation and compression/decompression functions are included. Providing and consuming systems are positioned on the same side of the integration; however, this does not affect the behaviour of the systems. Stakeholders and their related categories are also included. **Appendix 8.23** illustrates a possible view or interface that utilises the data from the various systems and makes it available to key stakeholders.

At this stage, the Design Model for a Live Healthcare Console version 0.1 incorporated the insights gained during the literature review. The next stage was engaging with relevant stakeholders to gain a deeper and more practical understanding of the public healthcare system within South Africa from a digital health perspective. Further insights gained would then be incorporated into the Design Model for a Live Healthcare Console version 0.1, resulting in the Design Model for a Live Healthcare Console version 0.2.

2.5 Summary of Chapter 2

The literature review, conducted in three phases, highlighted that the South African public healthcare system, though burdened by challenges like limited resources, also benefits from endeavours like the new HIS, which aims to optimise healthcare processes. The long-term vision of the Department of Health includes consolidating the fragmented healthcare system (private and public) into a unified healthcare system. However, the future-state architectural design is not adequately adapted to the anticipated changes in the healthcare system. To support the long-term visions of the Department of Health and promote current efficiency, a supporting digital health design model needed to be developed. By using a custom evaluation framework, the study determined a deficit within existing literature as no contextually relevant digital health graphical design model existed. This led to the development of a new digital health graphical design model, i.e., The Design Model for a Live Healthcare Console version 0.1. However, the literature alone could not influence the design of said design model; hence, it was necessary to engage with the relevant stakeholders to understand their perspectives on healthcare systems, processes and how the key stakeholders interact with each other and healthcare systems. **Chapter 3** presents the research method followed in collecting appropriate data, ethics considerations and data analysis.

Chapter 3: Research and Methodological Approach

The literature review, conducted in three stages, adopted elements of a systematic literature review to gain an understanding of the public healthcare system from a digital health perspective. The literature review revealed that a Live Healthcare Console can support the public healthcare system from a management and decision-making perspective. An initial design model for the Live Healthcare Console (Design Model for a Live Healthcare Console version 0.1) was developed based on the outcomes of the literature review.

The study needed to collect and analyse information from key stakeholders within the Gauteng healthcare ecosystem regarding hospital bed management processes and emergency patient transport to promote the accuracy and contextual relevance of the Design Model for a Live Healthcare Console version 0.1. Shaw et al. (2017) favour a qualitative approach to data collection (semi-structured interviews) and the analysis (thematic analysis) of information for the development of a conceptual model for eHealth. A study by Kayser et al. (2018) sought to construct a questionnaire for testing the eHealth literacy framework. A later study by Yusif et al. (2020) utilised qualitative and quantitative data to validate a digital health model. Notably, the objectives of the study conducted by Shaw et al. (2017) are inherently similar to the present research. Consequently, the researcher decided to adopt a qualitative research design method for this research. **Figure 20** illustrates the components of **Chapter 3**.

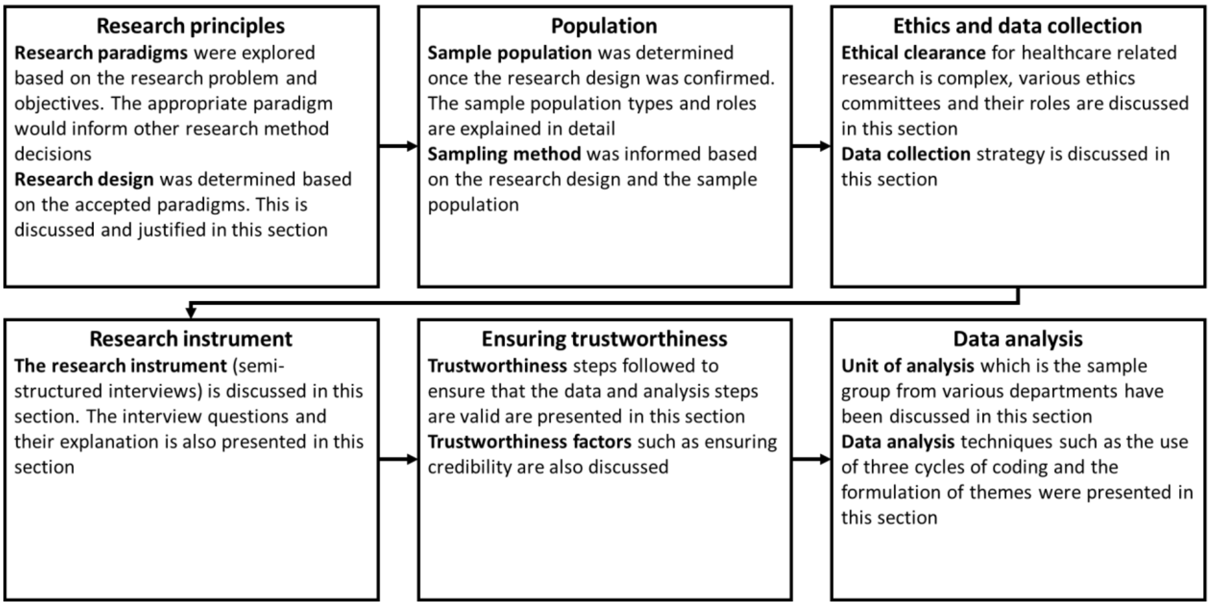


Figure 20. Structure of Chapter 3

This chapter details investigating the research principles to ascertain the appropriate research paradigm, which resulted in the research design. A contextually relevant sample population and sampling method were then determined. The sample population played a significant role in the ethics clearance application. **Chapter 3** presents the design of the research instrument in the form of a semi-structured interview and adds to the ethics clearance supporting documentation.

Furthermore, the chapter documents steps to ensure the trustworthiness of this research, followed by the unit of analysis and the data analysis techniques.

3.1 Research Paradigms Explored

Research paradigms are commonly used when studying human behaviour but can also have advantages in information research (Kankam, 2019) and information systems research (Shoniwa, 2021). The researcher explored three research paradigms at the commencement of the current research, briefly described in **Table 15**.

Table 15. Research paradigms explored during this research.

Paradigm	Description	Method
Critical theory	Reality is subjective and is affected by social or other factors.	Qualitative, e.g., open-ended interviews
Interpretivism	Multiple realities can exist.	Qualitative, e.g., open-ended interviews
Positivism	There is only one reality or truth.	Quantitative, e.g., closed-ended questionnaires

Source (adapted): (Rehman & Alharthi, 2016)

It was necessary to engage with stakeholders from various groups (discussed in **Section 3.3**) to understand the usage and availability of real-time healthcare-related data, with the assumption that each stakeholder had unique views (or realities) of the healthcare ecosystem. This eliminated the positivist paradigm of a single reality. Critical theory is utilised in information systems research (Richardson & Robinson, 2007); however, subjective reality does not align with the digital health systems and processes at which this research was aimed. Thus, the interpretivist approach was selected. This confirmed the qualitative research approach. Furthermore, elements of grounded theory, such as the interpretation of reality by the research participant as well as the lenses through which the researcher views the problem (Yusif et al., 2020), were incorporated into this research.

3.2 Research Design

This research selected a qualitative research approach, as in a similar study by Manyati and Mutsau (2021), which investigated the use of mobile health (mHealth) technologies in Africa. This research utilised elements of grounded theory, which was useful in uncovering key notions grounded in the collected data (Foley et al., 2021). Since much of the relevant healthcare information is unstructured, incomplete or not publicly available in South Africa, this negated the use of a quantitative approach using close-ended questions. Therefore, semi-structured interviews were selected for data collection. This was the approach used in an eHealth study conducted in Morocco by Parks et al. (2019) and by a similar PhD thesis based on the Zimbabwean healthcare system (Muhonde, 2023).

3.3 Sample Population

Qualitative eHealth research conducted by Nyatuka and De la Harpe (2022) used multiple stakeholder types. This approach supports the view that alternative interpretations can be uncovered from different stakeholders (Sholl et al., 2019). The sample population in this research was categorised based on the stakeholders' interaction with digital health data. The three stakeholder types are described below:

- Strategic – eHealth data are used for decision-making, such as ambulance diverts.[6]
- Management – eHealth data reports are used for daily tasks, such as resourcing.
- Operational – The origin of the eHealth data, such as admissions and discharges.

Table 16 describes the three stakeholder types in further detail.

Table 16. Description of the sample population

Stakeholder type	Example	Rationale
Strategic	Managing Medical Officer (MMO), Hospital CEO and Department Head	Strategic stakeholders are responsible for decision-making within their departments, healthcare facilities or at district levels. They are responsible for decisions, including diverting ambulances when certain departments have reached maximum capacity and load-balancing of resources where there is a shortage of staff or other key resources. The insights gained from engaging with these stakeholders gave rise to an enriched understanding of how real-time information could assist in the decision-making process.
Management	Doctors in clinical and emergency departments, technology managers, data managers, risk managers and administration managers	Doctors in the various departments use health information for daily tasks, such as treating, admitting and discharging patients. They use the information available to them to determine whether the capacity of a ward is adequate to accommodate a patient. They also use information to determine whether a patient can or should be transferred to another healthcare facility. Technology, data, risk and administration managers work with healthcare data at the originating and reporting levels. They

[6] Incoming ambulances can be redirected or diverted to another healthcare facility based on resource availability

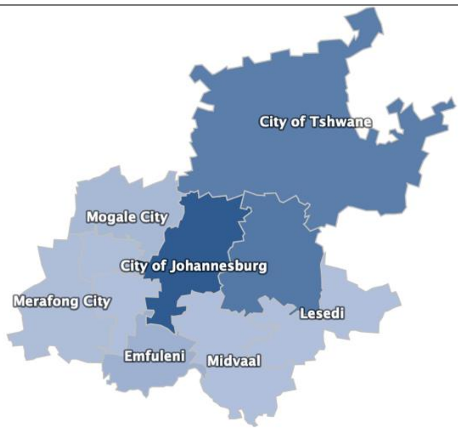
		perform key functions which prepare data for usage at other levels to support decision-making.
Operational	Admissions clerks, EMS call takers, data capturers, dispatchers, paramedics, paramedic trainers and ward clerks	Admissions clerks, data capturers and ward clerks originate data at the point of patient contact, such as admissions and discharges. Engaging with these stakeholders provides a view of the captured data and where the data are disseminated. Stakeholders from EMS have various contact points within patient care. These include incoming calls for emergencies, transporting patients from a scene to a healthcare facility, as well as transferring patients between healthcare facilities. These stakeholders provided insights into the various processes and systems originating and utilising healthcare data. They also provided views on the interconnectedness of systems and institutions.

3.4 Sample and Sampling Method

The participants in this research formed part of specific stakeholder groups with unique perspectives based on their interactions with healthcare data. Purposeful sampling can also be described as the "intentional selection of information-rich individuals" (Ng et al., 2023) and can be used when a researcher intends to gain insights from stakeholders with knowledge of a specific subject. It can also be combined with other sampling techniques depending on the scenario (Palinkas et al., 2015). Purposeful sampling was used to identify groups of individuals who originate from, work with or consume healthcare data, specifically, hospital occupancy, divert information or other related datasets. Since individuals' contact details were not known at the onset of this research, it was necessary to incorporate snowball sampling as an additional sampling method, which allows participants to identify other potential participants (Zickar & Keith, 2023). It was not possible to estimate the required number of participants so all stakeholders who met the required conditions were invited to participate.

Gauteng's public healthcare system is divided into five districts. The study planned to engage with stakeholders from all five districts to promote the diversity of the information. **Table 17** describes the five districts.

Table 17. Summary of the five districts in Gauteng

District name	Local municipalities	Population	Map
City of Joburg	None	4 434 827	
City of Tshwane	None	2 921 488	
Ekurhuleni	None	3 178 470	
Sedibeng	Emfuleni, Lesedi, Midvaal	916 484	
West Rand	Merafong City, Mogale City and Rand West City Local Municipality	820 995	

Source: (Stats SA, 2011)

3.5 Ethics Approval

The ethics approval process was initiated with UNISA's College of Agriculture and Environmental Sciences (CAES) and not the College of Science, Engineering and Technology (CSET), as healthcare-related participants were involved in this research, and thus, this research was deemed medically related. **Table 18** describes the ethics approval process for engaging with stakeholders from the healthcare facilities.

Table 18. Ethics application process for healthcare facilities

Step #	Approval body	Information required	Information supplied	Next steps
1	CAES	Research project information	National Health Research Ethics Committee (NHREC) application created. CAES pending approval, subject to receiving full approval from a healthcare facility	Create National Health Research Database (NHRD) application
2	NHRD	Research project information with CAES approval in a pending status	Provisional letter to conduct research at a district, subject to receiving full approval from CAES.	Submit documentation to CAES and await full approval
3	CAES	NHRD documentation as well as pending approval to conduct research at a district	Full approval from CAES.	Submit CAES documentation to NHRD to receive full approval from a district.
4	Five districts	CAES approval and NHRD registration	Full approval from districts with named healthcare facilities	Apply for approval to the relevant healthcare facility REC where applicable
5	Healthcare facilities REC (gatekeeper permission)	CAES approval, NHRD registration and approval from the district. In some cases, further applications via an online approval system were made, with more documentation, such as a permission letter supplied	Permission letter or email from the healthcare facility	Contact stakeholders

The ethics approval letters from UNISA CAES, the districts and the NHRD registration are presented in **Appendix 8.3** to **Appendix 8.10**. The main ethics application allowed for participants in this research to provide written or verbal consent before the interviews. All the participants opted to provide verbal consent at the start of the interview. Several participants found verbal consent more convenient, and others had no means to return a signed permission letter.

3.6 The Research Instrument

Semi-structured interviews were the main data collection instrument for this research. Before commencing the data collection phase, the research instrument was piloted with three individuals. The research instrument and the piloting of the research instrument are discussed in the upcoming sections.

3.6.1 Designing the Research Instrument

Semi-structured interviews are a data collection method used in the evaluation of eHealth systems (Wronikowska et al., 2021) and was the data collection method used in a qualitative study relating to the attitude of doctors towards the use of eHealth systems (De Wilt et al., 2020). This type of interview structure was also used for the present research as it allowed for follow-up questions and considered user narratives and processes (Stahl & King, 2020) that the participants could share.

Though the research participant groups differed, a single set of interview questions was used and dynamically adapted to each interview. The informed consent letter (**Appendix 8.24**) was shared with each participant before their interviews, but the salient points were read aloud to them at the start of the interview. Below is a portion of the interview transcript.

> *With your permission, may I start the recording?*
>
> *<Wait for answer>*
>
> *Before we start with the interview, I want to make note of a few points.*
>
> *There is a participant information sheet that you may sign and send back to me alternatively you may confirm your willingness to participate in this research verbally. The participant information sheet and consent has been approved by your organisation.*
>
> *Do you want to fill out the form or would you like to provide verbal consent?*
>
> *<Wait for answer>*
>
> *Do you consent to participating in this research?*
>
> *<Wait for answer>*

This is an anonymous interview so try not to mention your name, surname, place of work or position. For example, try not to say: "As the CEO of the hospital" or "As the head of the information technology department". Statements such as these might comprise your identity. With this in mind, I will try not to refer to you by your name or title.

If a question falls outside the scope of your role at the healthcare facility, please advise me so that I can adjust the question and we can continue.

Reading the interview script aloud to the participants ensured they were aware the interview was being recorded and would be used for this research. It also reinforced the directive for the participants not to mention anything that could compromise the anonymisation of their identity. The research participants noted no concerns during this part of the interview.

The interview was guided by ten questions that were not posed in any particular order but were instead numbered for convenience. **Table 19** presents the ten questions, their relation to this study and the rationale behind them. The questions were structured in a way to act as "icebreakers" and to encourage the participants to share their views and experiences.

Table 19. The ten interview questions

ID	Related aims	Question	Rationale
1	Combine Connect	In your day-to-day duties, what digital health systems do you use?	This is a high-level question that often encouraged the participants to discuss the systems that they used. The responses to this question allowed for minor dynamic adjustments to the following questions where appropriate.
2	Combine	What digital or other systems are used to track bed occupancy at the facility?	This is a more detailed question focusing on bed occupancy management. Participants had the opportunity to name the system used or describe its capabilities.
3	Communicate	Does the hospital or any departments close temporarily when they reach maximum occupancy?	The strategic or operational processes related to bed occupancy management could be understood from this question.
4	Communicate	Who has the authority to close down the hospital or department once it has reached maximum occupancy?	The responses to this question revealed the various decision levels and information needed at each level to make key decisions.
5	Collaborate Communicate Connect	Are you informed when the hospital or a certain department has reached maximum occupancy? Follow up: How are you informed of this?	The responses to this question revealed the various communication mechanisms and involved stakeholders.
6	Collaborate Combine Communicate Connect	Are external parties, such as incoming patients or the fire department, informed that the hospital or a department has been temporarily closed?	This question helped determine the extent of the healthcare ecosystem and whether parties not directly connected to the healthcare system were still kept informed during certain situations.
7	Collaborate Combine Communicate Connect	Are you informed when the hospital or a department has been reopened? If so, how is this done?	Responses to this question disclosed how information is disseminated within the healthcare facility and also between other related parties.

8	Collaborate Communicate	Would a live bed management system help you to perform your job function better?	This question was used to elicit the perceived benefits of the accessibility of real-time information for the participant.
9	Collaborate Communicate	Would a real-time system aid in the functioning of the hospital?	This question was used to elicit the perceived benefits of the accessibility of real-time information within the healthcare ecosystem.
10	Combine Communicate Connect	Is there a dashboard or real-time report that shows you the occupancy status of the hospital or neighbouring hospitals?	Various systems and processes provide reports. However, this question aimed to understand whether information can be accessed by certain stakeholders and whether the information provided was available in real-time.

3.6.2 Piloting the Research Instrument

Rowley (2012) suggests first piloting interviews with friends and family to remedy any issues relating to the questions. Another suggestion was that the pilot phase should include a member of the target audience. Therefore, the research instrument was piloted with three participants. Two were colleagues with a research background, and one friend was employed as a senior manager in the banking sector. Due to the limited target audience, it was not possible to pilot the research instrument with a healthcare worker. The researcher explained the various projected job roles to be interviewed to the pilot participants and asked them to select one and answer the questions in the way someone in that role would. The pilot participants made the following suggestions:

- Ask the participants whether you can start recording the meeting before announcing that the meeting recording has started. That way, the participant feels they have some say in the process.
- Make it clear that cameras will not be used during the interview to ensure that the interview is not disrupted due to a poor internet connection.
- Make Question 1 more general to encourage the participant to speak freely about their interaction with the various systems.

The researcher considered these suggestions and made the relevant changes to the interview script and interview questions. The pilot participants noted no other concerns.

3.7 Data Collection Procedure

The research ethics application process discussed in **Section 3.5** highlighted the various levels of approval required before commencing with the data collection. Since each district follows unique approval processes, the researcher expected the districts' response and approval times to differ. Considering the varying response times of the healthcare districts, it was decided that the data collection should commence once the first healthcare facility or EMS department had granted approval for the study. It must be noted that a healthcare facility or EMS department would only grant permission once all other levels of approval had been satisfied, which resulted in the data collection phase being staggered.

The COVID-19 pandemic accelerated the movement towards using technology to replace some face-to-face interactions. Qualitative interviews are one such example, whereby it is possible to conduct an interview online instead of face-to-face. Saarijärvi and Bratt (2021) argue that there are advantages and disadvantages to face-to-face as well as online interviews. Some advantages of a face-to-face interview include the visibility of facial expressions and noting body language. The disadvantages include travel and its associated costs and safety risks. The advantages of an online interview include location irrelevance and cost savings. Saarijärvi and Bratt (2021) include visual cues in this list, which assumes the interviewees' cameras are switched on. The disadvantages include technical challenges, and the availability of appropriate infrastructure could also be added to this list. Peasgood et al. (2023) note that participants have a (non-universal) preference for online interviews and further argue that online interviews are both feasible and acceptable. O'Brien et al. (2023) also support the view that online interviews are an acceptable medium for conducting interviews and focus groups. The debate and research regarding online interviews versus face-to-face interviews precede recent technology shifts. Curasi (2001) noted that online interviews are suited for gaining a better understanding of a problem. However, Curasi (2001) further explains that data gathered from online interviews should be triangulated with other datasets.

The study considered the arguments for online and face-to-face interviews, and it was decided that online interviews would be the only medium used. This decision was made against the backdrop of travel time and expenses for the researcher, the availability of a quiet meeting room in space-constrained facilities, and other safety-related concerns about conducting face-to-face interviews at a healthcare facility. It was also observed during the data collection phase that online interviews promoted scheduling flexibility, as some participants were able to reschedule the interview easily based on their availability.

The interviews were conducted via MS *Teams* (all participants either had direct access to MS *Teams* or could use a colleague's computer to access the meeting). The permission letters and ethics applications stated that the interviews would be 45 to 60 minutes long. When scheduling the interviews, several participants requested 30 minutes to be scheduled and that more time could be used if needed. Consequently, this approach was adopted, and the researcher observed that the participants were more likely to agree to being interviewed. None of the participants seemed to be in a rush to conclude the interview ahead of time. The average interview duration was 31 minutes. This time excludes the off-the-record conversation after the formal interview, which could have lasted up to an additional 15 minutes.

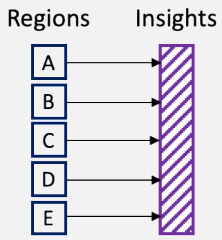
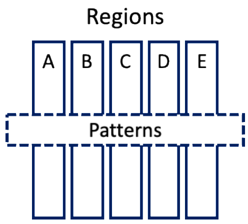
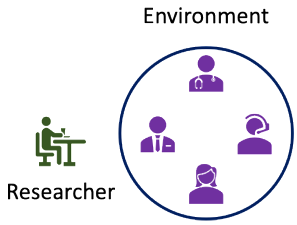
Further, the interviews were conducted from Monday to Friday, usually between 08:00 and 18:00. The participants were presented with the option of weekday interviews before 08:00 and after 18:00 or any time on weekends; however, the participants were comfortable with standard business hours.

The MS *Teams* settings for the interviews were configured before commencing the interview. These settings included disabling cameras since visual cues were not analysed or considered relevant for the interviews. Not using the cameras also ensured that internet fluctuations would have a lower impact on the interview. The meetings were configured not to record automatically as the participants were first asked permission to record the interview. Every meeting was recorded and saved on the researcher's Microsoft *OneDrive* student account and backed up on a private, password-secured cloud account. The meeting transcripts compiled by MS *Teams* were also saved in this manner. The recordings and transcripts were not made available to the participants, but they may request recordings should they wish to.

3.8 Trustworthiness and Research Rigour

The trustworthiness of qualitative data is subjective, but some factors should be considered when establishing whether qualitative data displays evidence of trustworthiness. These factors are: Credibility—how similar are the data? Transferability—are there comparable patterns in the data? Dependability—building trust in the data by using techniques such as peer reviewing. Confirmability—approaching a point where the data can reach objective or unbiased realities similar to that of quantitative data (Stahl & King, 2020). **Table 20** presents the adaptation of these trustworthiness factors to this research.

Table 20. Trustworthiness factors considered for this research.

Trustworthiness factors	Techniques used in this research	Illustration relevant to this research
Credibility	Environmental triangulation: using multiple environments to promote credibility. Multiple regions or districts (representing various environments) were included in this study.	
Transferability	Comparable and transferable patterns: collecting data from different environments allows for the identification of comparable patterns.	
Dependability	Parts of this research were presented at the Health Informatics in Africa conference in 2023. Three associated research papers have been peer-reviewed and published at the time of submitting this research.	
Confirmability	Reduction in contamination of the study: The researcher only engaged with stakeholders for the interviews and did not observe daily activities, which	

	might have introduced variables that could have influenced the study.

Source (adapted): (Stahl & King, 2020)

Researcher bias was also considered during this research, as the researcher was an experienced information systems practitioner and healthcare researcher with notions on how to design an HIS architecture. Johnson et al. (2020) argue that researcher bias is a concern in qualitative research. Their research, which also falls within the healthcare domain, highlights steps which can be taken to minimise researcher bias. One such measure is the use of purposeful sampling, which supports the appropriateness of participants considered in this research. **Section 3.4** discusses purposeful sampling and its role and adaptation to this research. In addition to engaging with appropriate participants, the researcher prompted the participants during the interview with follow-up questions beginning with "How do you think…?" or "How would you design…?". Phrasing the questions in this manner helped remove the researcher's bias on how to answer a particular question.

3.8.1 Maintaining Participant Anonymity

Badampudi et al. (2022) suggest that maintaining the anonymity of a research participant can help prevent harm to the participant arising from their participation in a research project. Allen (2017) argues that participants are more likely to share information if their anonymity is being maintained and suggests using pseudonyms to protect the anonymity of a participant in an interview transcript. Erasmus University Rotterdam (2023) supplements these suggestions by proposing the use of data minimisation techniques (collecting only necessary information during a recorded interview) and obtaining consent (preferably written) from the participants. These suggestions were either fully utilised or customised for use in this research. The technique of using pseudonyms was applied to the interview transcripts to anonymise the participants. In addition, the participants were asked not to share information that could potentially link them to their job role or facility, as this could reveal their identity. Informed consent was obtained from each participant verbally (preferred by the participants).

While reporting the research results, the sample population group, population size, participating research districts and participating healthcare facilities were carefully considered. Based on these criteria, the study determined that the anonymity of the participants might not be guaranteed if the number and type of participating healthcare facilities were reported (refer to **Figure 2** for facility types and levels). The job roles of the participants were reported but not linked to individuals, and the number of participants per role was not reported. **Figure 21** illustrates the participant identity reverse engineering considerations.

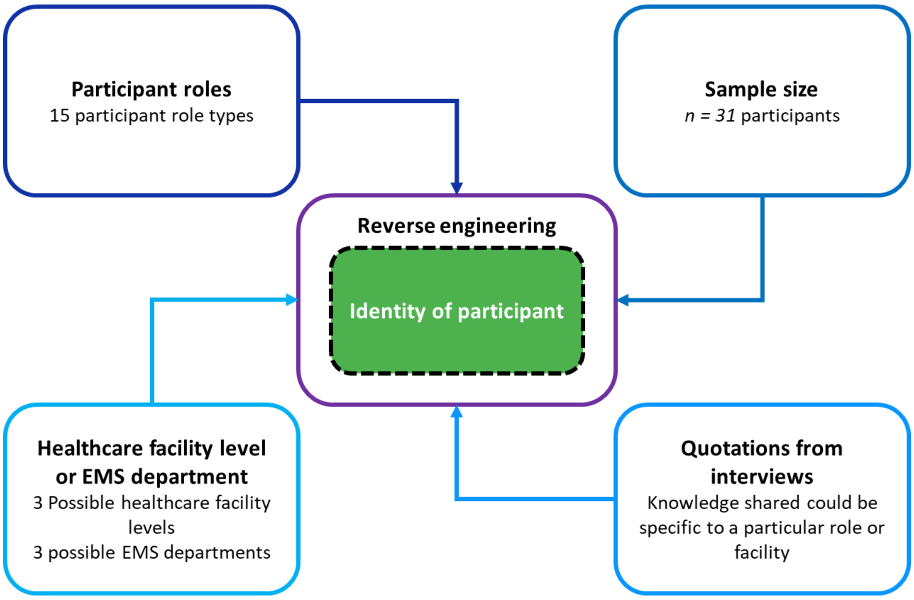


Figure 21. Considerations for the possible reverse engineering of research participants' identities

Figure 21 illustrates how a combination of participants' roles, sample size, healthcare facility levels or EMS departments and quotations from the interviews could be combined to reverse engineer the identity of a participant. The participants' job roles played a critical part in understanding the hospital bed management processes. Quotations from the interview transcripts were used to determine codes, which were then reported. Since reporting the healthcare facility types and number of healthcare facilities would not add further insights to this research, these criteria were not reported. Eliminating these criteria from the research report did not impact the data analysis negatively.

3.9 Unit of Analysis

The sample population discussed in **Section 3.3** noted that stakeholder types across multiple healthcare facilities would form part of this study. The sample population could be described as public healthcare workers who use or maintain digital health systems and subsequently formed the unit of analysis. Each participant was interviewed separately, meaning focus groups were not used during the data collection phase. Each participant's views and experiences (obtained from their interview transcripts), which could be termed their story, were analysed as an individual response. Responses were not grouped and analysed by department, healthcare facility or job role.

3.10 Data Analysis and Interpretation

Section 3.6 established that semi-structured interviews would be the primary method for obtaining data from the research participants. Once the data had been collected, the data were analysed and interpreted using a qualitative approach, which was the selected research method. **Section 3.10.1** discusses the data analysis method.

3.10.1 Data Analysis Method

Lester et al. (2020) list several qualitative data analysis methods. **Table 21** describes three of the methods considered for this research.

Table 21. Description of qualitive data analysis method options

Data analysis method	Description
Content analysis	The analysis and interpretation of text obtained from various sources, including interviews, which are text-heavy and open to interpretation. Outputs of content analysis include categories of data as well as themes. The approach used in content analysis is to identify codes in the interview text and then group them into categories and sub-categories (Lindgren et al., 2020).
Thematic analysis	Thematic analysis can be applied to interview text (Castleberry & Nolen, 2018; Kiger & Varpio, 2020). Kiger and Varpio (2020) suggest the researcher becomes familiar with the text by first reading the information and delaying the coding until they have gained an understanding of the data. Once the initial codes have been identified, themes can be identified and reviewed.
Basic interpretive analysis	This type of analysis utilises a similar approach of content analysis through coding (inductive and deductive); however, it might not result in a discussion or identification of themes (Hendren et al., 2023).

Table 21 describes the three data analysis methods considered for this research. Content analysis is a method that has been used in eHealth research to analyse interviews and other content (Broekhuis et al., 2021; Neher et al., 2022). Interview transcripts from eHealth research have also been analysed using the thematic analysis method (Brandt et al., 2018; Christie et al., 2020). However, elements from all three methods were incorporated into this research. Creswell and Poth (2016) argue that codes can be used to identify themes in qualitative data analysis. In this research, inductive codes were grouped and associated to form sub-networks or networks. The sub-networks were then further grouped into networks, and the networks were used to form themes. Therefore, combining the various data analysis techniques resulted in an interpretive analysis. **Figure 22** illustrates the data analysis steps.

Once gatekeeper permission had been received from an individual healthcare facility, eligible participants were contacted. Interviews were then scheduled with the participants who had agreed to be interviewed. This process was repeated until no new eligible participants confirmed their willingness to participate. Once an interview had been conducted via MS *Teams*, the meeting was automatically transcribed by MS *Teams*, the recording was saved and then used to correct any errors in the interview transcript. **Figure 22** illustrates the data analysis approach selected for this research. The study performed three cycles of coding to transform the information obtained from the interviews into themes. A completed interview transcript was first coded, and the codes were added to a list. Once all the interview transcripts had been coded, the second cycle of coding was initiated. During this phase, the codes were grouped, and within each group, direct relationships between codes were identified, which resulted in the formation of networks or sub-networks. The sub-networks were further grouped into networks. Once this phase had been completed, the third cycle of coding began. The networks were then grouped, and these groups were used to identify the themes.

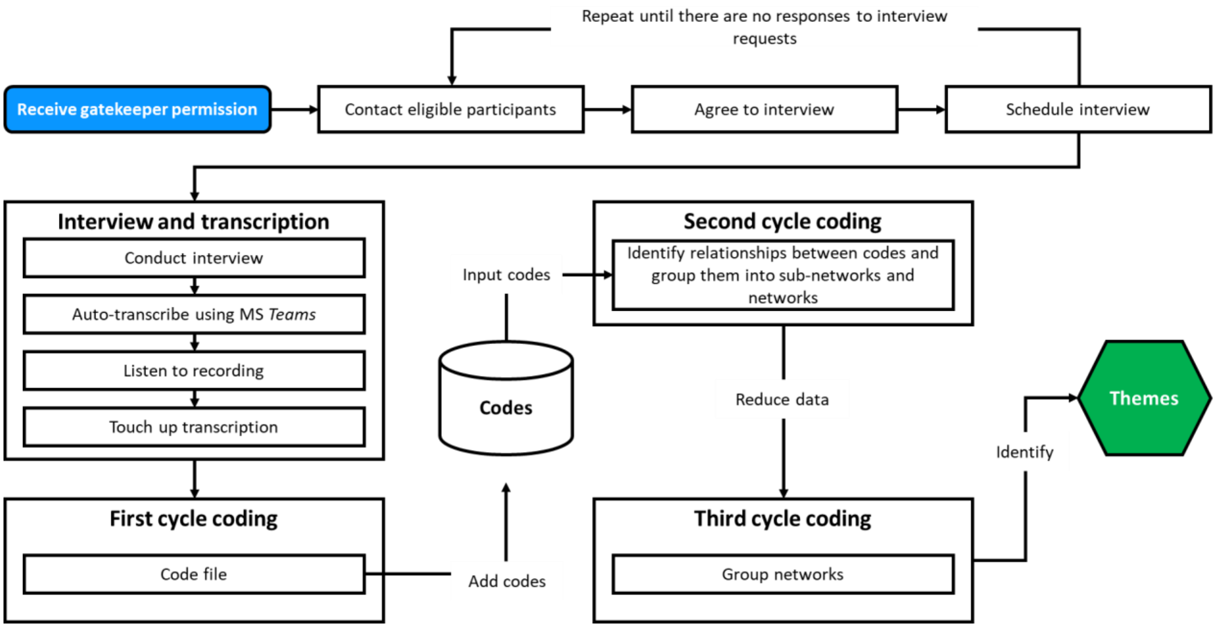


Figure 22. Data analysis process flow

The interviews were conducted as participants became available. The researcher decided to conduct as many interviews as possible to ensure the research went beyond data saturation and into the realm of "talking to people". Once an interview had been conducted, the transcript file was prepared for coding and then coded. This phase was the first cycle of coding. At the point where no more participants agreed to be interviewed, the codes were analysed for data saturation (discussed in **Section 3.10.2**). Second cycle coding then commenced. This phase involved grouping codes and then relating codes to each other within the group to form networks or sub-networks. Grouping of the sub-networks led to further networks being identified, and the networks were then named. The networks were grouped in the third cycle coding phase. Themes were identified from these groupings and incorporated into the improvement of the Design Model for a Live Healthcare Console version 0.1, resulting in the Design Model for a Live Healthcare Console version 0.2. The themes identified during the data analysis led to the development of the theoretical conjecture as well as the theoretical model, which is a graphical representation of the theoretical conjecture. **Section 3.10.2** discusses the determination of data saturation.

3.10.2 Data Saturation

Data saturation can be used to determine whether enough interviews have been conducted (Braun & Clarke, 2021; Guest et al., 2020). While the objective of the data collection phase was not to cease conducting interviews once data saturation was complete, it was necessary to determine whether sufficient data had been gathered. Guest et al. (2020) identify techniques to determine data saturation. One such technique is to measure the point where the emergence of new codes is <= 5%, which can be achieved by conducting six to seven interviews, depending on the sample type (in that case, a homogeneous sample). **Section 3.3** indicated that the sample population for this study consisted of multiple stakeholder groups; therefore, using a guide based on a homogeneous sample might not have yielded an appropriate saturation point. Hennink and Kaiser (2022) argue that saturation for interviews from homogeneous or heterogeneous groups can be achieved from anywhere between nine and 17 interviews. This process includes using codes or code categories as a measure. Hence, one could surmise that the use of a heterogeneous sample population results in a higher number of interviews to reach saturation.

From the information presented above, one could conclude that 17 interviews would confirm theoretical data saturation. However, **Section 3.10.1** affirmed that the data collection phase of this research was not just regarded as a process to obtain data but instead to talk to and engage with participants in a way that would allow them to transcend the questions at a surface level and speak freely about their perceptions of healthcare processes. Though Braun & Clarke (2021) acknowledge the concept of data saturation, they argue that the point at which data saturation is reached is subjective. The authors further encourage researchers in certain areas to interpret and not just excavate meaning from data.

Thus, this research satisfied accepted data saturation determination techniques as well as the subjective nature of uncovering meaning from a heterogeneous qualitative dataset. **Section 4.4** presents the data saturation points.

3.10.3 Data Analysis Software

The data analysis processes, such as the first, second and third cycles of coding (described above), were performed using *ATLAS.ti* version 23.3.4.28863. The software is licensed under the University of South Africa's student license agreement and was selected for use as the university does not provide full access to other qualitative data analysis tools.

Transcription software, such as *OtterAI* and the Microsoft *Word* dictating functionality, were considered for transcribing the audio files. Since there is a cost associated with these options and limitations on the free versions, the study used the MS *Teams* transcription function since it is included in the University of South Africa's student license agreement and has no limitations on its usage.

3.11 Validating the Design Model for a Live Healthcare Console Version 0.2

Once the Design Model for a Live Healthcare Console version 0.2 had been created, it was tested with a subset of the research participants via an informal discussion. These sessions were not recorded for the participants to speak freely about the models. The Design Model for a Live Healthcare Console version 0.2 and the theoretical model were discussed with the participant subset, and their comments were considered. This collaboration between the participants and the researcher resulted in the final version of the design model.

3.12 Summary of Chapter 3

This chapter introduced the research paradigms explored for this research. The study decided on the interpretivist paradigm using a grounded theory approach, leading to the qualitative research design utilising semi-structured interviews. The chapter introduced the various participant types and job roles; participants from public healthcare facilities such as hospitals and EMS were selected. Since this research was focused on the use of real-time data within the public healthcare system context, a purposeful sampling method was consequently adopted, thereby ensuring that the correct stakeholders were included. To ensure enough participants were invited to participate, snowball sampling was adopted to supplement the purposeful sampling technique. The use of trustworthiness factors, such as credibility, transferability, dependability and confirmability, was then explained. The chapter presented the qualitative data analysis techniques used in this study, such as coding in three cycles and identifying themes. Thereafter, the methods for the confirmation of reaching theoretical data saturation along with the details of the software analysis tool were presented. **Chapter 4** presents the analysis of the data.

Chapter 4: Data Analysis and Results

This chapter presents the details of the data analysis steps and the results of the analysis. The chapter begins with the steps followed to obtain the necessary ethics approvals and gatekeeper permissions. Thereafter, the chapter provides the details of the data collection phase and an overview of the interviews, followed by the data saturation techniques and results of the data saturation calculations, details about the data analysis, and an explanation of the structure of the identified themes along with a description of how the themes will be presented. The chapter then presents the six themes, how the themes were derived, the components of each theme (comprising networks, which themself are composed of grouped codes or sub-networks), and lastly, the interpretation of the themes and how each theme impacted the Design Model for a Live Healthcare Console version 0.1. **Figure 23** illustrates the structure of this chapter.

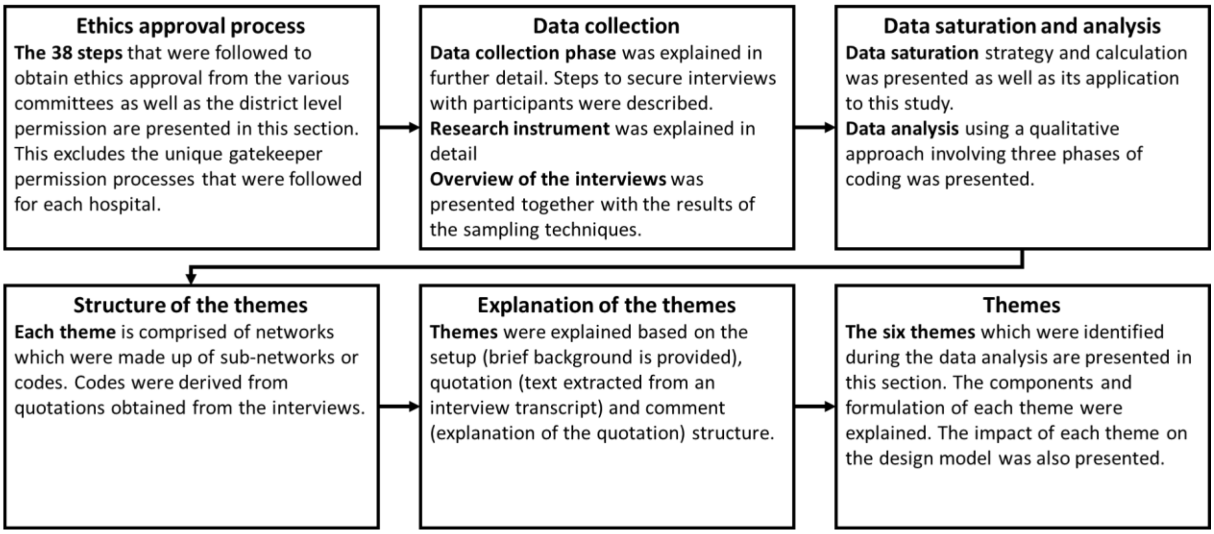


Figure 23. Structure of Chapter 4

4.1 Ethics Approval Process

Ethical review committees are responsible for ensuring researchers act with integrity when conducting their research. Integrity can include good data management practices and the promoting of beneficence of the research in a way that is aimed towards the participant (Bitter et al., 2020). This research focuses on digital health information systems and how they connect; it does not consider individual patient records or any other medically related information. To ensure that all relevant ethical protocols would be followed, the researcher consulted the University of South Africa's research ethics policies (University of South Africa, 2016). This led to the understanding that even though no patients would be engaged, and no medical records would be investigated, the research is considered health-related. Since the research falls within the healthcare category, the ethics application had to be submitted to a Health Research Ethics Committee (HREC); accordingly, the application was made to the UNISA College of Agriculture and Environmental Sciences (CAES) HREC. The ethics approval process required approximately

38 steps to obtain permission to conduct research at designated hospitals in four of the five districts in Gauteng. **Table 22** contains a summary of the steps followed in the ethics approval process.

Table 22. Steps followed to obtain ethics approval

Step #	Event
1	User registered on the online Research Ethics Application system.
2	Ethics application created.
3	Ethics application submitted to CAES HREC.
4	Ethics application review process was initiated by CAES HREC.
5	Conditional approval received from CAES HREC. An approval letter from a hospital was required for full approval to be granted.
6	Research project was registered on the National Health Research Database (NHRD).
7	Conditional approval letter received for certain hospitals from Health District 1.
8	The conditional approval letter from Health District 1 was submitted to CAES HREC. However, it was unknown whether CAES HREC would grant full permission based on this conditional approval.
9	Each hospital mentioned in the conditional approval letter from Health District 1 was contacted to determine if further permission was needed.
10	Health District 2 requested further information. It was discovered that the information required by Health District 2 had previously been uploaded onto the NHRD portal. The information was resent via email.
11	Provisional approval letters were received from some of the hospitals. The researcher attempted to upload the provisional letters received from these hospitals to the Research Ethics Application System; however, there were no provisions for additional documentation to be uploaded.
12	Contacted UNISA's information technology personnel responsible for the Research Ethics Application System to rectify this.
13	The Research Ethics Application System was reconfigured, and the provisional approval letters were uploaded.
14	Attempted to make telephonic contact with Health District 2 to determine if they had received the requested documentation; however, the telephone number did not work.
15	Contacted Health District 3 to confirm whether the NHRD application had been received by them. The application had not been received via the system. Information was sent to Health District 3 via email.
16	CAES HREC confirmed that the provisional approval letters were received, and the status of the ethics application was reset to "under review".

17	One of the hospitals asked for the documentation to be sent via email, as they did not receive this from the NHRD system. This was provided to the hospital.
18	Health District 4 received the NHRD information but requested letters of support from the respective hospitals for the district-level approval to be granted. This process differed from that of Health District 1. Contact was made or attempted with the respective hospitals in Health District 4 to obtain letters of support.
19	Health District 1 granted full permission to conduct research at the designated hospitals. Health District 1 full permission letter submitted to CAES HREC on the Research Ethics Application System.
20	CAES HREC full approval letter received. The CAES HREC full approval letter was sent to Health Districts 1 to 5 via email.
21	The researcher was informed that one of the hospitals had a different process to other hospitals in its district. It required the application to be submitted at a provincial level; however, a permission letter from the hospital had to be obtained first.
22	One of the hospitals granted conditional approval, subject to certain information being submitted. It was found that this information had already been shared with them. The people responsible for the application from the hospital's Research Ethics Committee (REC) went on leave and substitutes had to be contacted in this regard.
23	Health District 3 was meant to provide feedback but had not done so. The researcher followed up.
24	A hospital's nominated key stakeholder refused to produce a letter of support and requested the researcher to ask another department to provide the letter of support. The researcher then requested another department at that hospital to provide the letter of support.
25	At this point, it had been ascertained that EMS does not follow the same approval channels as the health districts and that an additional ethics approval process had to be followed for interviewing paramedics and other related staff. A contact person was suggested to assist with this process, who was then contacted by the researcher to determine what the EMS ethics approval process required.
26	A relevant department from a hospital refused to grant permission to conduct this research but was willing to assist if the hospital CEO granted permission. The hospital CEO would not grant permission unless departmental permission had been granted. This resulted in a process entanglement. The researcher approached another department for assistance with the permission letter.
27	Health District 2 granted full permission to conduct research at designated hospitals, subject to the individual hospitals' ethics approval processes. Each hospital named in the Health District 2 full permission letter was contacted to request approval from the hospital's REC.
28	One of the hospitals required approval from WITS HREC, notwithstanding that UNISA's CAES department is recognised as an HREC.
29	The online application process with the WITS HREC was initiated.

30	The WITS HREC required a letter of permission from the relevant hospital's CEO. Several attempts were made to obtain this letter, but the researcher did not have any success in this regard.
31	The researcher decided to abandon the WITS HREC application due to a lack of support from the associated hospital. The online application with WITS HREC was thus terminated.
32	Individual hospitals that had been contacted confirmed their willingness to assist. Several permission letters, previously requested, were obtained. The researcher contacted these hospitals to request interviews with participants.
33	During this process, the researcher received confirmation from the EMS contact person that obtaining ethics approval to interview EMS employees required an ethics application to be submitted to the University of Johannesburg (UJ).
34	New ethics application logged on the UJ online system.
35	Full permission granted from UJ. It was determined that the permission from UJ does not apply to EMS. The researcher spoke to more than seven people with contact numbers obtained via the public domain and eventually reached the correct contact person for the EMS ethics approval process.
36	Full permission granted from Health District 4 to conduct research at the designated facilities. The researcher contacted these hospitals to request interviews with participants.
37	EMS ethics application created.
38	EMS ethics application approved.

After several attempts to obtain permission from Health District 5, the researcher decided to abandon the application. Permission was eventually granted by the district after the data collection phase had concluded. Consequently, no data collection was conducted in Health District 5. **Section 3.7** indicates that the data collection phase would commence as soon as full permission from the first hospital was received. Therefore, the data collection phase followed a staggered approach and is discussed in **Section 4.2**.

4.2 The Data Collection Phase

Umoh et al. (2023) identify several challenges associated with data collection. These include low response rates to requests for participation and difficulties with access to appropriate stakeholders. They further suggest that research involving healthcare faces additional obstacles because of the potential handling of sensitive data and having to ensure the confidentiality of participants. This research, focusing on public healthcare management in South Africa, experienced similar challenges with the data collection phase, even though no patients were involved in this research and no patient data were collected.

During the data collection phase, over 300 emails were sent to hospital and EMS staff to introduce the study and request stakeholder participation. These emails also included follow-up communication and interview scheduling. The emails to prospective participants were usually accompanied by two telephone calls as a follow-up or for scheduling the interviews.

McGrath et al. (2019) identified twelve tips for qualitative researchers to consider when conducting semi-structured interviews. These tips were considered and adapted to this research and are described in **Table 23**.

Table 23. Twelve semi-structured interview tips adapted to this study.

Tip #	Description	Adaptation to this research
1	Identify when qualitative research interviews are appropriate	**Section 3.2** and **Section 3.6** provided a detailed explanation regarding the use of semi-structured interviews for this research.
2	Prepare yourself as an interviewer	Interviews were conducted online using MS *Teams*, as described in **Section 3.7**. Meeting invitations were sent to the participants with a copy of the informed consent letter (**Appendix 8.24**) at least 24 hours before the interview. A follow-up email with a link to the interview was also shared in some cases. An interview transcript was used at the beginning of every interview to ensure consistency at the beginning and to ensure that certain aspects, such as obtaining permission to record the session and confirming consent, were not forgotten. Measures were put in place to ensure minimal background noise. Extra time was also allocated at the end of the interview to ensure participants were not limited to the allocated time should they have wanted to share more information. In certain cases, follow-up emails were sent after the interview if a participant indicated they would share further information via email.
3	Construct an interview guide and test your questions	An interview script, described in Tip #2 and **Section 3.6.1,** was used at the beginning of each interview. The interviews were also piloted, and the lessons learnt are described in **Section 3.6.2**.
4	Consider cultural and power dimensions of the interview situation	During the interview, the participants were encouraged to answer the questions based on their role within the organisation. If they were not comfortable answering a certain question, they were free to say so, and the next question would be asked.
5	Build rapport with your respondents	Though this research was briefly explained in the informed consent document sent before the interview, it was again explained briefly at the start of the interview. In some cases, this served as an "icebreaker", whereby the participant's involvement in this research was reaffirmed.
6	Remember you are a co-creator of the data	McGrath et al. (2019) suggest that the interviewer should not play a passive role in the interview but should rather consider themselves co-creators of the information. Considering this notion, the interviews were conducted as a conversation between two knowledgeable participants where one (the stakeholder) has

		more context considering their role in public healthcare. Therefore, follow-up questions played a vital role, as this supported a more in-depth discussion on certain key aspects.
7	Talk less and listen more	During the interviews, silence between answers was used to encourage the participants to supplement their answers. In some cases, the researcher observed that silence was met with silence, which then led to the next question being asked.
8	Allow yourself to adjust the interview guide	This tip was the most often used during the interviews. The interview questions introduced in **Table 19** were used as baseline questions. After a few interviews, the order of the questions was changed to suit the interview. Some participants were asked to describe their roles at the healthcare facility. As they related their experiences and daily operational tasks, they indirectly answered other questions. This afforded the opportunity to delve deeper into certain responses. As the interviews progressed, they became more conversational (Tip #6) while ensuring that the participant elaborated (Tip #7). At the end of certain interviews, further insights relating to the research were provided to the participants. At times, this prompted the participants to share more information. At the end of the interview, the participants were informed that the recording had been stopped. In certain instances, some participants seemed more relaxed and were willing to share more of their thoughts.
9	Be prepared to handle unanticipated emotions	No unanticipated emotions were encountered during this research. Some participants felt strongly about certain aspects of their daily tasks, but these did not require any intervention.
10	Transcribe the interviews in good time	After each interview, general comments were recorded. The interview transcripts were automatically generated by MS *Teams*. The transcripts were saved, and the researcher read them while listening to the meeting recording. This enabled the transcripts to be cleaned and corrected.
11	Check the data	McGrath et al. (2019) suggest the use of member checking. By using this method, the interview transcript could be returned to the participant for validation. This approach was not directly used; however, listening to the recording and correcting the transcriptions were considered a form of validation.
12	Initiate analysis early	Interview transcripts were usually analysed (coded) on the day of the interview or the day after. This approach, as McGrath et al. (2019) suggest, removed the perception of an insurmountable amount of work that needed to be done.

The twelve steps presented in **Table 23** were adapted to this research during the appropriate stage. **Section 4.3** provides an overview of the 31 interviews conducted.

4.3 Overview of the Interviews

Thirty-one semi-structured interviews were conducted during the data collection phase. **Section 3.4** highlighted the use of purposeful and snowball sampling during this research. Based on the description of this research (obtained from the research proposal), hospital and EMS managers made recommendations regarding which staff members would be most appropriate for this research. Once their contact details had been shared, the potential participants were contacted and asked if they would like to participate in this research. Several positive responses were received, expressing willingness to participate. Some potential participants did not respond to either the emails or telephone calls. Some participants opted to abstain from participating, and some suggested a substitute as they were busy with other projects. In one case, a stakeholder requested a pre-interview discussion to understand the research better (notwithstanding that the full research proposal had been shared). The stakeholder seemed to be concerned that their role within the public healthcare system did not justify involvement in this research. This concern was not shared by others in similar roles who participated in the research. The stakeholder was informed that participation in this research was voluntary, and the stakeholder decided to abstain from further participation. The snowball sampling effect was documented during the data collection phase and is presented in **Table 24**.

Table 24. The snowball sampling effect on the data collection.

Original participant	Led to				
A1	A4				
A2					
A3	A5				
A6	A7				
A8					
A9					
A10					
A11					
A12	A13				
A14					
A15					
A17	A16				
A18	A20				
A19	A21	A22	A25	A26	A27
A23					
A24					

A28
A29
A30
A31

Table 24 demonstrates how using snowball sampling led to 11 additional participants. From the 31 participants, 15 unique roles were identified and then grouped into stakeholder types. These roles are described in **Table 25**. The number of participants from each role was omitted to promote the anonymity of the participants.

Table 25. Research participant roles and descriptions

Participant role	Based at	Description	Participant category
Administration Manager	Hospital	Management of data capturers and handles escalation of administrative matters.	[2]Management
Admissions Clerk	Hospital	Admissions of inpatients.	[1]Operational
Call Taker	EMS	Takes emergency calls from patients or family members. Can also take calls from paramedics and hospital staff. Responsible for recording information on a digital system and referring the case to the relevant person or department.	[1]Operational
Data Capturer	Hospital	Captures paper-based information and records this on a digital system. This can include a spreadsheet. The information can originate from the wards during admissions or discharges, as well as overnight information.	[1]Operational
Dispatcher	EMS	Uses the information from a case to dispatch a paramedic team to a site, clinic or hospital.	[1]Operational
Emergency Doctor	Hospital	Responsible for patient care and deciding whether to admit a patient. In some cases, they also manage resources and people within a team. Collaborates with EMS during patient transport.	[2]Management

Head of Emergency Department	Hospital	Responsible for patient care and management of the department. They are responsible for the management of resources and reporting on certain activities relating to patient care. Cooperates with other managers to share resources.	[3]Strategic
Health Information Officer	Hospital	Coordinates the movement of hospital data (including admissions and discharges) from the point of creation (usually at the ward) onto the relevant spreadsheets and finally into the DHIS. They are also responsible for data validation throughout the process. Collaborates with data capturers and healthcare professionals.	[2]Management
Hospital Clinic Doctor	Hospital	Responsible for patient care and deciding whether a patient needs to be admitted to the hospital. Collaborates with admissions clerks to determine if beds are available.	[2]Management
Managing Medical Officer	Hospital	Plays a role in the decisions relating to ambulance diverts. Uses the information provided to them by the hospital management to determine whether an emergency department should be temporarily closed for incoming ambulances until the occupancy within the department allows them to reopen. Cooperates with hospital CEOs and other managers.	[3]Strategic
Paramedic	EMS	Responsible for patient care and the handling of paper-based patient documentation. Hands over a patient, including the relevant documentation to a receiving doctor at a hospital. Also responsible for patient transport between an accident scene, clinic or hospital. Collaborates with other emergency crews, dispatchers and emergency department personnel.	[1]Operational

Paramedic Trainer	EMS	Responsible for training paramedics in terms of patient care and other operational processes, including documentation and digital processes.	[1]Operational
Risk Manager	Hospital	Ensures that the information relating to the operation of the hospital is accurate and valid. Can perform functions relating to the coordination of data from source to DHIS and attending strategic meetings. Collaborates with data capturers and other managers.	[2]Management
Technology Manager	Hospital	Ensures the system users (medical staff, health information officers, data capturers, admissions staff, etc.) can access the relevant systems. Resolves issues relating to authorisation and governance of systems. Performs other maintenance checks on the digital systems.	[2]Management
Ward Clerk	Hospital	Responsible for documenting the details related to admissions and discharges. Also performs head counts at certain times of the day. Information is usually recorded on paper, but digital systems can be used in some cases.	[1]Operational

[1]*Operational:* *Responsible for tasks relating to administration and data.*

[2]*Management:* *Responsible for the management of people, resources or data.*

[3]*Strategic:* *Responsible for key decision-making.*

The interviews were conducted from Monday to Friday. Participants were informed that they could be accommodated on any day and at any time that suited them; however, all participants preferred to be interviewed on a weekday. Friday was the most popular day selected, with a total of 10 interviews conducted on Fridays over the data collection period. The average interview length was 31 minutes. Participants were initially asked to make themselves available for 45 to 60 minutes; however, some participants requested a 30-minute interview and were willing to grant extra time if needed. The request for a 45- to 60-minute interview resulted in a lower participation uptake. The switch to a 30-minute interview seemed to influence the likelihood of a stakeholder agreeing to participate in this research. All participants provided verbal consent, but two participants provided written consent as well. All interviews were successfully recorded and transcribed.

St. George et al. (2023) argue that rapid qualitative analysis (also referred to as RQA) techniques, such as summarising interviews and converting them into data matrices, support faster data analysis compared to the traditional approaches used in research. Though the RQA technique was not directly used in this research, a simple matrix was used to summarise each interview. At the end of each interview, prior to transcribing, reflection notes from the researcher's perspective about the interview were captured. These reflections were documented and summarised into a one-sentence description, as presented in **Table 26**.

Table 26. Post-interview reflection descriptions

Participant	Date of interview	Duration (mins)	One sentence summary of reflection
A1	October 2023	30	More experienced doctors might not be willing to adopt the use of new technologies.
A2	October 2023	45	Technology must be used with caution as humans might try to circumvent the governance measures put in place.
A3	October 2023	45	There are mixed views about the new SAP HIS.
A4	October 2023	30	Digital health systems and access to data are fragmented.
A5	October 2023	30	The pilot bed management system used previously was useful but has been decommissioned.
A6	October 2023	25	There are still many paper-based systems in use.
A7	October 2023	12	Access to information should be protected.
A8	October 2023	40	The aim of a unified patient record cannot be achieved if staff are not adequately trained on first searching for existing records before creating new patient records.
A9	October 2023	40	Digital evidence is important and should be used more effectively.
A10	October 2023	35	Gauteng lags the Western Cape with the effective use of digital health technologies.
A11	October 2023	30	Focused on the importance of the DHIS reports.
A12	November 2023	30	The frustrations friends and family members of patients experience in the emergency department could be alleviated by making real-time information available to them.
A13	November 2023	30	Community perceptions of healthcare facilities are important as they influence which facilities patients feel comfortable visiting.
A14	November 2023	32	The implementation of the NHI must be done carefully to avoid unwanted consequences.
A15	November 2023	35	The NHI could have a positive impact on the overall healthcare system.
A16	November 2023	25	A combination of paper-based and digital information is used at healthcare facilities.
A17	November 2023	35	Quality healthcare data play a critical role in patient care.

A18	November 2023	45	Provided a detailed description of the admissions and discharge process.
A19	November 2023	35	Provided an explanation of the EMS processes related to patient transport and transfer.
A20	November 2023	35	Provided a view that the admissions process can be smooth, provided that the staff knows how to use the digital systems appropriately.
A21	November 2023	30	Communication between EMS and hospitals is crucial to positive patient outcomes.
A22	November 2023	20	Patient routing and transfer depend on resource availability at the receiving healthcare facilities.
A23	November 2023	22	Bed occupancy information might not always be available in real-time as the ward clerks do not work on weekends or at night.
A24	November 2023	20	Information must be communicated to the right stakeholders.
A25	November 2023	30	Patients could be educated on the triage processes to empower them during a medical emergency.
A26	November 2023	30	Intelligent routing, which includes several variables, could have a positive effect on patient transport.
A27	November 2023	30	Patient routing systems could be enhanced by including new ideas.
A28	November 2023	30	Medical-related information should be highly protected and should be provided on a need-to-know basis.
A29	November 2023	20	Overall healthcare information should remain internal to healthcare facilities.
A30	November 2023	30	Digital evidence can play a vital role in ensuring accountability among healthcare staff.
A31	November 2023	40	DHIS information should be accurate as this is used for resource planning.

The summary presented in **Table 26** provides the researcher's high-level view of what each participant described in their interviews. Some of the descriptions are similar, but each participant shared unique views. This supports the interpretivist paradigm applied to this study.

4.4 Arriving at Data Saturation

Data saturation was not determined while data were being collected. The stance taken during this research was to conduct as many interviews as possible. Given the limited access to key participants in the healthcare sector, the study estimated that the number of interviews would not be high. Once the researcher noticed that it was no longer possible to confirm new interviews with relevant stakeholders (after 31 interviews), the researcher decided to determine if data saturation had been reached. **Section 3.10.2** noted two potential theories to confirm whether data saturation had been reached. The first theory suggested the point where <= 5% of new codes emerged. The second theory states that for a heterogeneous population group, somewhere between nine and 17 interviews could achieve data saturation. Two hundred and fourteen codes were identified during the analysis, and these illustrate the data saturation in **Figure 24**.

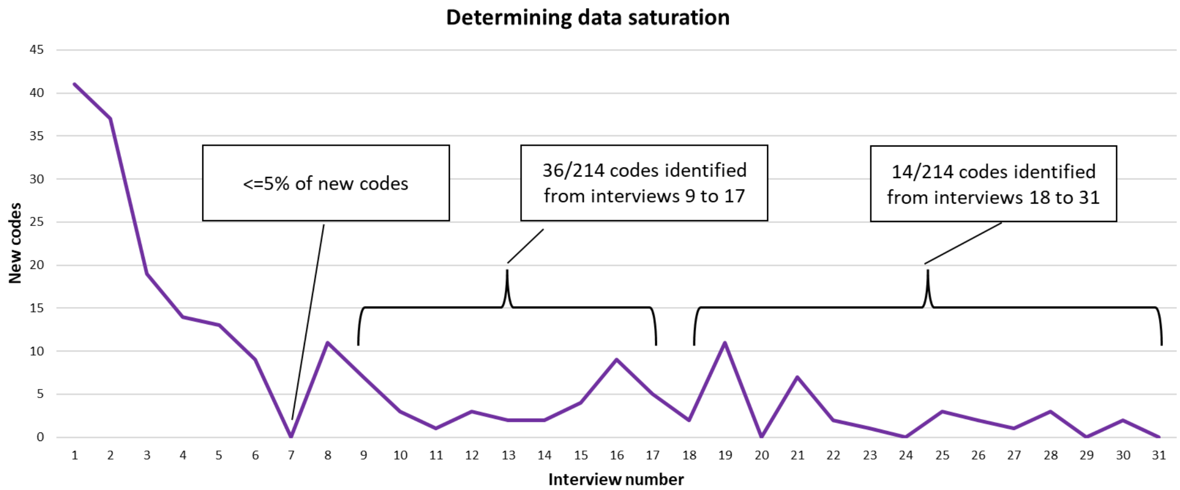


Figure 24. Determining data saturation

Based on the two data saturation theories, **Figure 24** demonstrates that data saturation was reached from Interview 7 or Interview 17. However, Interview 7 concluded ahead of time because the participant was called into another meeting, and a follow-up interview could not be scheduled. Accordingly, data saturation was reached during Interview 17. Further, the 14 interviews from 18 to 31 could be considered "talking to people".

4.5 Analysing the Data

The 31 interviews acted as the primary source of data and were qualitatively analysed to determine the overall themes. Each interview transcript was first coded; the codes were then grouped, and relationships between the codes in each group were identified using the *ATLAS.ti* network function, which resulted in sub-networks or networks. The sub-networks were further grouped into additional networks, which were then grouped into themes. These themes were utilised to improve the Design Model for a Live Healthcare Console version 0.1 to formulate the Design Model for a Live Healthcare Console version 0.2. The data analysis process was conducted in four main steps, described in **Table 27**.

Table 27. Data analysis steps followed

Step	Description	Evidence
1	Upload the transcripts into *ATLAS.ti*	**Figure 25**
2	First cycle coding: Code the transcripts	**Figure 26**
3	Second cycle coding: Create sub-networks and networks using the identified codes	**Figure 27**, **Figure 28**
4	Third cycle coding: Group the networks into themes	**Figure 29**

Search Documents

ID	Name	Media Type	Location
D 1	A1_Edited	Text	Library
D 2	A2_Edited	Text	Library
D 4	A3_Edited	Text	Library
D 5	A4_Edited	Text	Library
D 6	A5_Edited	Text	Library
D 7	A6_Edited	Text	Library
D 8	A8_Edited	Text	Library
D 11	A9_Edited	Text	Library
D 12	A10_Edited	Text	Library
D 13	A11_Edited	Text	Library
D 14	A7_1_Edited	Text	Library
D 15	A12_Edited	Text	Library
D 16	A13_Edited	Text	Library
D 17	A14 Edited	Text	Library
D 18	A15_Edited	Text	Library
D 19	A16_Edited	Text	Library
D 20	A17_Edited	Text	Library
D 21	A18_Edited	Text	Library
D 22	A19_Edited	Text	Library
D 23	A20_Edited	Text	Library
D 24	A21_Edited	Text	Library
D 25	A22_Edited	Text	Library
D 26	A23_Edited	Text	Library
D 27	A24_Edited	Text	Library
D 29	A26_Edited	Text	Library

Figure 25. Documents uploaded to *ATLAS.ti*

Figure 25 displays a screenshot of the documents uploaded to *ATLAS.ti* for analysis. The transcripts were uploaded in a standard MS *Word* document format (.docx). **Figure 26** displays an example of a document being coded during the first cycle of coding.

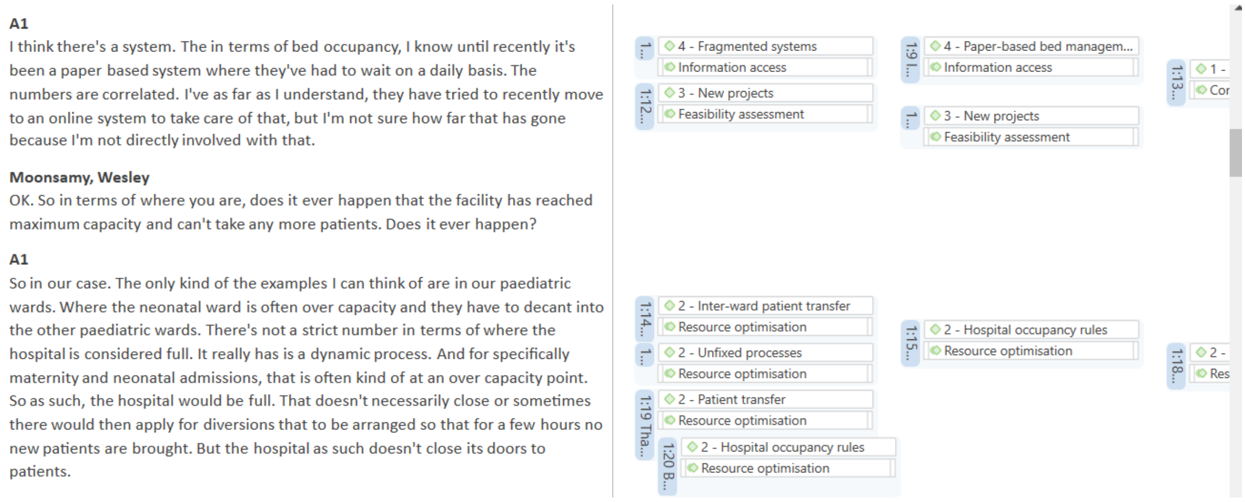


Figure 26. First cycle coding of a transcript

During the first cycle of coding, text was highlighted and a new or existing code was applied to it, as seen in **Figure 26**.

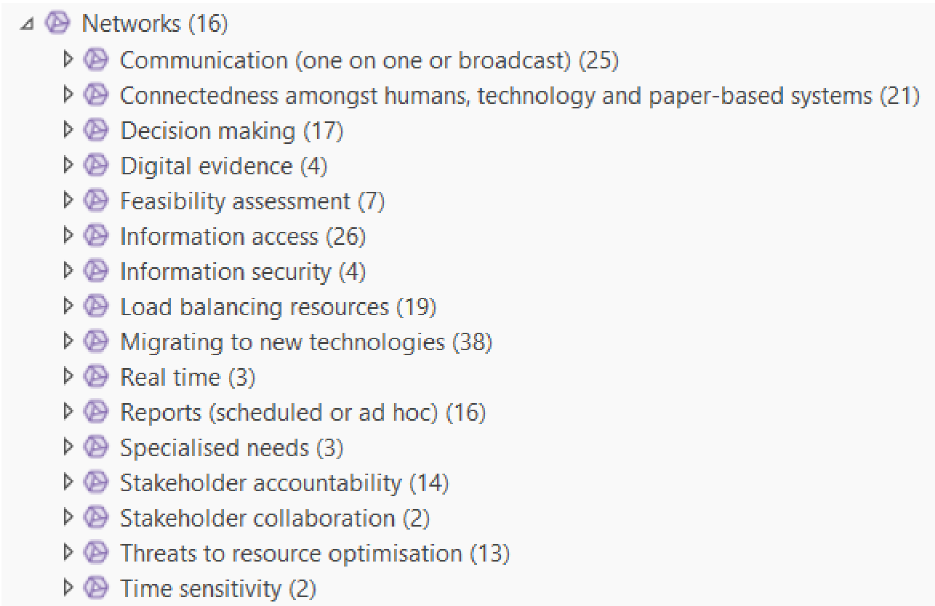


Figure 27. The 16 identified networks.

Figure 27 displays a screenshot of the 16 networks identified in *ATLAS.ti*. The numbers in brackets represent the number of codes associated with each network.

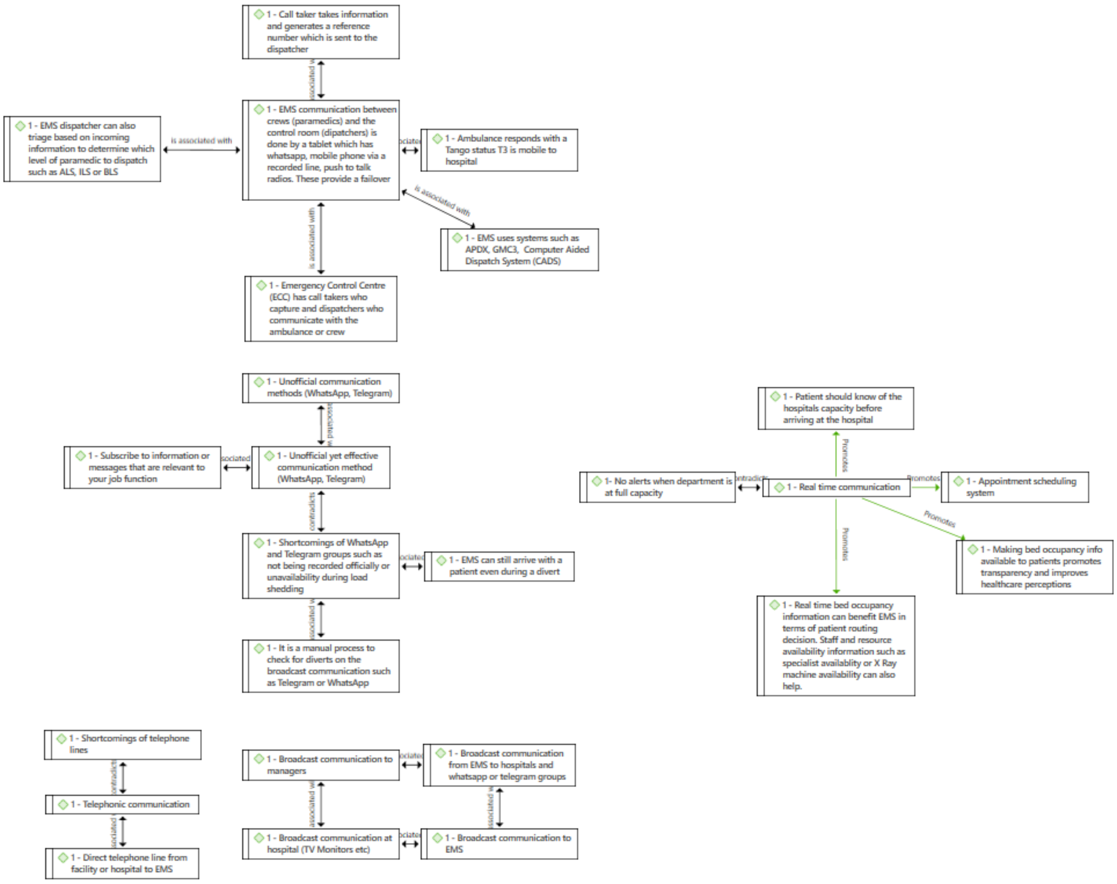
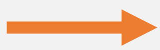
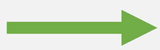


Figure 28. An example of related codes which formed networks.

The blocks within **Figure 28** are codes. The codes were grouped, placed next to each other, and then associated using a relation operator described in **Table 28**. The relations could be either unidirectional or bidirectional based on the relationship between the codes. **Figure 28** displays one (1) network containing five (5) sub-networks. The sub-networks are the smaller units with associated codes. The relationships between the codes were created using the standard relation operators provided by *ATLAS.ti*. In cases where the standard relation operators did not apply to the code relationships, a new relation operator was created. The relation operators are described in **Table 28**.

Table 28. Description of the relation operators

Name	Description	Direction	Standard or custom	Usage	Image[1]
Causes	A code causes a phenomenon to occur.	One-way	Custom	15	
Contradicts	Two codes contradict each other.	Two-way	Standard	17	
Enables	A code allows for another phenomenon to occur.	One-way	Custom	3	

Is a property of	A code forms part of the properties of another code.	One-way	Standard	11	
Is associated with	Two codes are related to each other, but the relationship is not detailed enough to be named.	Two-way	Standard	131	
Is the cause of	A code affects another code.	One-way	Standard	1	
Jeopardises	A code puts another code at risk.	One-way	Custom	4	
Promotes	A code positively affects another code.	One-way	Custom	15	

[1]The colours of the relation do not affect the relation operator; they are used to distinguish between some of the relation operators.

The derivation of the themes from the networks was accomplished using MS *Excel*.

Networks	Themes
Communication (one-on-one or broadcast)	Communicate
Connectedness amongst humans, technology and paper-based systems	Connect
Decision-making	Cooperate
Digital evidence	Combine
Feasibility assessment	Cooperate
Information access	Contain
Information security	Contain
Load-balancing resources	Communicate
Migrating to new technologies	Connect
Real-time	Communicate
Reports (scheduled or ad hoc)	Collaborate
Specialised needs	Cooperate
Stakeholder accountability	Cooperate
Stakeholder collaboration	Collaborate
Threats to resource optimisation	Contain
Time sensitivity	Communicate

Figure 29. Grouping of networks into themes

The network names from **Figure 28** were copied into MS *Excel* and were grouped into common themes, as illustrated in **Figure 29**.

4.6 Structure of the Themes

Each theme comprises components, which are one or more networks. Each network comprises either (i) codes associated with each other or (ii) one or more sub-networks. Each sub-network comprises associated codes, and the codes comprise quotations obtained from the interview transcripts.

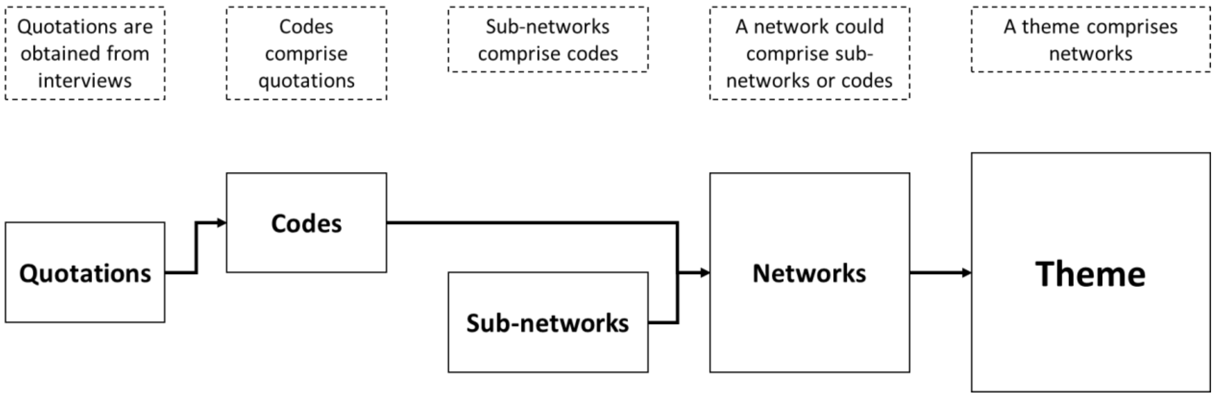


Figure 30. The structure of the themes

Figure 30 illustrates the structure of the themes; hence, each theme is presented based on this structure.

4.7 Explanation of the Themes

The six themes are explained using an adaptation of the Setup–Quotation–Comment (SQC) technique described by Weaver-Hightower (2015). The components of each theme contain the networks, which comprise the codes or sub-networks. Each code has associated quotations from the interviews. The explanation of each theme utilised the SQC technique as follows:

- Setup – A paragraph preceding each quotation provides background to the quotation and how it relates to the theme. Another sentence might then be provided to introduce the quotation.
- Quotation – A quotation extracted from one or multiple interviews. The quotations can be linked to a code, then to a network, and lastly, to a theme. The pseudonym of each participant is provided after each quotation except in circumstances where the information shared was deemed too sensitive to reveal the pseudonym. It must be noted the participants' names are not revealed in this study and cannot be traced back to the pseudonyms in this thesis.
- Comment – The paragraph following each quotation or group of quotations. This paragraph serves to summarise or emphasise certain salient parts of the quotation above it. Where applicable, this paragraph might also serve as the setup for the next quotation.

Each theme is substantiated with the relevant network diagrams obtained from *ATLAS.ti*. The high-resolution network diagram images can be accessed from https://doi.org/10.6084/m9.figshare.25902667 (Moonsamy, 2024). The six themes identified during the analysis phase are explained in the upcoming sections.

4.8 Theme: Connect → Connecting People to Information

The Connect theme relates to connecting existing systems in a manner that supports the availability of real-time information and the reduction of data duplication and data inconsistencies prevalent in disparate systems. Ultimately, this theme applies to connecting people to information and people to people. The people-to-people aspect is more apparent in the Communicate theme. Connecting people to information is a function of several aspects, including system availability and internet or WIFI connectivity. **Section 4.8.1** describes how this theme was formulated.

4.8.1 Arriving at this Theme

The Connect theme is a synergy between the following two networks:

- Connectedness among humans, technology and paper-based systems – This network focuses on the importance of connecting existing systems within the public healthcare landscape. This network exceeds the boundaries of a single hospital and includes other hospitals within the district and province. There is also a higher-level to consider within the digital health landscape, namely the connectivity between hospitals, EMS and the public.

- Migrating to new technologies – When migrating to new technologies, an existing system is replaced with a new system. This action usually aims to enhance existing processes. One such example is providing information in real-time or connecting information for improved decision-making. When introducing new technologies into a landscape, it is important to consider which systems, processes and people will connect to it.

Section 4.8.2 describes the components of the connect theme.

4.8.2 Components of this Theme

Twenty-one codes were associated to form the connectedness among humans, technology and paper-based systems network, and 38 codes were associated to form the Migrating to New Technologies network. **Table 29** presents these codes.

Table 29. Components of the Connect theme.

Connectedness among humans, technology and paper-based systems (21 codes)
Admissions and discharges is a hybrid process involving humans (clerks), paper and digital systems.
Bed occupancy information is used by doctors.
EMS does not have information when a patient comes from home or outside a hospital.
EMS has access to information during a patient transfer from another hospital.
Information, such as bed occupancy, supports decision-making and prioritising.
Making information available to patients gives them the ability to make more informed decisions (patient empowerment).

No integration between hospitals and Emergency Medical Services (EMS).
Official paper-based system (inter-ward patient transfer)
Patient discharge process is paper-based and digital via ward or data clerks.
Patients can be transferred and information captured.
Real-time and accurate information could prevent patient routing errors.
Rolling up of bed occupancy information from wards to managers to districts.
Sharing patient records between facilities.
Some EMS systems are paper-based, from the control room to the ambulance.
Technology or systems and humans should work together. There should not be too much reliance on only one.
There are concerns over the possible misuse of bed occupancy information to the benefit of individuals.
There is a call for the use of AI to assist patients with self-triage.
There should be less focus on reporting for its own sake, especially with inaccurate information.
TPH99 is a paper-based form the paramedic fills out and hands a copy to the hospital. Contains an ECC reference number.
Unusable digital systems (patient transfer)
Use of a TPH21 document for ward reporting
Migrating to New Technologies (38 codes)
A new system, project or process should be introduced to help solve certain problems and improve healthcare.
Continuation of paper-based processes due to governance and other factors.
Customising system to add new functionality
Deactivation of working systems (such as the PAX system)
Delays caused by capturing paper-based information
Digital footprint should be used to promote data and process integrity.
Digital pharmacy scripts or e-scripts
Disjointed access to patient or related information
Each facility or hospital has a non-graphical or text-based bed capacity or ward plan.
Fears over job loss due to technology
Financial benefits of consolidating systems
Lack of operational digital healthcare systems
Managers might not yet be using the system
Manual correction of bed occupancy information
Manual processing
More integration of the various systems is needed. Specialist systems cannot easily be replaced.
New SAP HIS does not assign a patient to a bed.
New SAP HIS is reliable.
New SAP HIS will support a paperless system (digitise).
New SAP system offers bed occupancy flexibility.
Outdated information or ad hoc requests can cause duplication of effort.

Pharmacy system
Pilot bed management system deactivated
Pilot bed management system was good.
POPIA is considered, and high standards of data privacy are followed.
Previous bed management system needed manual updates for TV monitors.
Reverting to old processes due to failed projects.
Risks of a centralised system is data loss (single point of failure).
SAP HIS might not have sub-wards or specialised beds configured.
Scams and schemes by people or patients result in medicine theft, compromising the integrity of the healthcare system.
Some systems are not user-friendly or easy to use.
Staff must use systems correctly.
Systems should be flexible and consider human input. Patients might have unique needs, such as intense pain or a fracture.
The use of AI in patient routing
There is currently a lack of digital records or a digital footprint.
There is trustworthiness in real-time data.
Using *SharePoint* as an official communication medium.
Using digital files, such as X-rays, instead of printing.

4.8.2.1 Connectedness among Humans, Technology and Paper-Based Systems

Networks were created based on the associations between the components presented in **Table 29**. The Connectedness among Humans, Technology and Paper-Based Systems network consisted of two sub-networks, illustrated in **Figure 31** and **Figure 33**. People and information are connected by using digital systems and paper-based documents. **Section 2.1.1** introduced Gauteng's new SAP HIS, which connects healthcare professionals to information available in real-time or, in some cases, near-real-time. The system has a centralised bed management component; however, inter-facility access to this information is limited. In addition, third-party systems, such as EMS, are not connected to SAP HIS and thus do not have access to the bed-management information.

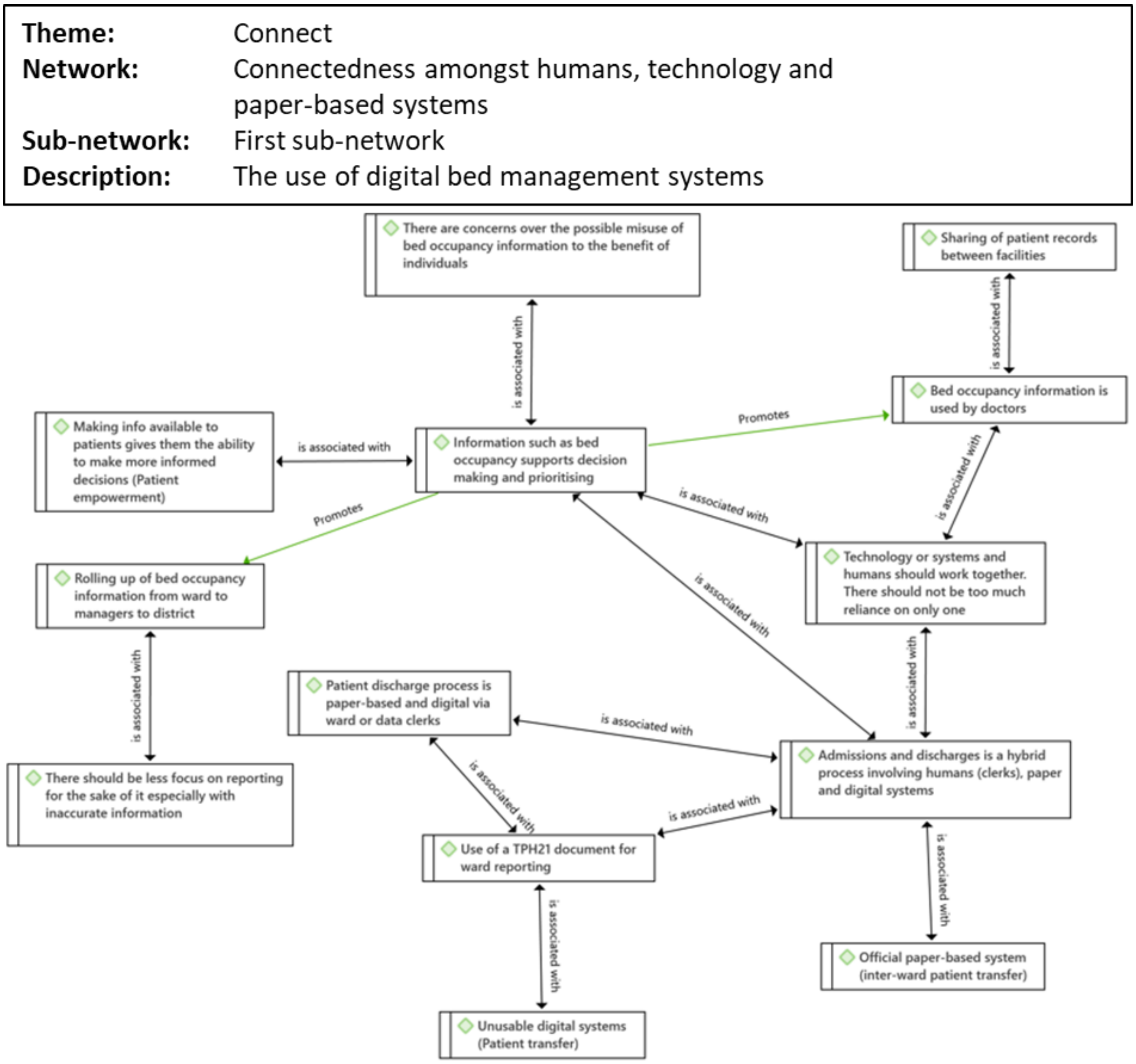


Figure 31. The first sub-network of the Connectedness Among Humans, Technology and Paper-Based Systems network.

Figure 31 highlights the use of digital bed management data within the healthcare system. Gauteng's new SAP HIS provides an opportunity to standardise the admissions and discharge processes, which impact digital bed occupancy information. Participants shared their experiences with SAP HIS in terms of bed management.

> *The HIS system that Gauteng province is in the process of rolling out as well also has a bed management aspect of it. [Participant: A6]*

> *They would then be able to use the system and would automatically pick up where the patient is. [Participant: A6]*

Though system access is available to the relevant stakeholders, they are not necessarily connecting directly to the system to access the information they need. This can cause duplication of effort, as participants mentioned the use of collating information to generate reports for various levels of management. These reports are used to disseminate information rather than individuals accessing the information they require.

> *That will make things easier because we are pretty much repeating one and the same thing with each and every different document[s]. It's a text document. It's an internal document. We are pretty much repeating. It's a repetition of things. So if you can have a system that will literally when you input in one then it fits the rest. Then it would make things very much easier. [Participant: A16]*

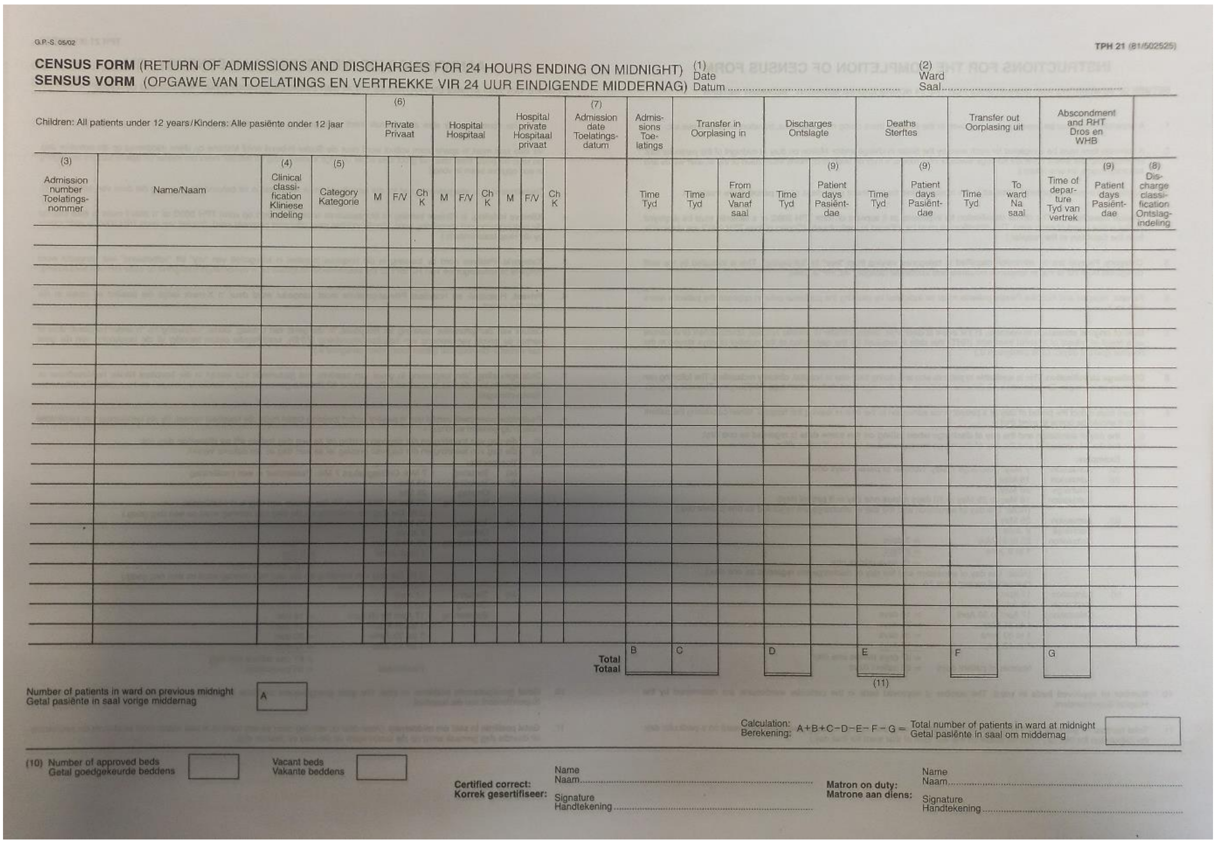
> *There is sometimes duplication of efforts. In certain areas. Sometimes it could be due to reporting. [Participant: A17]*

Paper-based documents are the source of information in certain areas of the hospital. The use of paper-based documents, such as the TPH21, plays an important role within the wards. Information captured on these documents is later transcribed by data clerks onto spreadsheets or into SAP HIS. The use of the TPH21 documents were described in detail by some participants and summarised by others.

> *OK, I'm using on a daily basis, we have our TPH21, which is a yellow pages that they are using to admit and discharge transfer that had the ward they usually* (sic)*. [Participant: A11]*

> *In the ward so that's the one that we use to determine the occupancy of the ward. TPH21. [Participant: A12]*

The TPH21 document acts as a census form, keeping track of patients currently occupying a bed. This form is handed over to the data capturers daily. New forms are created from Monday to Friday, as ward clerks do not work on weekends. **Figure 32** presents an image of the TPH21 document provided by a participant.



G.P.-S. 05/02 TPH 21 (81/502525)

CENSUS FORM (RETURN OF ADMISSIONS AND DISCHARGES FOR 24 HOURS ENDING ON MIDNIGHT) (1) Date
SENSUS VORM (OPGAWE VAN TOELATINGS EN VERTREKKE VIR 24 UUR EINDIGENDE MIDDERNAG) Datum ....

(2) Ward
Saal ....

Children: All patients under 12 years/Kinders: Alle pasiënte onder 12 jaar

(3) Admission number Toelatings-nommer	Name/Naam	(4) Clinical classi-fication Kliniese indeling	(5) Category Kategorie	(6) Private Privaat			Hospital Hospitaal			Hospital private Hospitaal privaat			(7) Admission date Toelatings-datum	Admis-sions Toe-latings	Transfer in Oorplasing in		Discharges Ontslagte		Deaths Sterftes		Transfer out Oorplasing uit		Abscondment and RHT Dros en WHB		(8) Dis-charge classi-fication Ontslag-indeling
				M	F/V	Ch K	M	F/V	Ch K	M	F/V	Ch K		Time Tyd	Time Tyd	From ward Vanaf saal	Time Tyd	(9) Patient days Pasiënt-dae	Time Tyd	(9) Patient days Pasiënt-dae	Time Tyd	To ward Na saal	Time of depar-ture Tyd van vertrek	(9) Patient days Pasiënt-dae	

Total Totaal: B C D E (11) F G

Number of patients in ward on previous midnight
Getal pasiënte in saal vorige middernag: A

Calculation: A+B+C−D−E−F−G = Total number of patients in ward at midnight
Berekening: Getal pasiënte in saal om middernag

(10) Number of approved beds
Getal goedgekeurde beddens

Vacant beds
Vakante beddens

Certified correct: Name Naam ....
Korrek gesertifiseer: Signature Handtekening ....

Matron on duty: Name Naam ....
Matrone aan diens: Signature Handtekening ....

Figure 32. TPH21 document used in the hospital wards to track bed occupancy.

The TPH21 document could be completed by a ward clerk or a nurse. Some facilities differ regarding the responsibility for this document.

Theme: Connect
Network: Connectedness amongst humans, technology and paper-based systems
Sub-network: Second sub-network
Description: Fragmented hospital and EMS systems

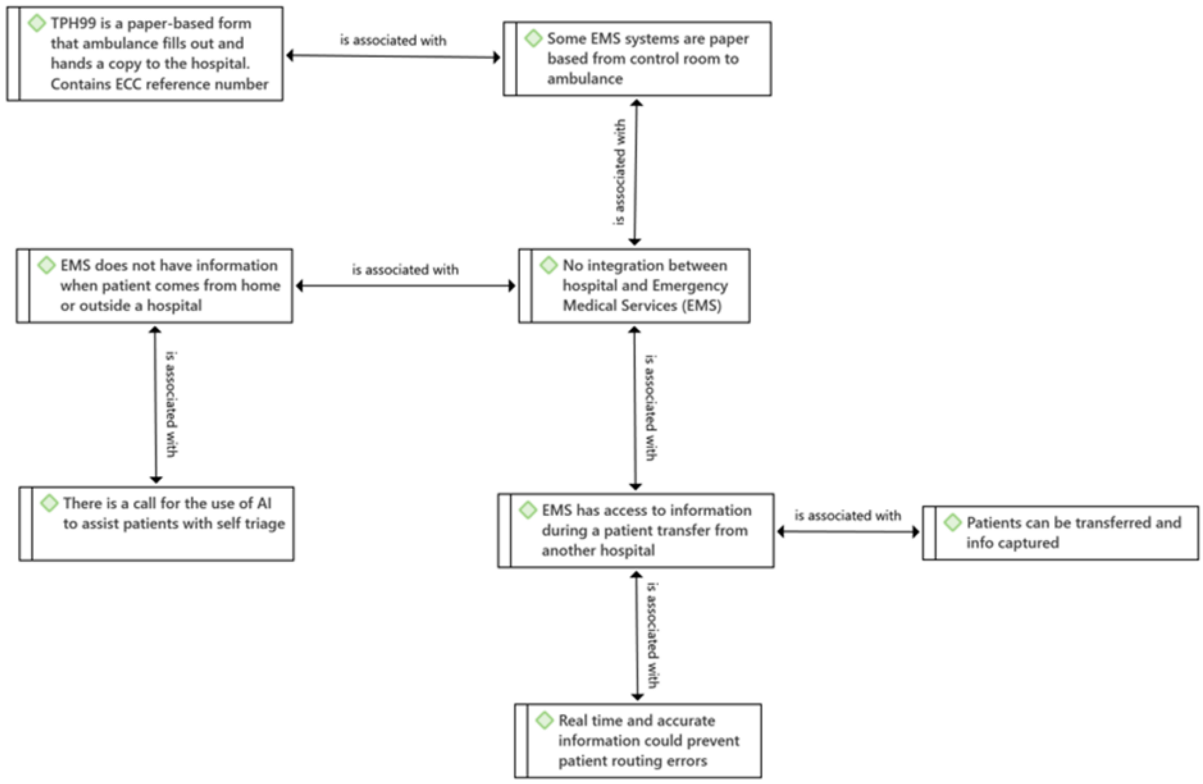
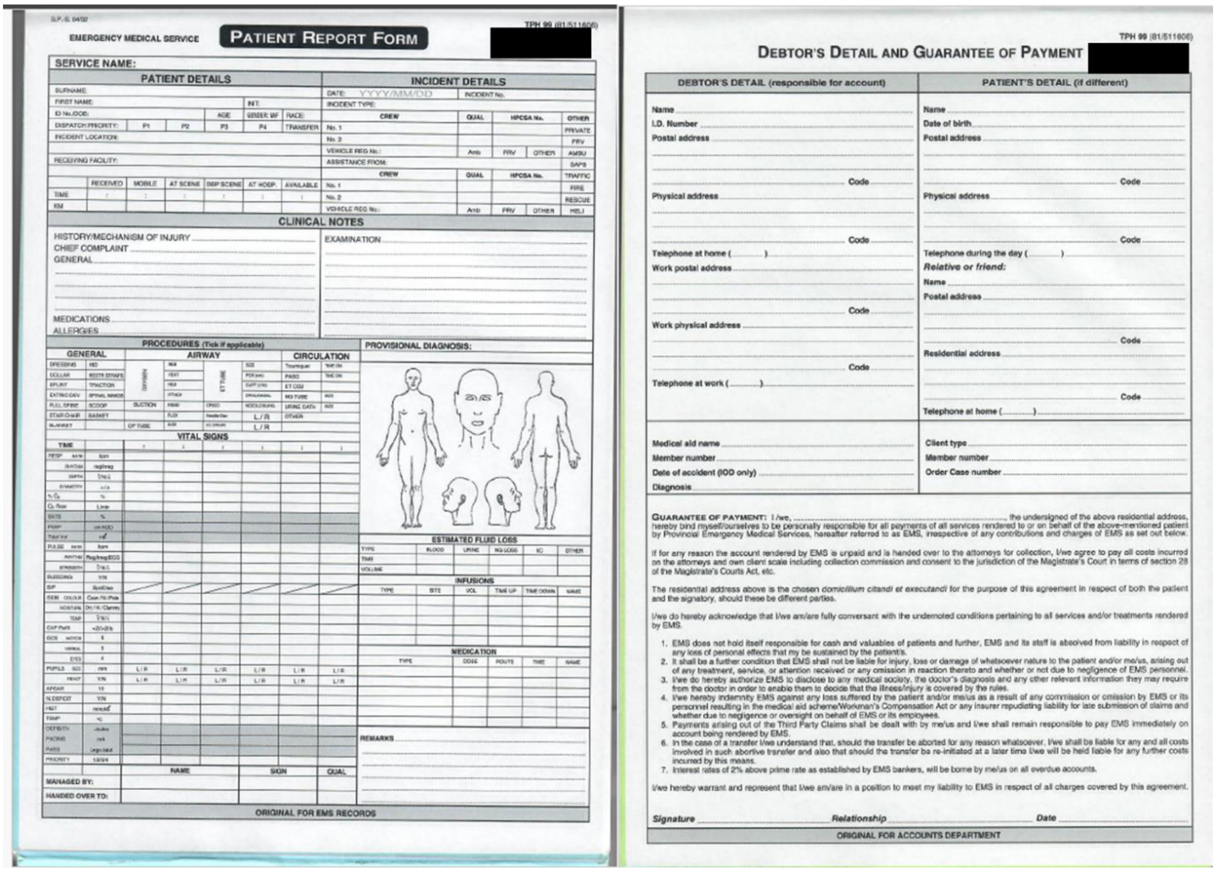


Figure 33. The second sub-network of the Connectedness among Humans, Technology and Paper-Based Systems network.

Figure 33 highlights that healthcare facility systems, such as SAP HIS, are not connected to EMS systems like the dispatch system. Such fragmented access to information can lead to stakeholders requesting information from each other rather than being able to access the requisite information. Another important paper-based document, the TPH99, is used by ambulance crews when they transfer a patient to another facility or transport a patient from a scene. This document is completed by the paramedic and handed to the receiving healthcare professional during the patient handover process. **Figure 34** presents a copy of the TPH99 form (provided by a participant). Usage of the TPH99 form could be because the EMS and healthcare facility systems are not connected; hence, there would be no way to share the information captured on the form.



EMERGENCY MEDICAL SERVICE PATIENT REPORT FORM TPH 99 [redacted]

SERVICE NAME:

PATIENT DETAILS | INCIDENT DETAILS

CLINICAL NOTES

HISTORY/MECHANISM OF INJURY
CHIEF COMPLAINT
GENERAL
MEDICATIONS
ALLERGIES
EXAMINATION

PROCEDURES (Tick if applicable)
GENERAL | AIRWAY | CIRCULATION
PROVISIONAL DIAGNOSIS:
VITAL SIGNS
ESTIMATED FLUID LOSS
INFUSIONS
MEDICATION
REMARKS
MANAGED BY:
HANDED OVER TO:
NAME | SIGN | QUAL

ORIGINAL FOR EMS RECORDS

DEBTOR'S DETAIL AND GUARANTEE OF PAYMENT TPH 99 [redacted]

DEBTOR'S DETAIL (responsible for account) | PATIENT'S DETAIL (if different)

GUARANTEE OF PAYMENT

Signature Relationship Date

ORIGINAL FOR ACCOUNTS DEPARTMENT

Figure 34. TPH99 form used during patient transport and transfer.

The TPH99 form is completed by the ambulance crew and handed to the receiving doctor at the hospital (usually the emergency department).

> *So the EMS, when they bring the patient, they've got their own forms from the ambulance, right? [Participant: A20]*

The reference number on the TPH99 (redacted in **Figure 34**) links the EMS, patient and receiving hospital. The TPH99 is linked to the ambulance crew, the trip and possibly the admission of a patient.

> *TPH99 yes so when we give them the call on their thing on their trip log, they put the reference number, our reference number that we gave them and even when they arrive at the scene when they're treating the patient with a TPH and they put the reference number in future reference. Maybe reported to court cases and for investigation purpose, it needs to match with the one that is on their own on our system. [Participant: A21]*

The information captured on the TPH99 form must be entered into a digital system, presumably the SAP HIS. The participants did not describe this process but stressed the linkage of the form with the digital patient record. They could not confirm whether the information was also captured on the EMS systems.

4.8.2.2 Migrating to New Technologies

The Migrating to New Technologies network was created through four sub-networks, as illustrated in **Figure 35**, **Figure 36** and **Figure 37** (two sub-networks are presented in this figure).

Theme:	Connect
Network:	Migrating to new technologies
Sub-network:	First sub-network
Description:	New digital health systems can support healthcare services

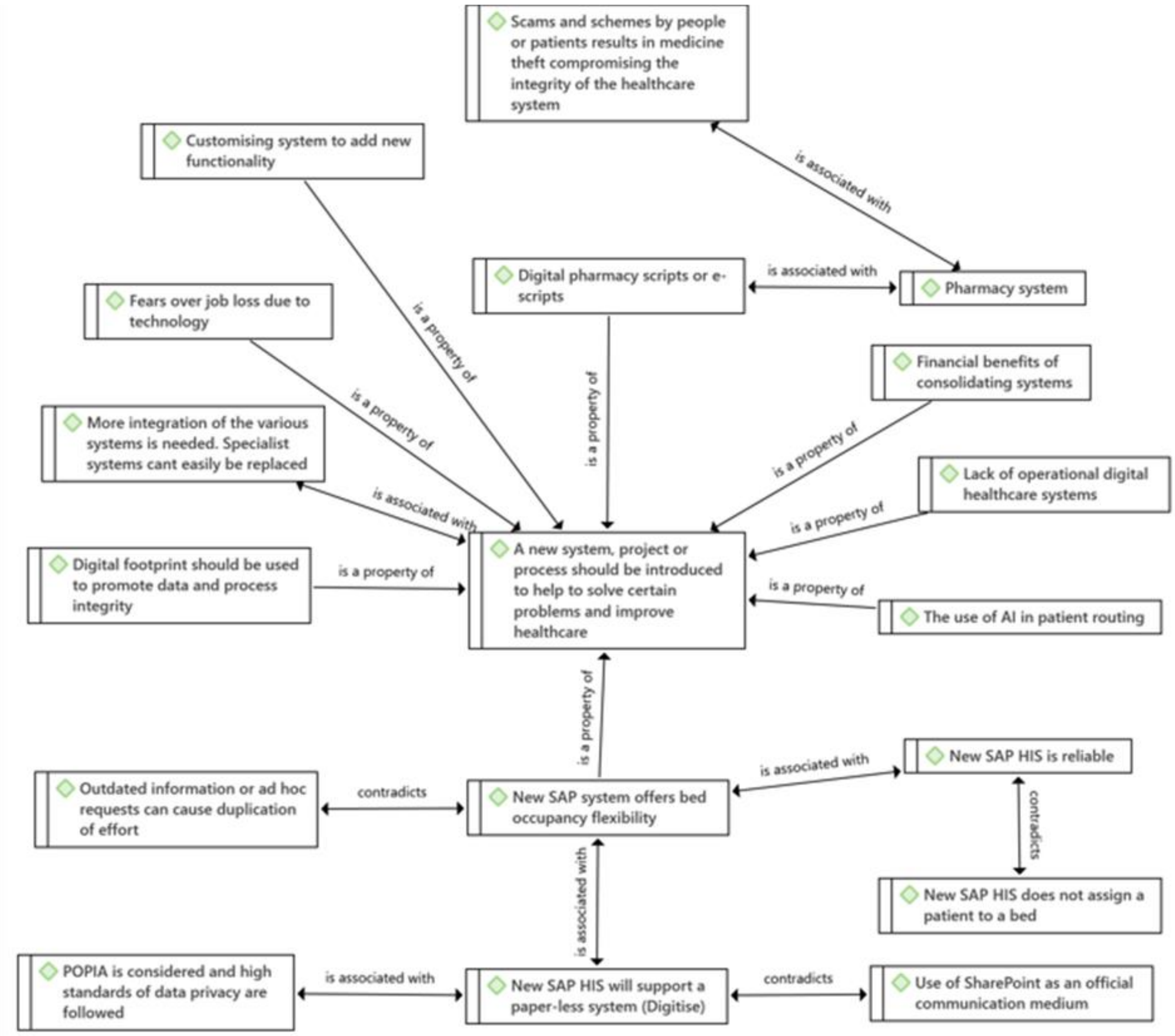


Figure 35. The first sub-network of the Migrating to New Technologies network

Participants highlighted that there must be synergy between hospitals and EMS, yet there is a distinction between their digital health systems. The respective digital systems are not connected and, thus, do not automatically sync information. This aspect is emphasised by the call for more connectivity between the systems shown in **Figure 35**. The participants noted the lack of connectivity between these systems:

No, the EMS does not run on our system. [Participant: A3]

No, no, I don't think there's a link at the moment. [Participant: A5]

Yeah, that's the weakness of the divide. The weakness of the divide is that it doesn’t talk to the EMS. [Participant: A14]

I think there's definitely the disconnect between EMS and the clinics in the hospitals in general, I feel that there should be a single system where it starts with the ambulance crews and the digital. [Participant: A19]

So EMS the dispatch system, everything like that is happening in one silo and then the hospital will have their own system. [Participant: A19]

SAP HIS seems to connect healthcare professionals to patient records to enable them to provide patient care. However, there is a lack of connectivity between SAP HIS and EMS systems, even though the emergency departments and EMS work closely together. Numerous participants were aware that the hospital and EMS systems were not connected and expressed sentiments indicating that connectivity between these systems would support them. This disconnect between the systems could be owing to migration to new technology. These systems could be integrated in future, but none of the stakeholders noted this possibility.

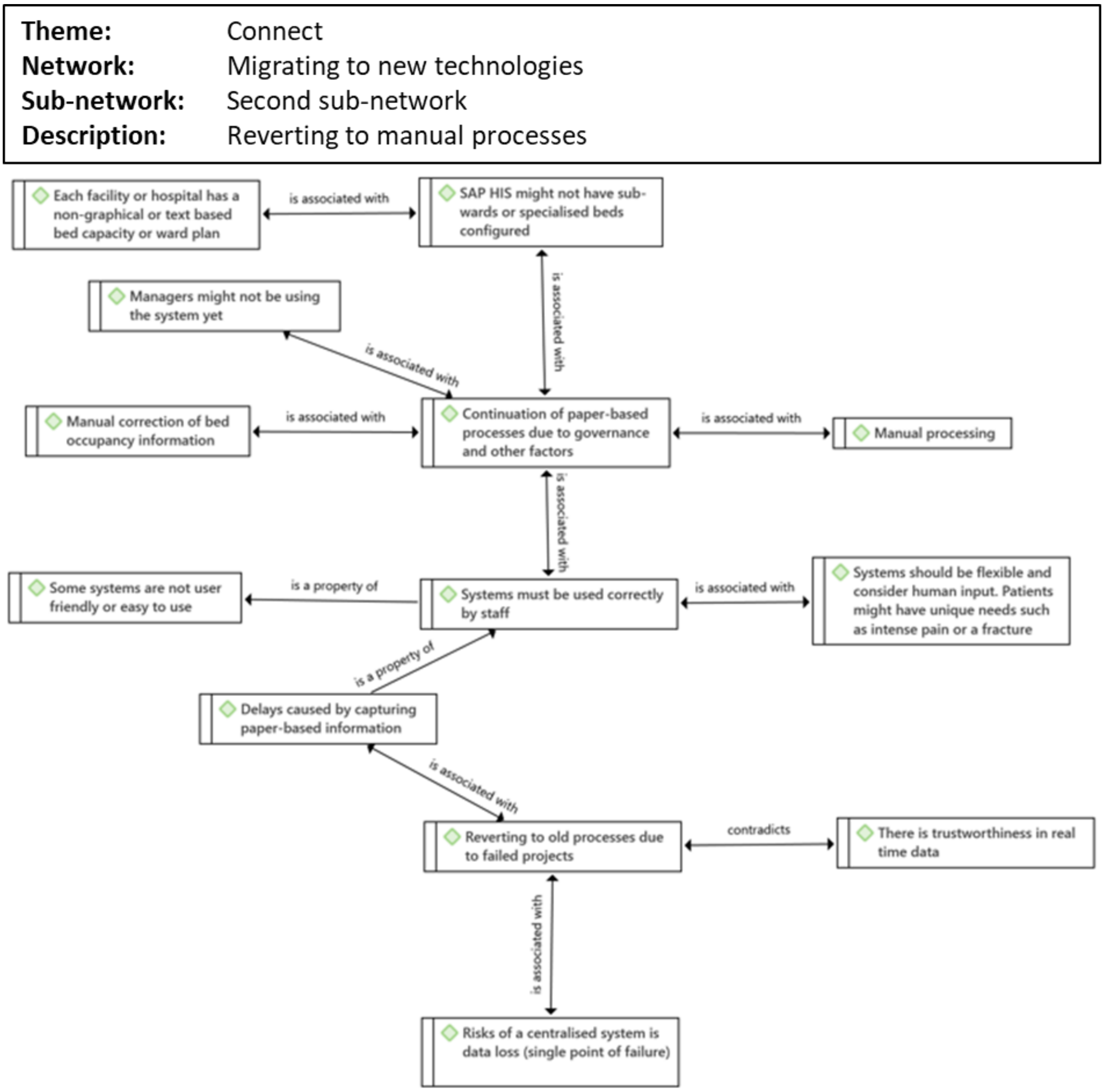


Figure 36. The second sub-network of the Migrating to New Technologies network.

Figure 36 illustrates the use or sometimes lack of use relating to new systems. Though new digital systems have been implemented, in some cases, managers prefer to receive reports rather than access and disseminate information.

> *Have cluster meeting and then have a form of communication so they do share information even if they're not using the system. [Participant: A3]*

In some cases, new projects, such as digital X-ray images, are not used for several reasons, including system unavailability or a break in the system integration. This can result in reverting to old processes like printing X-rays.

> *So if a patient was seen in the emergency department and had an X-ray and had to go to the ward, then the X-ray still had to be printed because the ward doctor had to see the X-ray. [Participant: A2]*

Participants expressed that reverting to older technology and previous processes is necessary when newer technology is not properly integrated into the healthcare system. This causes duplication of effort at various healthcare levels and leaves discrepancies in future patient records, as paper-based notes might not be captured once the systems become available. Some participants also decried the lack of training on new systems, which precipitated some stakeholders to revert to older processes with which they were more familiar.

Theme:	Connect
Network:	Migrating to new technologies
Sub-network:	Third sub-network
Description:	Decommissioning of working systems
Sub-network:	Fourth sub-network
Description:	Disjointed access to healthcare information

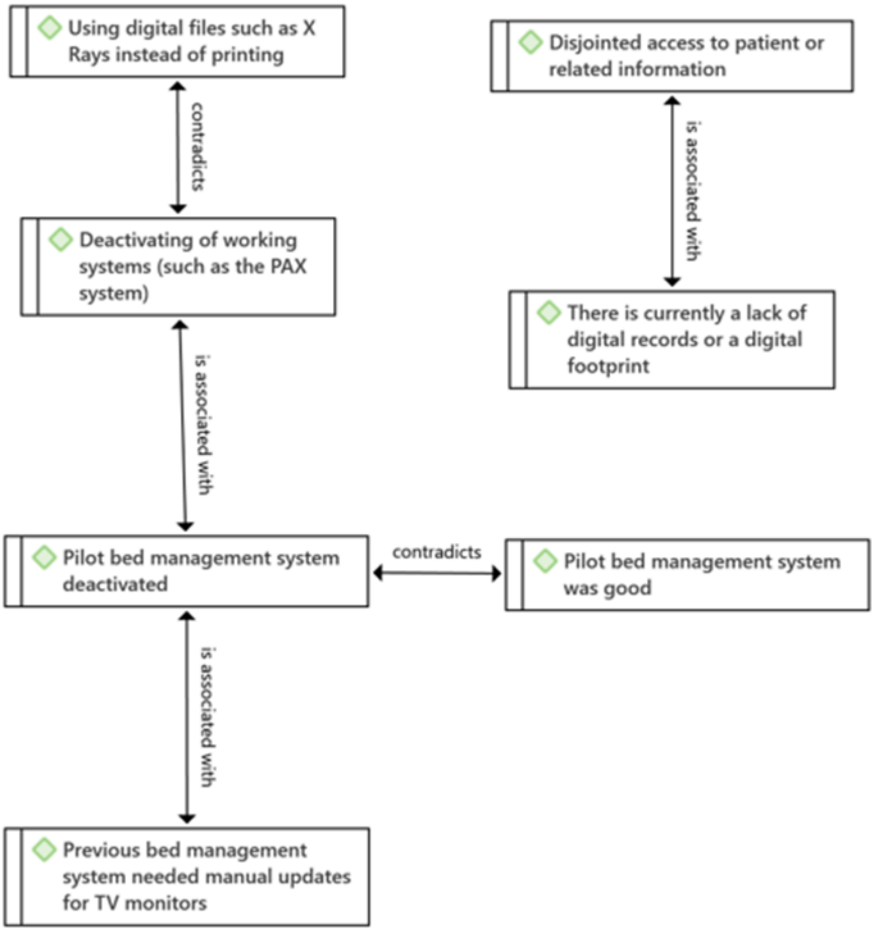


Figure 37. The third and fourth sub-networks of the Migrating to New Technologies network.

In addition to a lack of connectivity between certain systems, some participants noted their inability to access or connect to the requisite information. This phenomenon could also be referred to as fragmented access to information.

> *At the end, management, like the people who've got that, is actually very protected one because when we look in, we look and it's actually it will prevent the name on*

top of our system. So only the person who's actually registered to use the app will actually be able to log in and see. [Participant: 21]

The participant mentioned how only certain people within a department might have access (user credentials) to a particular system. This mechanism might cause congestion when multiple people need to access information from that system. **Figure 37** also illustrates that a previous pilot bed management system was deactivated even though it served its purpose. The participants were not sure why the pilot bed management systems were shut down. The pilot system could have been deactivated because of challenges such as a lack of project coordination (O'Brien et al., 2023). However, one could argue that SAP HIS indeed has a bed management component that performs some of the previous functions. Conversely, participants noted that the pilot systems allowed hospitals to view the bed occupancy in neighbouring hospitals, whereas SAP HIS has access controls in place preventing stakeholders from one hospital viewing the bed occupancy of another hospital.

4.8.3 Interpretation of this Theme

News24 (2023e) notes the benefits of Gauteng's new HIS as being more efficient at patient management and supporting the reduction of duplicate patient records. However, no mention is made of the connectivity of SAP HIS to existing healthcare systems within the overall landscape. In addition, O'Brien et al. (2023) argue that digital health systems in sub-Saharan Africa are restricted by poor integration and interoperability issues. The Connect theme highlights the need for better connectivity to information so that stakeholders and people at various levels can make informed decisions. In this case, connecting people to information would imply the relevant technology systems are connected. In addition, access rights to information might need to be reconsidered, as some participants did not seem to have access to the information they needed. **Section 4.9** discusses the close relationship between the Connect and Communicate themes.

4.8.4 Impact on the Design Model for a Live Healthcare Console version 0.1

The Design Model for a Live Healthcare Console version 0.1 illustrates connections between systems by using an integration layer, which is also responsible for user authentication and validation. Since EMS systems play a critical role in the overall patient transfer and transport process, the connection to their systems should be represented. However, connectivity between systems does not imply that all data are shared between them; therefore, sharing data can consist of key datasets.

4.9 Theme: Communicate → Strengthening Communication Among People

The Communicate theme is closely linked to the Connect theme and focuses on system-to-system, people-to-system and people-to-people communication. Once systems and people are connected, it becomes possible for them to communicate through message-sending services.

Digital health systems within the hospital landscape and EMS, which fall outside the hospital systems' landscape, were discussed during the formulation of this theme. Real-time as well as broadcast communication were considered.

4.9.1 Arriving at this Theme

This theme was identified after grouping the four related networks described below.

- Communication (one-on-one or broadcast) – This network comprises five sub-networks. Real-time communication between the ambulance crews and EMS dispatchers is crucial to promoting positive patient care outcomes. EMS uses a push-to-talk radio for communication but also employs other forms of communication. There are unofficial yet effective means of real-time communication among hospital staff and EMS in the form of WhatsApp and Telegram groups. These groups are used with caution and sensitivity to ensure patients' anonymity. Numerous systems have been implemented to ensure real-time communication among key stakeholders; however, patients are not necessarily included in real-time or even non-real-time communication. Telephonic communication might seem outdated; however, this medium of communication remains in use and can be effective, even though some shortcomings have been noted. Broadcast communication is used via WhatsApp and Telegram groups; however, additional broadcast communication opportunities have been identified.
- Load-balancing resources – **Section 2.1.1** and **Section 2.1.2** noted scarce public health resources. This network comprising two sub-networks identifies occurrences exacerbating the issue of scarce public healthcare resources. Fears relating to employment, long patient stays, equipment theft and seasonal incidents spark the need for balancing resources between departments and other healthcare facilities. Effective communication was identified as supportive of load-balancing resources.
- Real-time – Healthcare information, including bed occupancy available in real-time, can support decision-makers. Outdated or inconsistent information can affect the related stakeholders negatively, which could include patients.
- Time-sensitivity – Medical care is time-sensitive in numerous situations. Patient transportation to the correct facility can save time and impact patient care positively. Therefore, effective communication between hospitals, EMS (dispatchers and call takers) and ambulance crews is vital.

Section 4.9.2. describes the components of this theme.

4.9.2 Components of this Theme

Twenty-five codes were associated with five sub-networks that formed the Communication (one-on-one or broadcast) network. The Load-Balancing Resources network comprised two sub-networks associated with 19 codes. The real-time network had three codes, of which time-sensitivity comprised two codes. **Table 30** presents these codes.

Table 30. Components of the communicate theme.

Communication (one-on-one or broadcast) (25 codes)
Ambulance responds with Tango status T3[7]
Appointment scheduling system
Broadcast communication at hospitals (TV monitors, etc.)
Broadcast communication from EMS to hospitals and WhatsApp or Telegram groups
Broadcast communication to EMS
Broadcast communication to managers
Call taker takes information and generates a reference number, which is sent to the dispatcher.
Direct telephone line from facility or hospital to EMS
Emergency Control Centre (ECC) has call takers who capture information and dispatchers who communicate with the ambulance or crew.
EMS can still arrive with a patient, even during a divert.
EMS communication between crews (paramedics) and the control room (dispatcher) is conducted via a tablet containing WhatsApp, a mobile phone via a recorded line, and push-to-talk radios. These provide a failover.
EMS dispatchers can also triage based on incoming information to determine which level of a paramedic to dispatch, such as ALS, ILS or BLS.
EMS uses systems such as APDX, GMC3, and computer-aided dispatch systems (CADS).
It is a manual process to check for diverts in broadcast communication, such as Telegram or WhatsApp.
Making bed occupancy information available to patients promotes transparency and improves healthcare perceptions.
Patients should know the hospital's capacity before arriving at the hospital.
Real-time bed occupancy information can benefit EMS in terms of patient routing decisions. Staff and resource availability information, such as specialist availability or X-ray machine availability, can also assist.
Real-time communication
Shortcomings of telephone lines
Shortcomings of WhatsApp and Telegram groups, such as not being recorded officially or unavailability during load shedding.
Subscribe to information or messages relevant to your job function.

[7]A Tango Status is an abbreviated form of communication between EMS dispatchers and ambulance crews. In this case T3 means that the ambulance is on its way to the hospital with a patient.

Telephonic communication
Unofficial communication methods (WhatsApp, Telegram)
Unofficial yet effective communication method (WhatsApp, Telegram)
No alerts when department is at capacity
Load-balancing resources (19 codes)
Beds can be reallocated to similar departments. Facilities have to be dynamic.
Data capturers support ward clerks.
Data capturing by admissions clerks
Data capturing by ward clerks or nurses
Data manager projects (Patient transfer)
Fears of visibility of actual workload to managers
High degree of effort required for new projects
Hybrid processes (Digital and paper-based)
Inter-ward patient transfer
Mental health patients spend a long time and use up beds, causing further constraints on the healthcare system.
Scarce hospital resources
Scarce resources require load-balancing between facilities.
Seasonally related incidents, such as holiday periods, must be considered in terms of the effect on resources.
Security guards are the first to greet patients during the admissions process.
Sharing resources between healthcare facilities
Staff or users will be trained on the new SAP HIS.
Theft of public and private equipment, such as laptops
There is a link between stabilising a patient in the ER and being able to admit the patient to a ward.
There might be space in the ER but not in the hospital, resulting in further patient transport.
When hospitals are taking strain in terms of resources like beds and staff, this can result in transfers, which, in turn, affects EMS.
Real-time (three codes)
Outdated bed occupancy information
Real-time bed occupancy would be beneficial (resources, scheduling, time, patient treatment)
Real-time information supports the healthcare system
Time-sensitivity (two codes)
Delays in bed occupancy update due to bed status
Delays in patient care

4.9.2.1 Communication (one-on-one or broadcast)

The five sub-networks associated with the Communication (one-on-one or broadcast) network are illustrated in **Figure 38**, **Figure 39**, **Figure 40** and **Figure 41** (two sub-networks are presented in this figure).

Theme: Communicate
Network: Communication (one-on-one or broadcast)
Sub-network: First sub-network
Description: Real-time communication between ambulance crews, call takers and dispatchers

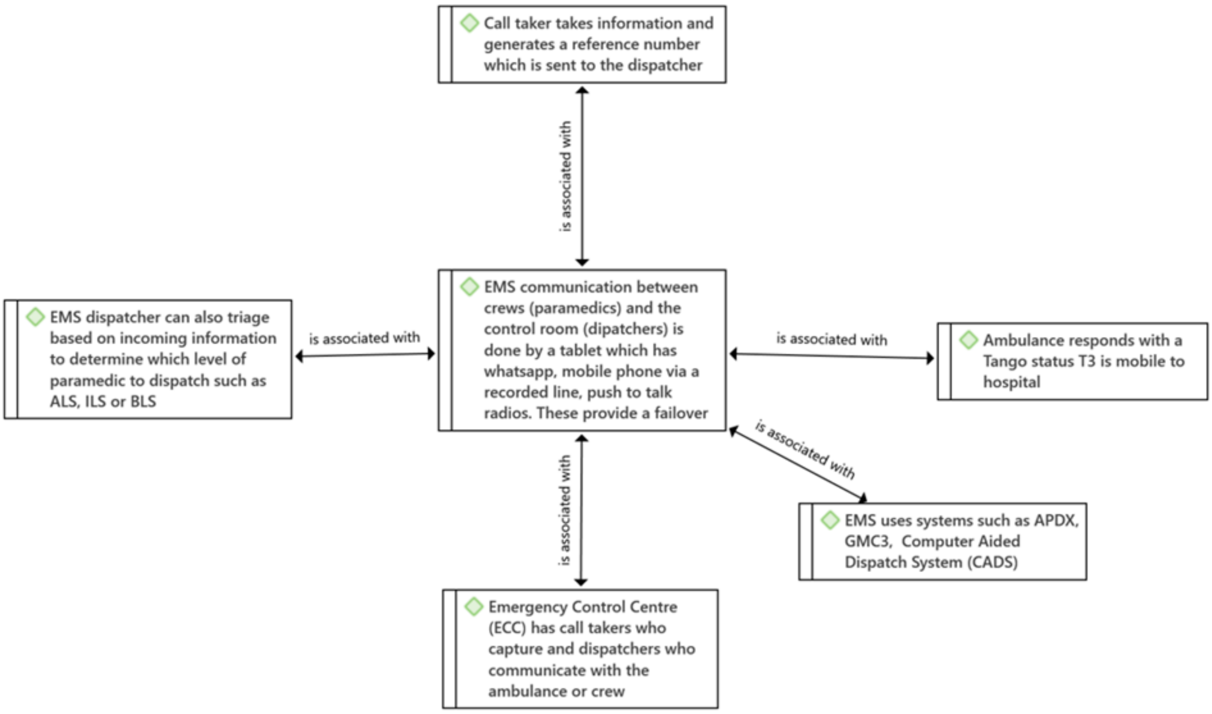


Figure 38. The first sub-network related to the Communication (one-on-one or broadcast) network.

Figure 38 provides a view of the codes related to the call taking and dispatching processes followed by EMS. The EMS back-end comprises call takers and dispatchers. The call takers receive calls from healthcare facilities, such as hospitals and clinics, informing them that a patient needs to be transferred to another facility. They can also receive calls from people at home or at an accident scene informing them that a patient needs assistance. This communication is handled by incoming telephone lines managed through a call centre.

> *When the call comes in, the call taker or the call agent will pick up the phone and everything is actually programmed on that system that we are using when they are actually, for an example, if they are calling from the clinic, the sister or the person who's actually calling for an ambulance will mention their name, their numbers and the name of the patient. [Participant: A21]*

The participant described a scenario in which a patient needs to be transferred to a different facility, which could be a step-down (lower-level) facility or a more specialised facility, depending on the patient’s condition. Ambulance crews are informed by the dispatchers that they need to transfer (facility to facility) or transport (scene to facility) a patient. This communication happens in several ways since failovers are built in. Participants described several communication mechanisms:

> *We have all the mode[s] of communicating with our crews. We have a tablet. We will communicate with them with WhatsApp. We have the phone, the recorded line when we send information that are vitals, that's where we prefer using the phone because of now it's on the recorded line. We have [a] two-way radios where we actually relay the message. [Participant: A21]*

> *Is* (sic) *used telephones to contact the emergency department and inform them that they are on the way with a patient. [Participant: A9]*

> *They communicate with hospitals and then to find out if they've got space or beds to accommodate the patients that need transfers and then they organise a transport around that and then transfers* (sic) *them. [Participant: A12]*

Participants identified telephone lines, push-to-talk or two-way radios and WhatsApp as possible communication mechanisms. Therefore, communication between EMS and ambulance crews was found effective due to the number of failovers built into the communication processes. However, the participants did not mention communication with patients. One could reasonably assume that the call takers would make a note of the contact person's telephone number so that they can communicate with the patient or first responder. The next sub-network focused specifically on the use of social media communication (WhatsApp and Telegram) by hospitals and EMS.

Theme: Communicate
Network: Communication (one-on-one or broadcast)
Sub-network: Second sub-network
Description: The use of unofficial communication methods such as WhatsApp

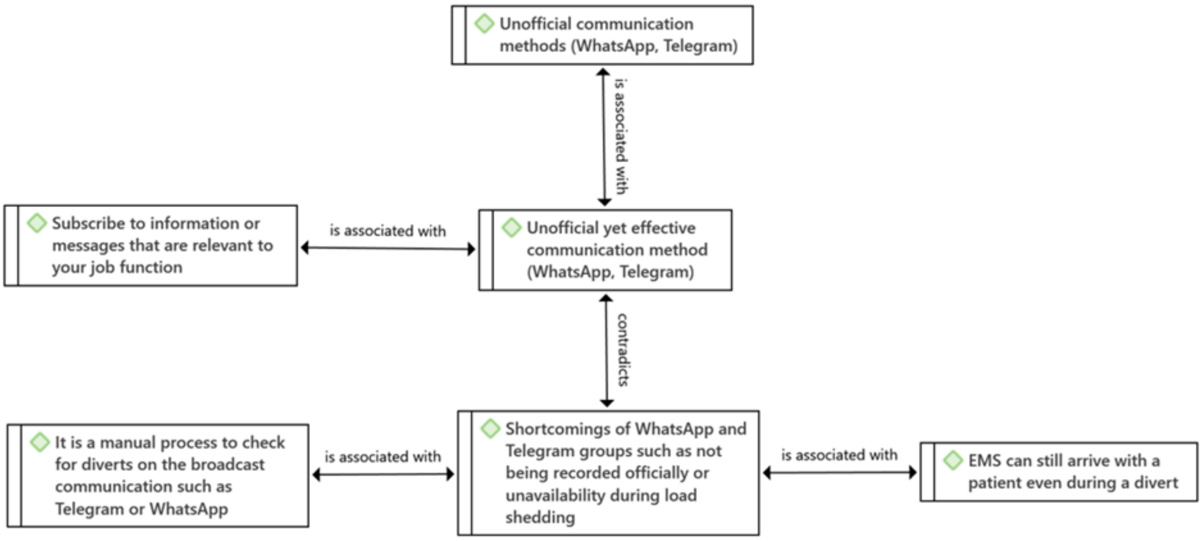


Figure 39. The second sub-network related to the Communication (one-on-one or broadcast) network

The effective use of WhatsApp and Telegram groups allows the relevant stakeholders to share information in real-time. However, there are shortcomings in these forms of communication. **Figure 39** illustrated the codes related to these shortcomings. Given the large number of participants in these groups, numerous messages are generated during a single day, causing stakeholders having to read large numbers of messages to stay up to date with information. One participant mentioned that, at some point, more than 1, 000 messages were generated in a single day. Copious numbers of messages could be mitigated by using official systems able to target specific individuals or by allowing individuals to subscribe to messages relevant to them.

> *Many it will depend day-to-day but moving from like 50 to 80, depending on how interactive people are on the like messaging platforms…You would have to scroll back to get the information that had been posted and to confirm whether there's anything further that you needed to know. So, it would be a little bit more labour-intensive in that regard. [Participant: A10]*

Participants mentioned that keeping track of general messages (not necessarily intended for them) is labour-intensive. This could inadvertently result in a stakeholder missing a relevant message requiring their attention.

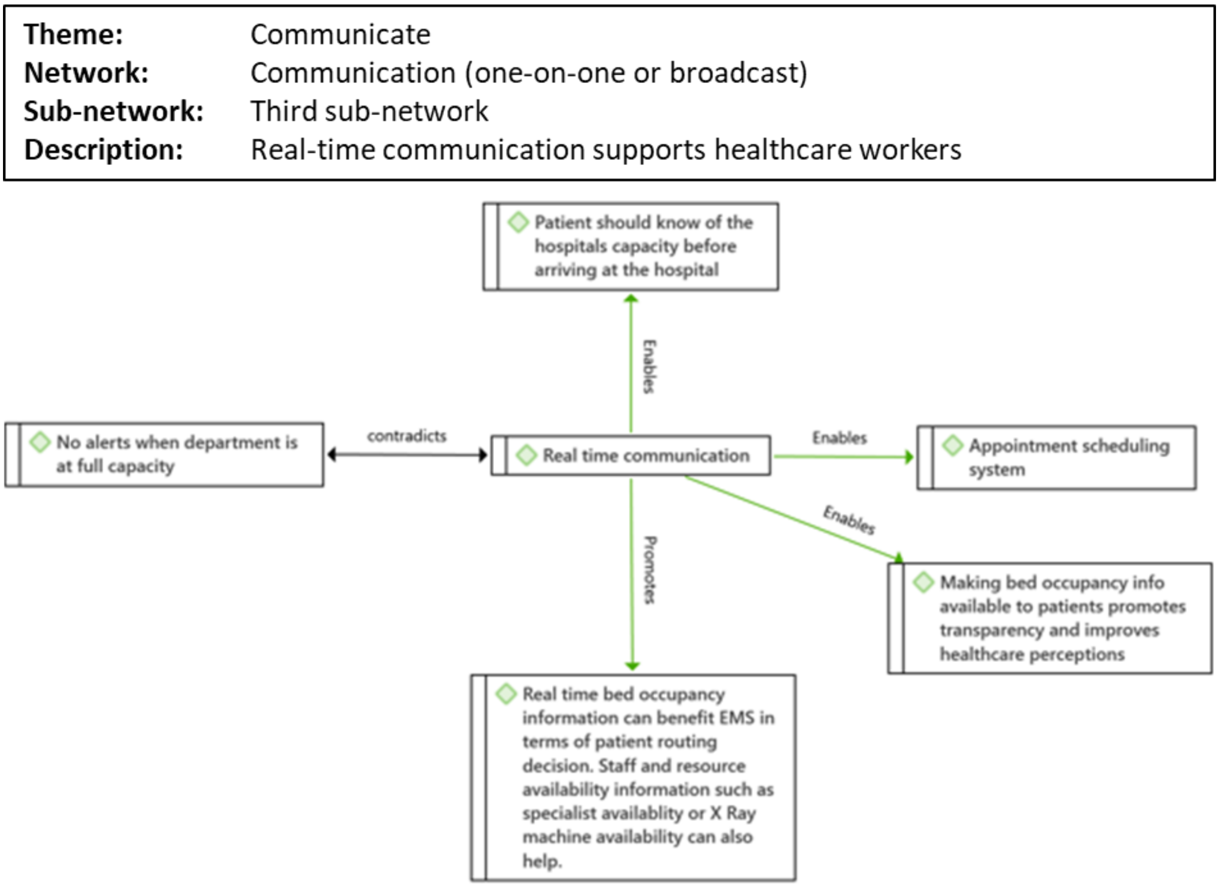


Figure 40. The third sub-network related to the Communication (one-on-one or broadcast) network

Figure 40 highlights the use of real-time communication. The value of information currently available in real-time, as well as information that could be made available in real-time is evident. In **Section 1.2,** the study first noted that patients could also be considered key stakeholders within the healthcare system in terms of communication. Real-time information could also be furnished to patients and the public to ensure their ability to make informed decisions. There was a sense that real-time information could promote transparency and improve the perceptions of public healthcare.

> *Yes, I think you will. It will assist a lot and the patients 'cause, they will be able to know about the activities that are taking place within the hospital, they'll be able to know what is happening. [Participant: A17]*

> *At emergency and they see that screen maybe for the condition that they've come for. They see that all has got 20 beds, they've got 19 patients. [Participant: A12]*

Some participants noted that making real-time information available within hospitals (particularly emergency departments) could indicate waiting times to patients and result in fewer queries or disturbances to the staff on duty. They felt that transparency with patients could alleviate frustration and improve the public's perceptions of the healthcare system. However, this view regarding the availability of information to the public was not shared by all participants. Participant A28 noted that public-related healthcare information should be shared with extreme caution, and such information should only be used for strategic purposes by decision-makers in the healthcare system:

> *I think that information is strategic rather than anything… What is important though, is that when the paramedics come and pick up the patient, they are when they know where they are taking the patient because they have to do an assessment of the patient themselves… The exception would be the patient condition being at risk or the danger. Then they need to start there for the sake of stabilising the patient before coming here. [Participant: A28]*

Hospitals use healthcare information, such as bed occupancy, diverts and other forms of information, for operational and strategic purposes. Non-healthcare-related stakeholders might not understand this information, and thus, it could be misinterpreted. Therefore, this information should only be furnished as needed.

Theme:	Communicate
Network:	Communication (one-on-one or broadcast)
Sub-network:	Fourth sub-network
Description:	Shortcomings of telephonic communication
Sub-network:	Fifth sub-network
Description:	Information is shared using broadcast communication

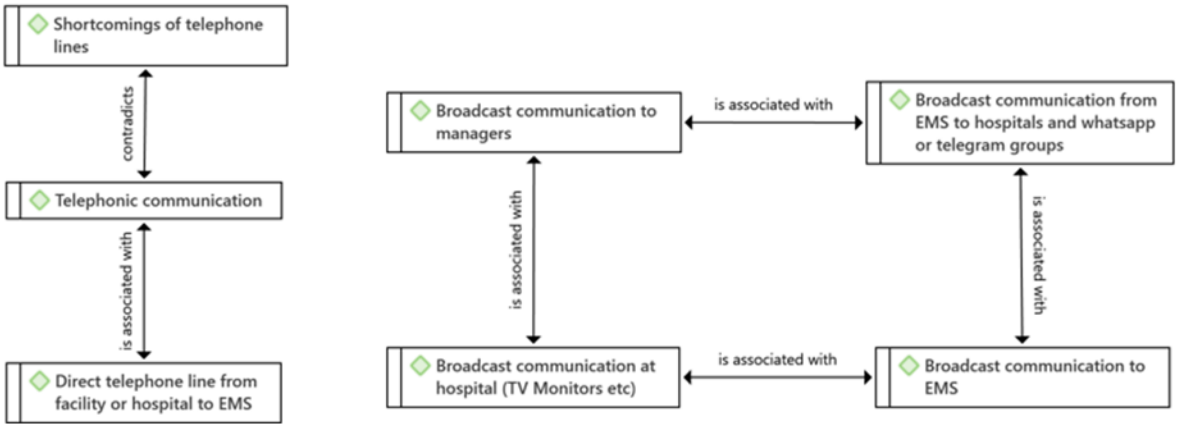


Figure 41. The fourth and fifth sub-networks related to the Communication (one-on-one or broadcast) network

The analysis of the interviews confirmed the understanding that communication is vital to the public healthcare system. Telephonic communication is used within hospitals and between hospitals and EMS. **Figure 41** briefly highlights the use of telephonic communication and its potential shortcomings. A participant explained that communication between hospitals and EMS happens via a (dedicated) telephone line.

> *Normally it's a telephone call where we will inform them. [Participant: A8]*

Hospital staff would phone EMS to relay important messages or request services like patient transfer. The statement below refers to the divert procedures. When the emergency department of a particular hospital cannot accept patients for a given time, the MMO has the authority to place the hospital on ambulance divert, which impacts EMS dispatchers and incoming ambulances. The EMS dispatching team is informed of the divert via a telephone call.

> *EMS will be notified by the MMO to say that this hospital is being under diversion for so many hours, and then they'll stop coming for that time. [Participant: A28]*

Once a hospital is placed on ambi-divert (ambulance divert), ambulances must transport patients to the next closest and appropriate hospital. The participants noted that exceptions could apply under time-sensitive conditions such as a heart attack or stroke, as discussed in **Section 4.9.2.4**. Even though telephonic communication is effective in several instances, there are associated shortcomings, such as when telephone lines are down or a person or department cannot be reached.

> *Phone lines don't work all the time. [Participant: A2]*

Telephone lines can be disrupted at a hospital or EMS, precipitating a break in real-time communication. A call could also be missed if there is no substitute staff member to take the call.

> *We have a person who's sitting there all day long. [Participant: A22]*

EMS has a staff member dedicated to managing the direct telephone line used by hospitals to inform them of situations such as diverts; however, that staff member or their substitute might be unavailable, which could result in a break in communication. The impact of a break in communication can have negative consequences on patient care.

> *There have definitely been cases where the hospital is apparently on divert status, but then when an ambulance would get there, they are informed that no the hospital's on divert and they can't accept the patient. But even our control centre isn't aware of it. [Participant: A26]*

Ambulance crews might arrive at a hospital with a patient during a divert, which could be due to a break in communication. Other than a case of a time-sensitive condition, the ambulance crew would have to transport the patient elsewhere. Such instances place a further strain on the system since the ambulance and crew would not be available to assist another patient.

Figure 41 also highlights opportunities for using real-time information within the hospital and, potentially, other settings. These opportunities include the use of digital message boards.

> *So when you['re] visiting our facility or office you are able to see those things that on the board. So I think that was meant for everyone to see our performance as a facility. So it's very much important even though maybe some might not*

understand what is it for but for those that have an idea I think it's yeah it would be interesting for them. [Participant: A16]

Participant A16 noted that a digital board or TV monitor could provide real-time information within the emergency department, which could indicate waiting times or the status of the hospital to patients. Some participants highlighted that similar initiatives had been implemented as pilot systems at other facilities but were decommissioned. They did not confirm the reasons for these systems being shut down.

4.9.2.2 Load-Balancing Resources

Figure 42 and **Figure 43** present the two sub-networks related to the Load-Balancing Resources network.

Theme:	Communicate
Network:	Load-balancing resources
Sub-network:	First sub-network
Description:	Limited healthcare resources requires resource balancing

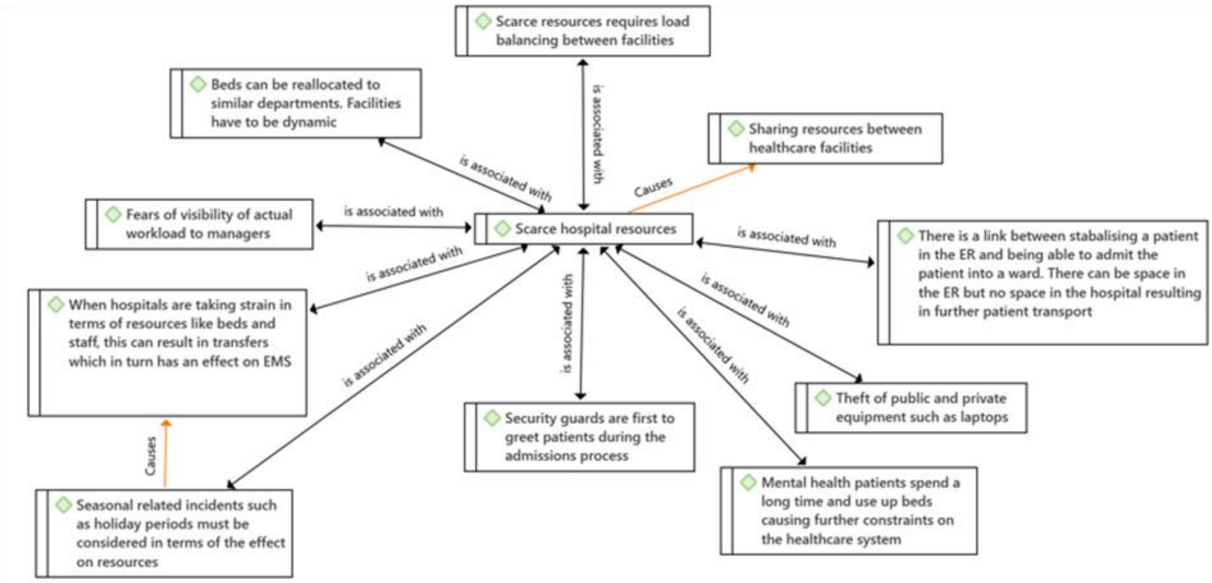


Figure 42. The first sub-network related to the Load-Balancing Resources network.

Section 2.1.1 introduced the challenges of resource scarcity within the public healthcare system. These might include limited bed capacity in specialised wards, shortage of available medical equipment and limited staff. Several participants explained how these challenges constrained hospitals.

Shortage of staffing, which limits us to get data in real-time. [Participant: A29]

There has been cases where I have taken a patient to a tertiary facility and that patient needs either an MRI or a CT scan. But then the radiology department is on hold because they had an infectious disease exposure, for example. So now no patients can't go through the either the MRI or CT scan because their radiology is *closed. And again that then will create a delay. So being able to know the status, availability of resources such as that. Both for long-term care and for acute care, it would definitely inform decision-making on a way to then take that patient to receive the appropriate care. [Participant: A26]*

Five or six hundred deliveries in that hospital and they are only attached to in a month only attached to about two to three doctors, and they're doing so many that Caesarean section and there's been this many patient safety incidences that are coming from around there monitoring is not so good. [Participant: A15]

Resources can be a challenge, really. [Participant: A12]

This province doesn't have enough beds for its patient load. [Participant: A2]

And for specifically maternity and neonatal admissions, that is often kind of at an over capacity point. [Participant: A1]

The challenges highlighted by the participants call for sharing resources between facilities. Though load-balancing was not identified as a defined business process, this phenomenon is understood and used within the healthcare system. In cases of malfunctioning medical equipment, the relevant staff follow processes for diverting patients to other facilities for their treatment to continue, which they described as sharing the load between facilities.

Sharing the load between the different institutions. [Participant: A1]

Having access to quality information could assist stakeholders in making decisions related to patient transport or transfer and could support load-balancing efforts. The previously mentioned examples of malfunctioning medical equipment or of an emergency department on divert due to a shortage of beds call for sharing or communicating real-time information between facilities. This could prevent scenarios such as rerouting of patients.

Knowing that the emergency department is overwhelmed and you able to then reroute in emergency case to a facility that is more able to deal with it and not leave your crew in a situation where they get to the hospital and the hospital is full patients. [Participant: A27]

There is a synergy between hospital and EMS staff that aims to promote an efficient healthcare system. This requires all parties to be up to date with the latest hospital statuses.

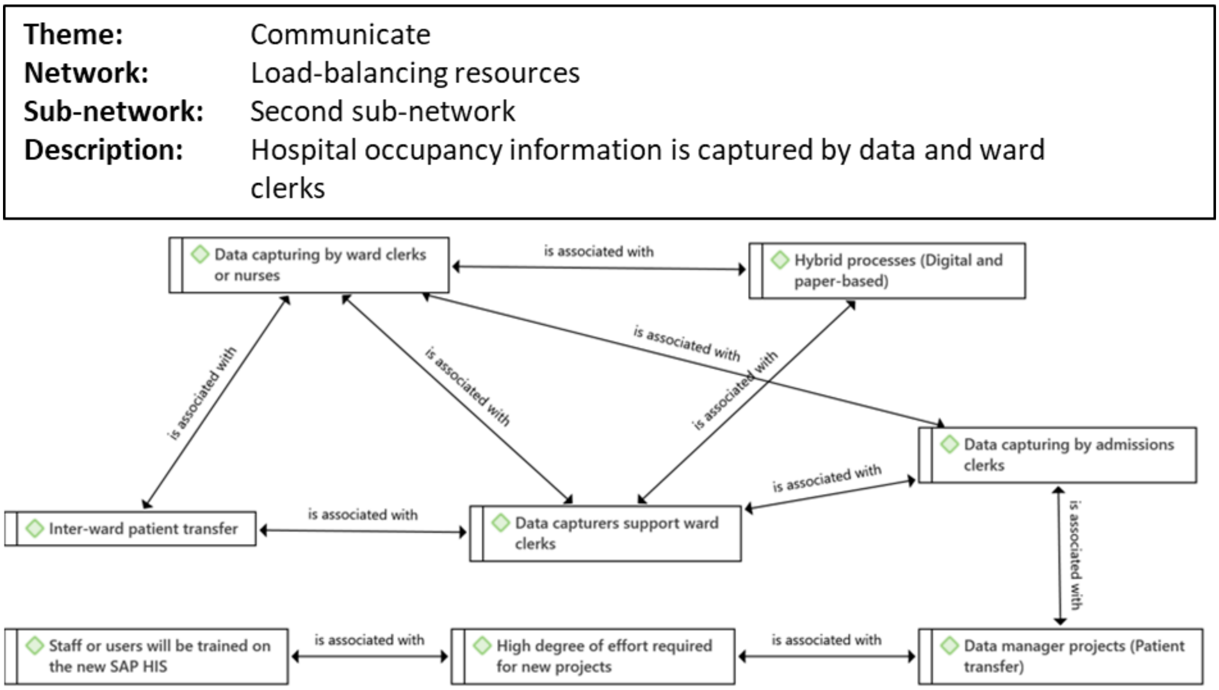


Figure 43. The second sub-network related to the Load-Balancing Resources network.

Figure 43 illustrates the significant role of ward clerks and data capturers. These stakeholders convert the information captured on paper-based documents into a digital format. The information being captured is usually related to the admission and discharge processes and has a follow-on impact on bed occupancy. This information contributes towards the DHIS reports, which are used for strategic purposes related to load-balancing of resources.

Ward clerk capturing everything that the matron is doing. [Participant: A6]

Admin clerk, who just finalised their discharge. [Participant: A18]

So we have midnight records that are available, and then we also have a DHIS. [Participant: A28]

I'll be the person who's using that midnight to say how many it tells us how many patients admitted in this date how many patient transfer internally or externally on this date. [Participant: A31]

The admission and discharge information captured in the wards is transformed from paper-based to spreadsheets and then transferred to the DHIS. Ensuring that healthcare resources are used efficiently requires patients to receive care at the most appropriate healthcare facility in the fastest time. Patient transport and transfer are accordingly crucial to this. Bed occupancy information serves to inform operational decision-makers like department managers so patients can be routed efficiently. **Section 4.9.2.3** discusses access to real-time information.

4.9.2.3 Real-Time

The real-time network is presented in **Figure 44**.

Theme:	Communicate
Network:	Real-time
Sub-network:	None
Description:	Real-time information supports healthcare services

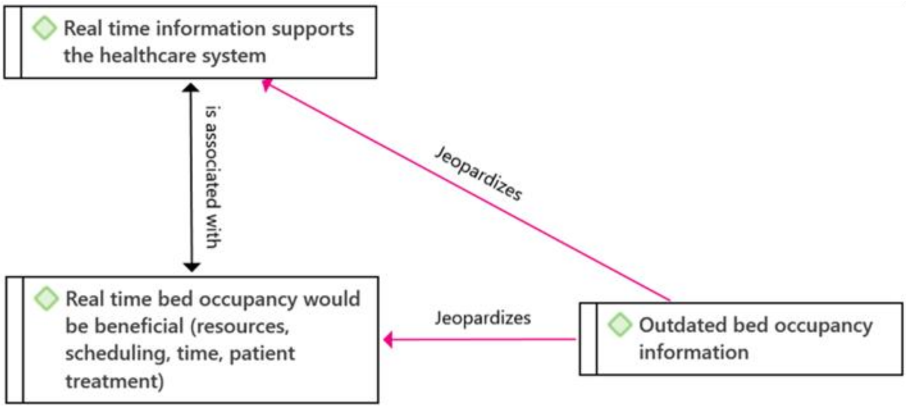


Figure 44. The Real-Time network.

One of the focus areas of this research was the availability of real-time information. **Figure 44** illustrates that outdated bed occupancy information (non-real-time) could jeopardise the healthcare system and its associated stakeholders. Conversely, access to quality information in real-time can support the healthcare system. Access to real-time information could also make an impact at a hospital departmental level or even within the EMS.

> *Where, for example, a consultant in an emergency department can open his computer and see exactly how many patients are in his emergency department… Look, I mean, it would be absolutely amazing. Because to be able to look and see and say, well, hospital one's emergency department [is] clearly only has three beds and they are full, whereas hospital two has ten beds and there are only five patients there. [Participant: A2]*

> *I would want to really see the information on real-time… And you know, it's always helpful to have that on real-time. [Participant: A15]*

> *Definitely. I think especially from the dispatch perspective, if you could have a real-time view of hospital capacity, then I think you're, you know it can inform your dispatch decisions. You wouldn't necessarily send a priority one patient to a hospital if they if the trauma unit is, let's say full. And they you know that the hospital will imminently announce that they are divert for trauma cases. So you would rather advise the crew to move somewhere else. [Participant: A19]*

> *At dispatch level would assist greatly in coordinating the resources and managing them appropriately to then and allow the patients based care within the at timeframe without then extending that timeframe. [Participant: A26]*

Participants expressed positive sentiments about the availability of real-time information, such as bed occupancy within their departments. The emergency departments could be optimised if the emergency doctors knew the status of all their beds. EMS could use hospital bed occupancy information for patient routing. Conversely, participants commented on the challenges associated with outdated bed occupancy information.

> *Absolutely. And I think this is a big fear in our province. I mean we just had a had a meeting the other day because the whole issue in the hospital is the bed status. And we should have said but other hospitals give out bed status three or four times a day in our hospital. If we get one bed status between 10:00 and 11:00 in the morning, which was actually an update from 7 o'clock in the morning. That's the best we can get. [Participant: A2]*

Hospital bed occupancy information is made available by hospitals, but the data feeds can be delayed or inconsistent. A participant described a scenario of a double booking of a bed in a ward.

> *And if you try to admit patients to those vacant beds, the bed would in fact be occupied or not accessible. And so it didn't really solve the problem at all. [Participant: A9]*

A bed could be vacant on the system but not physically available, which could result in a double booking. Thus, access to real-time bed occupancy information can affect various levels within the public healthcare system. It can also affect admissions and discharges as well as management responsible for resource optimisation. **Section 4.9.2.4** discusses the impact of medical scenarios that require immediate attention.

4.9.2.4 Time-Sensitivity

Figure 45 presents the Time-Sensitivity network.

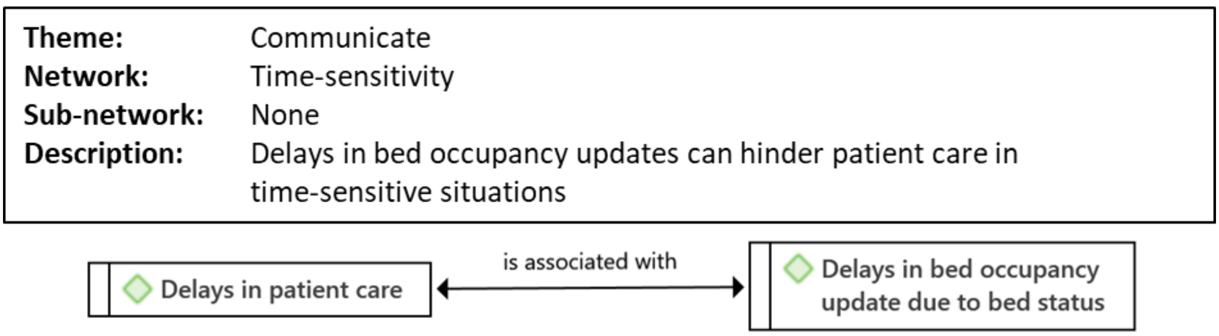


Figure 45. The Time-Sensitivity network

In some cases, medical conditions can be extremely time-sensitive. A participant mentioned that a patient experiencing a stroke or cardiac arrest would need immediate medical attention. In such a case, the ambulance crew could head directly to an appropriate facility regardless of its divert status. However, they would have to inform the receiving emergency department to ensure it is prepared to receive the patient. This scenario also touches on the Connect theme since people and information need to be interconnected.

> *They don't check with the hospital whether they can come. The only time that you would do a pre-notification to a hospital would be if the patient is a priority one or critical. Or you have something like that's time-sensitive. If the hospital, for example, is a stroke centre and then you would notify them so that the team can prepare for the ambulance’s arrival. But the general. I'd say 95% of the patients, there's no pre-notification. [Participant: A19]*

Time-sensitive scenarios require real-time communication to ensure the receiving emergency department is prepared for the incoming patient. Participants noted the importance of notifying the receiving emergency department that a time-sensitive patient is enroute.

4.9.3 Interpretation of this Theme

Ratna (2019) stresses the importance of communication within healthcare, and several participants in this research echoed this view. Broadcast messages are sent in real-time to the relevant social media groups for key stakeholders to be prepared for temporary changes within the healthcare system. This type of communication can spam recipients, who would have to catch up on missed messages once they are available. Telephonic communication is used between hospitals and EMS in situations like ambulance diverts. This could be due to a lack of digital system connectivity between healthcare facilities and EMS. Patients and the public are not included in real-time healthcare communications. Though some messages might be relevant to the public, some participants argued that public health-related information, such as hospital bed occupancy, is intended for internal use rather than public consumption.

4.9.4 Impact on the Design Model for a Live Healthcare Console Version 0.1

Broadcast messaging was identified as a key communication medium that various stakeholders within the public healthcare system require to perform their job functions. Critical messages, such as ambulance diverts and patient transport statuses, are shared via broadcast messaging. Therefore, the Design Model for a Live Healthcare Console version 0.2 needs to illustrate the use of broadcast messaging explicitly as an endpoint for system architects to consider. It is not intended to include the two social media platforms (WhatsApp and Telegram) in the model; however, the concept of broadcast communication needs to be incorporated into the Design Model for a Live Healthcare Console version 0.2, which would bring about an expansion of the representation of consuming systems.

4.10 Theme: Combine → Combining Relevant Information to Support Decision-Making

The Combine theme arose from the need to link people within the healthcare system to information relevant to them. Since public healthcare information does not reside in a single system, it would be necessary to form a connection between the systems housing the data for the information to be combined. The information refers to high-level bed occupancy information and not to patient records. Hospital diverts were identified as a key business process which assists with the load-balancing of resources (Theme Communicate → load-balancing resources). During an ambulance divert, a hospital department, such as the emergency department, is temporarily closed to ambulances but remains open for walk-in emergency patients.

4.10.1 Arriving at this Theme

This theme comprises a single network with four codes. Though the number of codes is lower than other networks, the codes were grounded in several quotations. The network is described below.

- Digital evidence – There is an essential relationship between hospitals and EMS, highlighted by the Connect and Communicate themes. The combination of digital and paper-based systems provides information that can be used by stakeholders within each of these healthcare areas. Hospital diverts are communicated in real-time via telephone or through social media channels such as WhatsApp and Telegram. Since there is a lack of connectivity between the digital healthcare systems used by the hospitals and EMS, correspondingly, there is a lack of centricity surrounding the divert process. The study discovered a lack of digital evidence regarding this business process.

4.10.2 Components of this Theme

Four codes were associated to form the Digital Evidence network, which resulted in the Combine theme. These codes are presented in **Table 31**.

Table 31. Components of the Combine theme

Digital evidence (four codes)
Creating a divert as a transaction and sharing it with other systems for processing and decision-making would be beneficial.
Divert information is captured as a note during a transfer but cannot be reported on.
EMS does not have adequate electronic or digital patient records management.
No official divert is created on the system for audit or alert purposes.

4.10.2.1 Digital Evidence

The Digital Evidence network is presented in **Figure 46**.

Theme:	Combine
Network:	Digital evidence
Sub-network:	None
Description:	Lack of digital evidence for ambulance diverts

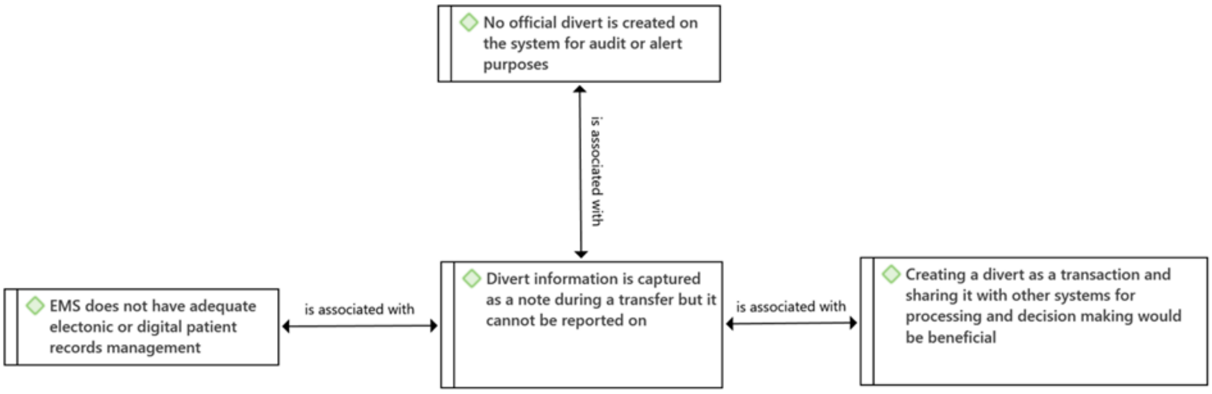


Figure 46. The Digital Evidence network.

The MMO makes the decision to place a hospital on divert for incoming ambulances. Several criteria are used to inform this decision, including the number of patients currently in the emergency department, the status of the different bed types within the departments and the availability of the relevant specialists within the hospital. A head of department could make a request by alerting the MMO of a possible need for an ambulance divert. The MMO would assess the available information and decide on the appropriate action. Once the decision is made to place the hospital on ambulance divert, it is communicated to the relevant stakeholders using the communication methods described in **Section 4.9**. One such method is a telephone call to EMS via a dedicated telephone line.

> *Normally, it is the head of the emergency unit with* (sic) *that will communicate on the management group and then obviously the CEO will take the decision and they put the hospital on divert. [Participant: A8]*

> *They will send it on the dispatchers list. [Participant: A22]*

Though the participant mentioned that the CEO makes the decision, they were referring to the MMO who makes the decision. Some participants viewed the role of the CEO and the MMO as the same; however, they are separate roles. Apart from communicating this decision, no official record with a reference number or timestamp is created.

> *So normally there is no alert that there's no system. [Participant: A4]*

Participant A4 refers to the lack of an automatic notification of a divert being generated and sent to the relevant stakeholders. There is also no official digital evidence of the divert.

Currently, we're not doing anything. There's nothing. There's no like a button that we are pressing to say. Now we are on divert. [Participant: A5]

No, as far as I know that there's no reporting that I do back to management regarding the number of diverts, the duration of the divert, the nature of the divert… You're absolutely right. I don't think it generates a transaction on the current system. So I don't think the hospital system generate a transaction when a divert takes place. [Participant: A9]

Divert information is used as metadata (supporting data) during dispatching to justify why a patient was transported to a particular hospital instead of another (possibly) closer hospital. This information is captured as a note based on whether the dispatcher has read the incoming message. Thus, without a flag, status change or official digital record, a dispatcher could send an ambulance to a hospital that is on ambulance divert.

We just put it as an occurrence as in like case notes. [Participant: A21]

OK maybe the person who received the divert from the MMO comes to me to say. I've got a lot in mind and then ten minutes later, there's a P1 patient, I'm frustrated. Then I'm sending the patient to Tembisa completely forgetting that I actually received that information even though I receive it and acknowledge it and then when the crew arrives and then to find out that, Oh no, they're on divert and they told me. So now I need to take responsibility and accountability to reroute that patient because they told me it's on divert and I forgot and you understand. [Participant: Anonymised]

The lack of combining information, such as diverts between the hospital and EMS systems, can have unwanted consequences. There is also no way to report easily on diverts, such as the average divert time, affected facilities or impacted patients. This phenomenon could also be described from a Connect perspective, as the systems do not connect or automatically share information between them.

4.10.3 Interpretation of this Theme

Communication between stakeholders in real-time is an effective tool which promotes positive patient outcomes; however, a communication breakdown can compromise patient care (Dúason et al., 2021). Participants also emphasised that critical information is shared between people via communication mechanisms. When prompted about the possibility for stakeholders to access real-time information relevant to them or for information to be displayed on systems they work on, they preferred to have the information at their fingertips instead of having to comb through messages on a social media communication group. There was also a desire for some form of digital evidence of ambulance diverts to generate the relevant reports. Participants agreed that ambulance divert information should be centralised. Nevertheless, the aspect of centrality does not necessarily mean the information is exclusively housed in one system. Systems can be connected in a way that gives users (stakeholders) the impression that the information is stored in a central location.

4.10.4 Impact on the Design Model for a Live Healthcare Console Version 0.1

The Design Model for a Live Healthcare Console version 0.1 represents centralised, cloud-based storage of bed occupancy information fed from healthcare facilities. This design intended to combine key datasets from the relevant systems to make them available to the appropriate stakeholders. The design also promotes the availability of real-time or near-real-time information. The importance of the EMS digital systems was highlighted during conversations with the participants. During the literature review phase, the study assumed (due to a lack of available literature) that hospitals and EMS run on the same system or technology platform. However, the participants noted that hospitals and EMS operate separately. This factor gave rise to the idea of connecting these two systems. The impact on the design model is accordingly to represent EMS (including the EMS dispatch system) as a separate entity, not a generic system. The importance yet lack of digital evidence relating to ambulance diverts resulted in a need to highlight this as a dataset shared between the key systems. These improvements are included in the Design Model for a Live Healthcare Console version 0.2.

4.11 Theme: Contain → Containing Security Threats so that People Can Access Information with Minimal Disruption

The Contain theme relates to maintaining the security and integrity of sensitive information by keeping intruders out of restricted parts of the system so that key stakeholders can access information with minimal interruption. As more systems and people become connected (related to the Connect and Communicate themes), the possibility of intercepting information increases. Deepfakes are one such recent threat to healthcare, whereby imposters masquerade as known people using video and audio media (Heidari et al., 2023). In addition, this theme appraises the threats associated with the appropriate stakeholders accessing information from unofficial devices.

4.11.1 Arriving at this Theme

The Contain theme was formulated based on the associations between the three networks discussed below.

- Information Access – In the Communicate theme, the study noted that even though stakeholders could benefit from having access to accurate, real-time information, such information must be considered sensitive and should only be made available to the appropriate stakeholders. Hence, governance and policies could play a vital part in protecting access to sensitive information.

- Information Security – Cyberattacks have increased significantly in recent years, with medical information becoming a key target. In some cases, protecting information could go beyond implementing strict governance but could also consider measures such as end-to-end encryption.

- Threats to Resource Optimisation – **Section 2.1** highlighted the scarcity of healthcare resources, with measures to circumvent the associated challenges covered by the Communicate theme. This network approaches threats to resource optimisation from the point of data entry into the digital healthcare systems, challenges with infrastructure and stakeholder training on the use of systems.

4.11.2 Components of this Theme

Twenty-six codes were associated to form the two sub-networks that comprised the information access network; four codes were related to formulating the Information Security network, and thirteen codes were linked to form the two sub-networks contained in the Threats to Resource Optimisation network. **Table 32** presents the codes associated with the sub-networks and networks.

Table 32. Components of the Contain theme.

Information Access (26 codes)
Access to other facilities' bed occupancy
Accurate information is needed from the facility to national-levels
Benefits of a centralised system
Centralised system
Clinic module for electronic health records
Complex systems and processes
Consolidation of systems
COVID-19 bed management system was manual
Emergency medical services (EMS) is a separate system
Fragmented systems
Governance and policies help protect information and processes
Information such as bed management is for internal strategic hospital use and should not be shared elsewhere (EMS or patients). It could cause confusion and compromise patient care in the healthcare system.
Integration with third-party systems
It is acceptable for a patient to be transferred multiple times if they need to be stabilised, seek specialist care and then return to a step-down facility.
MMO should have a high-level view

No access to other facilities' bed occupancy
No integration between SAP HIS, DHIS, and other systems
Paper-based bed management system
Patient management system (SAP HIS, PAB, case tracker or other)
Patient system (Tier)
Patient tracking system across facilities and possibly private facilities
Real-time bed occupancy data
Specialised medical systems, such as PAX, centricity, etc.
There is no link between public and private healthcare systems
There should be a link between private and public healthcare facilities
NHI integration can be executed via another system
Information security (four codes)
Cybersecurity specialists should be involved.
Cyberattacks
Health information needs to be encrypted as an additional cybersecurity measure.
More integrated systems can result in more cyberattacks.
Threats to resource optimisation (13 codes)
Cost of using personal data (internet)
Hybrid processes increase staff effort
Impact of outdated infrastructure, such as system availability and the duplication of work
Lack of feedback to stakeholders
Lack of training on new systems
Outdated infrastructure
Poor internet connectivity
Resistance to the use of technology
Shortage of computers, tablets, etc.
Some systems have low performance such as speed or being slow.
Unfair allocation of computers and related resources
Unfixed processes
Use of personal devices

4.11.2.1 Information Access

Figure 47 presents the first sub-network of the Information Access network.

Theme:	Contain
Network:	Information access
Sub-network:	First sub-network
Description:	Consolidating systems leads to connected healthcare data

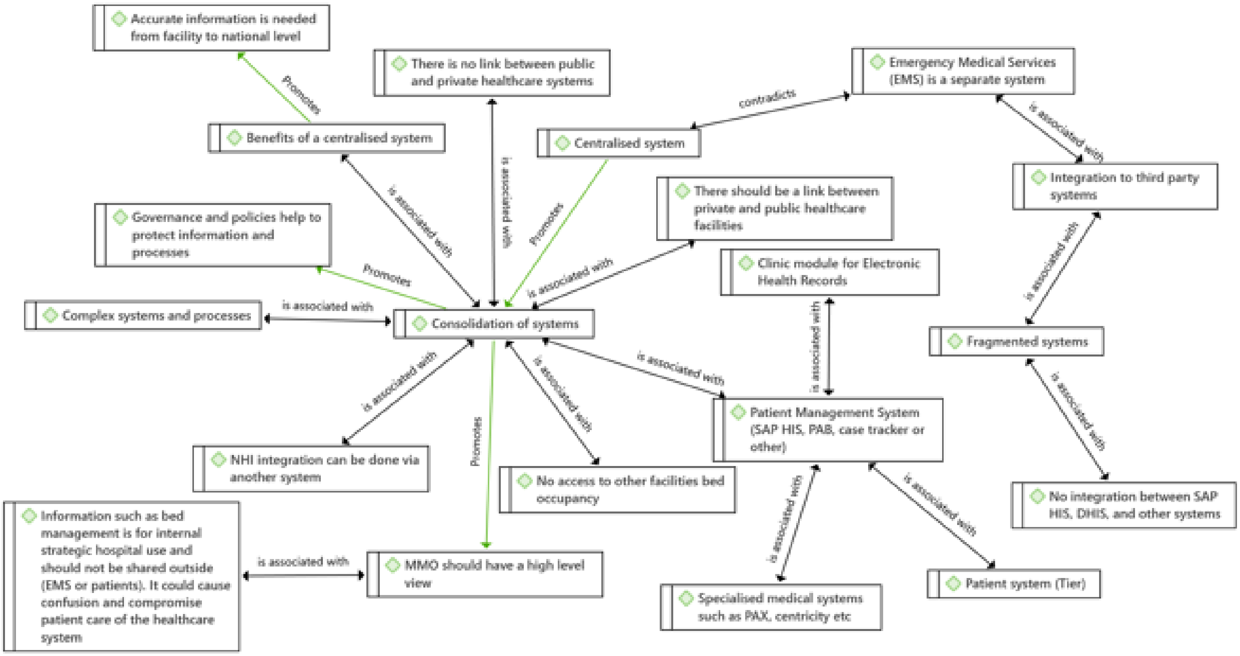


Figure 47. The first sub-network relating to the Information Access network

Gauteng's new SAP HIS, introduced in **Section 1.2**, was implemented with consolidating patient records as one of its aims. This would ensure that a single version of the records exists without duplication. Several participants understood this aim and agreed with its merits:

> *SAP HIS was introduced. The main idea was to eliminate multiple systems… Well, I think integration or consolidating of system into maybe one and your system will be the best ideas because, for example, we can reduce calls. [Participant: A3].*

Participant A3 mentioned the consolidation of systems. This could be due to a myriad of systems being decommissioned as a result of SAP HIS being implemented. Benefits such as having access to the bed occupancy of other wards within a hospital were accomplished by the new implementation; however, inter-hospital information sharing was not necessarily achieved due to governance policies.

> *Yes, I am able to see how many patients we have in our neonatal. How many patients do we have? In OPD and things like that. [Participant: A4]*

> *It's hospital specific. So each hospital has its own bed management system that's there. [Participant: A6]*

So we are all using the HIS system as Department of Health, but we are allocated rights according to the facility at which you are working at which you are reporting from. [Participant: A4]

Participant A4 noted that access to information is contained within certain areas of the healthcare system to maintain the overall integrity of the data. Based on the participants' responses, the decision to limit access only to within their facility is a by-design decision. The second sub-network relating to the Information Access network takes a different stance on this decision by considering promoting access to information (bed occupancy) with other facilities and even with the private healthcare system. The sentiments expressed by the participants indicate that access to information is being limited. **Figure 48** presents the second sub-network.

Theme:	Contain
Network:	Information access
Sub-network:	Second sub-network
Description:	Previous bed management systems supported healthcare services

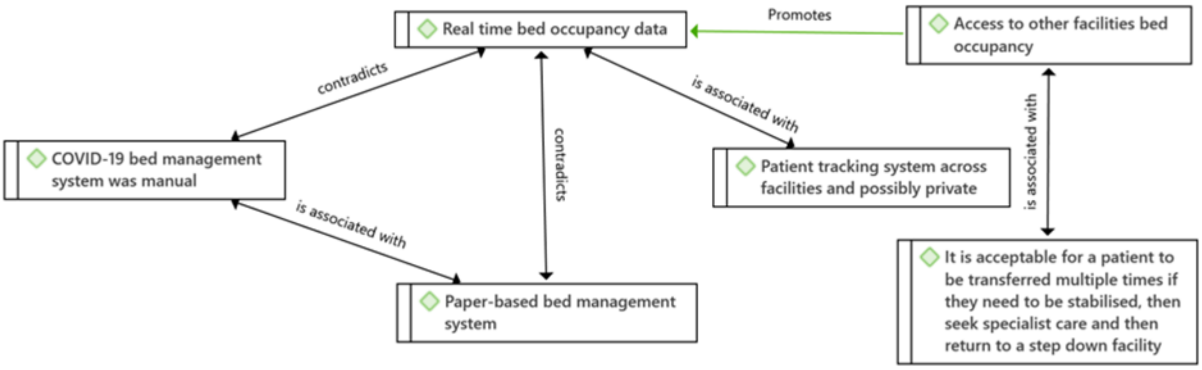


Figure 48. The second sub-network relating to the Information Access network.

A pilot bed management system mentioned in **Section 4.8.2.2** allowed the appropriate staff at the hospital to view bed management data for their facility as well as other facilities within the district. A few participants mentioned such systems.

Previous years we would have an this is (sic) *there was a system called EBMS. It was an electronic bed management system. So with this system you'll be able to see which institution is full, which institution still has beds and also the sections in that institution or the specialities. [Participant: A12]*

The EBMS, a standalone system, centralised bed management information and functions. This system was discontinued, presumably due to the implementation of SAP HIS, which has its own bed management capabilities. Due to the access policies or governance implemented with SAP HIS, the previous benefits of the EBMS, such as informing admissions or EMS-related processes, have ceased. The (now) limited access to information (previously available) impacts decision-making for admissions and patient transfers.

Especially at head office and other institutions. In order to allow the transfer in and transfer out, those are relevant, including EMS. [Participant: A18]

Participant A18 refers to how bed occupancy information can inform decision-making. Since the EBMS has been decommissioned, less information is now available. The Information Access network demonstrates how access to information such as bed occupancy information should be promoted and protected concurrently. Consequently, this calls for flexibility relating to information access.

4.11.2.2 Information Security

Figure 49 presents the Information Security network.

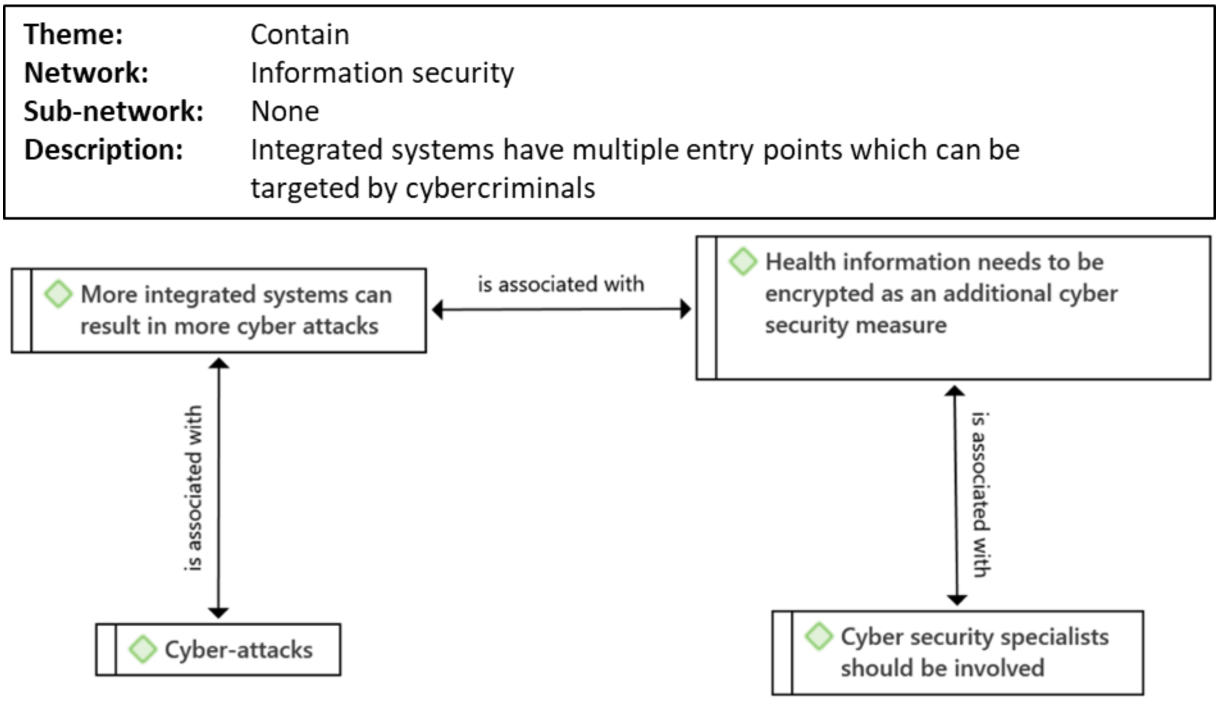


Figure 49. The Information Security network

The themes discussed so far (Connect, Communicate and Combine) call for increased availability of quality information to the appropriate stakeholders. As the accessibility of systems increases, so too could the possibility of unauthorised access. The Information Security network highlights the need for securing systems to prevent the various forms of prevalent cyberattacks.

Just that, you know, we are living, we are living in a like. In an era whereby anything is possible, we have got a lot of cyberattacks, those things. But then, according to security, somehow I think we will like before, like such thing happens. It's like a security specialist can be involved. [Participant: A5]

Participant A5 expressed that due to growing concerns around cyberattacks, the services of cybersecurity specialists should be used to promote information security. It must be noted that though technology staff were interviewed, none were specialists in cybersecurity; subsequently, no detailed suggestions relating to cybersecurity were made.

4.11.2.3 Threats to Resource Optimisation

Figure 50 presents the first sub-network related to the Threats to Resource Optimisation network.

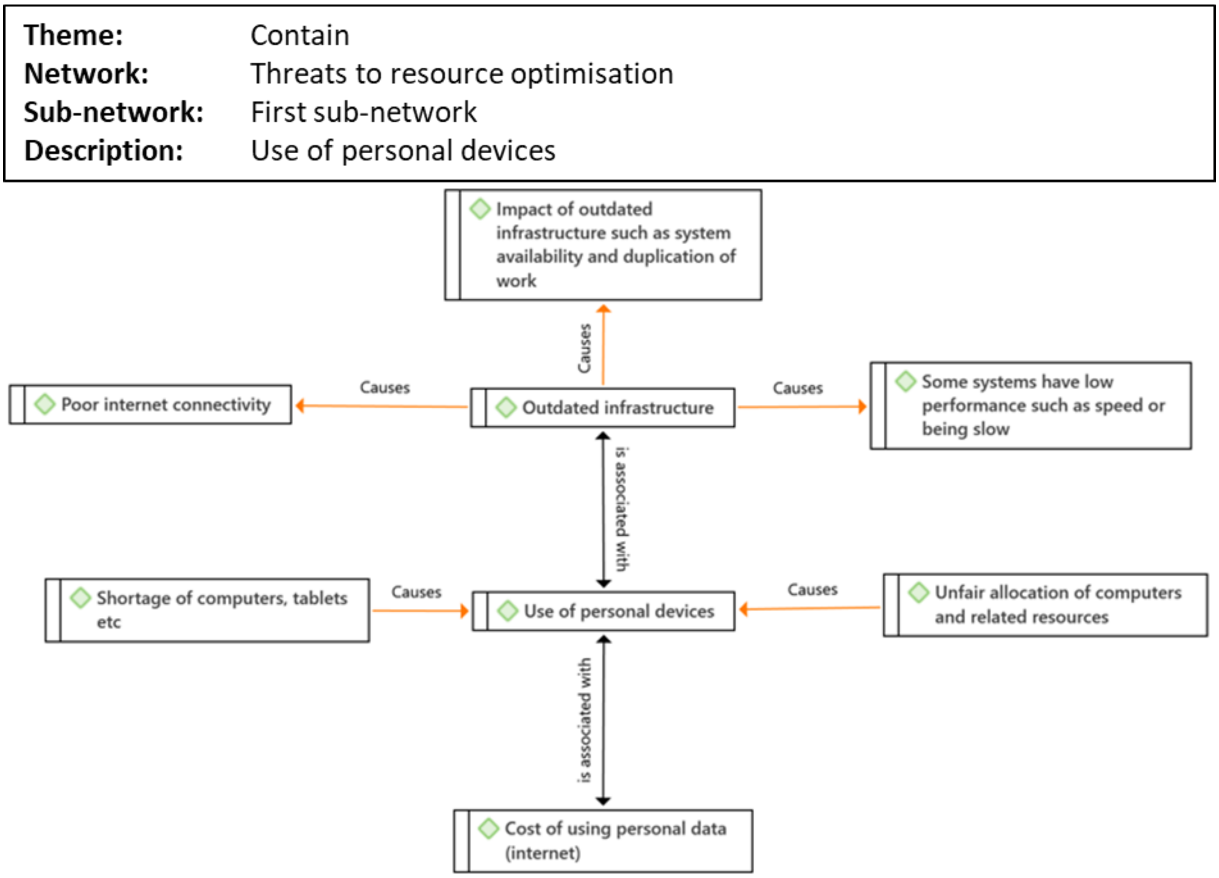


Figure 50. The first sub-network relating to the Threats to Resource Optimisation network

Section 2.1 highlighted that using quality information is key to circumventing some of the challenges associated with the scarcity of resources within the public healthcare system. This phenomenon can be described as the load-balancing of resources. It was also noted (through the themes discussed thus far) that connectedness promotes the accessibility of information. However, the participants expressed challenges related to their inability to access systems.

> *It's yes, and access to a computer that is up to date and functional and has internet connection is extremely rare… Internet is very poor. [Participant: A2]*

Participant A2 referred to slow and outdated computers that struggle to keep up with basic functions. There is also a lack of resources, as one computer is usually shared among several staff members within a department. Participant A8 echoed the shortage of working computers.

> *Also, the other thing that is really a concern and make systems to fail is that they will improve on one side by bringing a new system that is more up to date with*

current situations in the country or in the ward, but they don't improve the current infrastructure. [Participant: A8]

Poorly maintained infrastructure can compromise access to systems and, correspondingly, information. Some participants also noted a disparity in the allocation of resources such as computers. O'Brien et al. (2023) echo this sentiment by noting a constrained allocation of devices, which could include computers.

That, you know, certain people have computers and certain people don't have computers, and it seems very random. [Participant: A2]

Consequently, the shortage of official laptops and limited access to the internet means stakeholders must use personal devices and internet connections to access the information they need. This situation places a personal strain on the stakeholders' resources, and using unofficial devices could undoubtedly compromise information security.

There are no computers except the personal laptops of the consultants in the department…So a lot of the staff are using their own phones and their own data to access most of the internet. [Participant: A2]

The use of personal devices and personally funded internet access seems prevalent in areas with limited resources within hospitals. The challenges described within the first sub-network can result in a breakdown in the different types of communication, such as people-to-system and people-to-people. This can affect aspects related to the load-balancing resources network negatively (Communicate theme). **Figure 51** presents the second sub-network relating to the Threats to Resource Optimisation network.

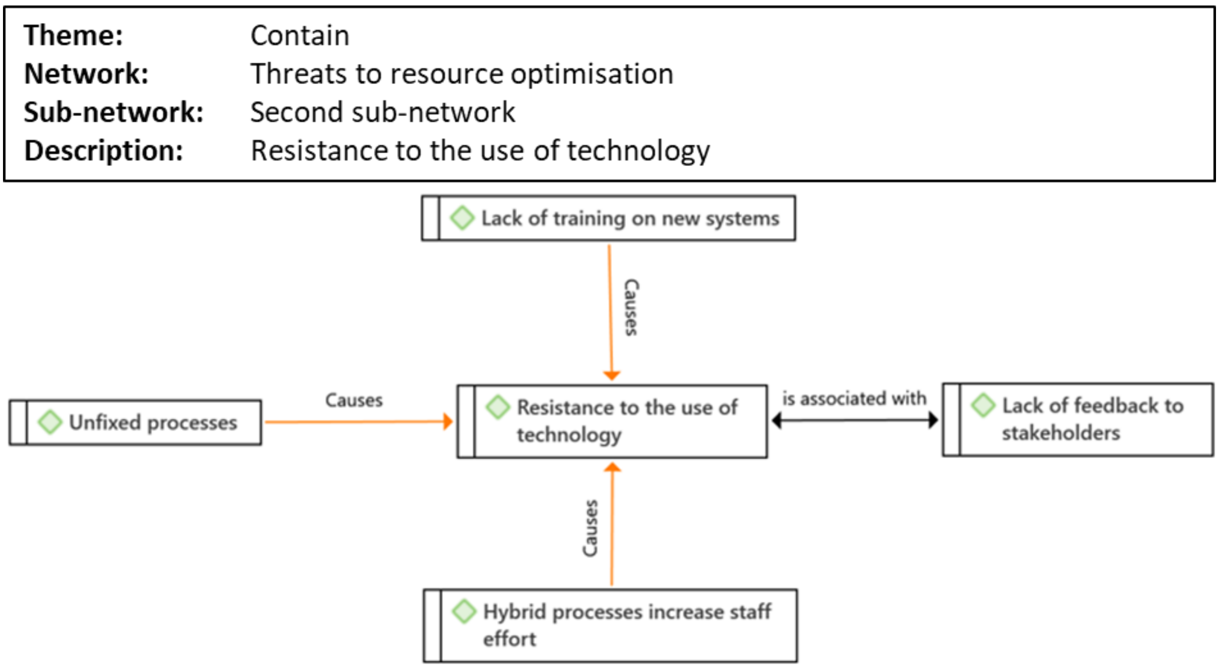


Figure 51. The second sub-network relating to the Threats to Resource Optimisation network

Table 2 introduced the possible effects of insufficient training on the healthcare system. In some cases, this could result in compromised patient care. Within the digital health system scenario, a lack of training could lead to stakeholders becoming apprehensive about making mistakes with the system, which causes resistance to using technology.

> *Look, and I think nurses, I think the nursing staff would probably the fear is more it fear because having never used it this is not* (sic)*. [Participant: A2]*

It was noted that some staff members might have limited access to advanced technologies such as laptops. They might also have limited training on the use of critical software packages, the misuse of which could have negative consequences, causing resistance to using technology, which might result in processes not being followed.

> *But the human resistance, yeah, is also unfortunately incredible. [Participant: A2]*

The resistance to using technology and processes that have not been fully automated leaves a void that could be filled by reverting to older processes, which could include paper-based processes. This hybrid approach could result in increased effort further on.

However, the participants indeed called for a transformation of existing processes; they preferred digital processes to some of the paper-based processes. Such a transformation could reduce the current duplication of effort expressed by several participants.

> *Not duplicating work by doing paper and electronic and having a system that automatically takes care of all the efficiency stuff. [Participant: A1]*

> *Well, it's not just a duplication. It is sometimes, you know, triplets because you the same information that you entered on the SAP system is what is in the patient's file. [Participant: A8]*

Though systems have been implemented to reduce effort, the resistance to technology, lack of end-user training and duplication of effort can threaten resource optimisation efforts.

4.11.3 Interpretation of this Theme

Granting the appropriate stakeholders access to quality information could lead to more informed decisions. The stakeholders, introduced in **Section 1.2**, can also include patients or the public. However, data should be categorised based on their level of sensitivity and, accordingly, be made available to the appropriate stakeholders. Ngesimani et al. (2022) suggest that good data governance is critical to maintaining the integrity of an organisation’s information, including healthcare information. In addition, measures such as encryption should be used to ensure the security of critical healthcare information (Das & Namasudra, 2022). Stakeholders should also access information from official or secured endpoints, such as officially supplied laptops or personal laptops, provided adequate security measures are implemented. Stakeholders should also be trained on the use of relevant systems.

4.11.4 Impact on the Design Model for a Live Healthcare Console Version 0.1

Authentication and validation are some of the key aspects of the Design Model for a Live Healthcare Console version 0.1. Such aspects were intended to require healthcare facilities and consuming systems to use valid credentials for connecting to the integration layer before providing and consuming data. Although it could be assumed that endpoints would be secured, some participants' emphasis on information security suggests that secured endpoints should be explicit. End-to-end encryption is presumed to be a part of the secured endpoints represented in the Design Model for a Live Healthcare Console version 0.2.

4.12 Theme: Collaborate → Leveraging Real-Time Information to Promote Collaboration Among People

The public healthcare system comprises several stakeholder groups. This theme focuses on the collaboration within and among these stakeholder groups. Through the interviews, the study determined that generating daily, weekly and monthly reports within the healthcare system is critical for load-balancing resources and strategic decision-making. This research focuses on a subset of the reported information (hospital bed occupancy); it does not seek to replace or alter any of the existing processes but considers the possibility and opportunities of making bed occupancy information available in real-time, the benefits of which were highlighted in the Combine theme. Participants shared their experiences of creating scheduled and ad hoc reports. They also elaborated on their stakeholder collaboration experiences.

The reports discussed during the interviews contain historical information compiled and shared among the key stakeholders. The rationale for the Collaborate theme is to make real-time or near-real-time hospital bed occupancy information available to key stakeholders because that could promote collaboration between hospital and EMS staff, as they would have access to the same version of the information.

4.12.1 Arriving at this Theme

The Collaborate theme comprises two networks, as described below:

- Reports (scheduled or ad hoc) – Bed occupancy-related data originates at the admissions desk (during patient admission) or from the ward (during daily rounds or when a patient is discharged). The data originates from paper-based records in the wards, are then transcribed into digital formats, and, eventually, uploaded to the DHIS. Data from the admissions process originate in a digital format on SAP HIS. The report compilation process is complex and requires a collaborative effort between the stakeholders involved.

- Stakeholder Collaboration – This network focuses on collaboration between hospital and EMS staff. These two stakeholder groups work closely to ensure effective patient transport and transfers.

4.12.2 Components of this Theme

Sixteen codes were associated to form the four sub-networks of the Reports (scheduled or ad hoc) network and two codes were associated to form the Stakeholder Collaboration network. **Table 33** presents the codes associated with the sub-networks and networks.

Table 33. Components of the Collaborate theme

Reports (scheduled or ad hoc) (16 codes)
Collaboration when generating reports
Daily or scheduled head count of patients in each ward
Dashboard for CEOs and managers is available via the new SAP HIS.
Exception reports for clinical or hospital operations or bed occupancy
Health information officer or data manager reports
Inconsistent data between systems (new or old)
Lack of motivation by managers to retrieve the information they need.
Lack of valuable information, data or reports
Reports are generated daily for the wards
Reports are sent to managers instead of managers accessing them.
Reports need to be accurate and captured on time
Reports sent by email
Retrospective and manual data validation or verification processes
Scheduled reports or statistics on DHIS or other system
Use of custom *Excel* spreadsheet to capture bed occupancy information
Use of the National Indicator Data Set (NIDS)
Stakeholder collaboration (two codes)
Ineffective routing
There is collaboration between doctors and EMS.

4.12.2.1 Reports (scheduled or ad hoc)

Figure 52 presents the first three sub-networks of the Reports (scheduled or ad hoc) network.

Theme:	Collaborate
Network:	Reports (scheduled or ad hoc)
Sub-network:	First sub-network
Description:	Importance of the DHIS reports
Sub-network:	Second sub-network
Description:	Manual validation processes for reports
Sub-network:	Third sub-network
Description:	Reports need to be accurate

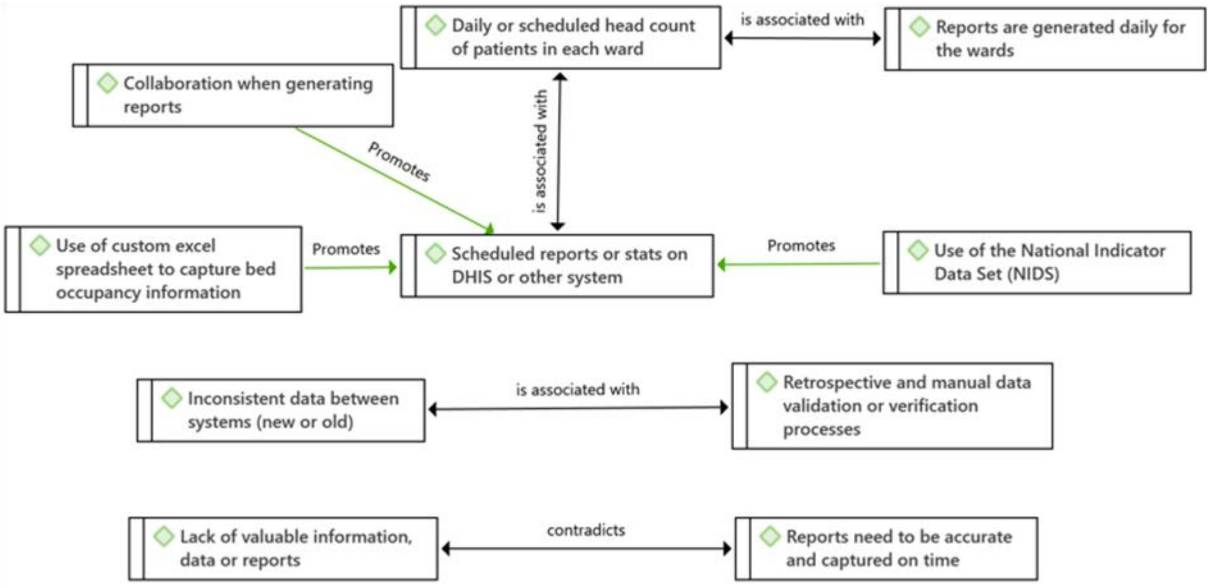


Figure 52. The first three sub-networks relating to the Reports (scheduled or ad hoc) network

Bed occupancy information is updated at the point of admission and in the wards as patients could be discharged or transferred from the ward. Therefore, the use of the TPH21 document (discussed in the Connect theme) as a head count or census form is important.

> *So when I say per unit, it mean each ward would need to complete they completed at night and then we get it in the morning and then we input also on our system. [Participant: A16]*

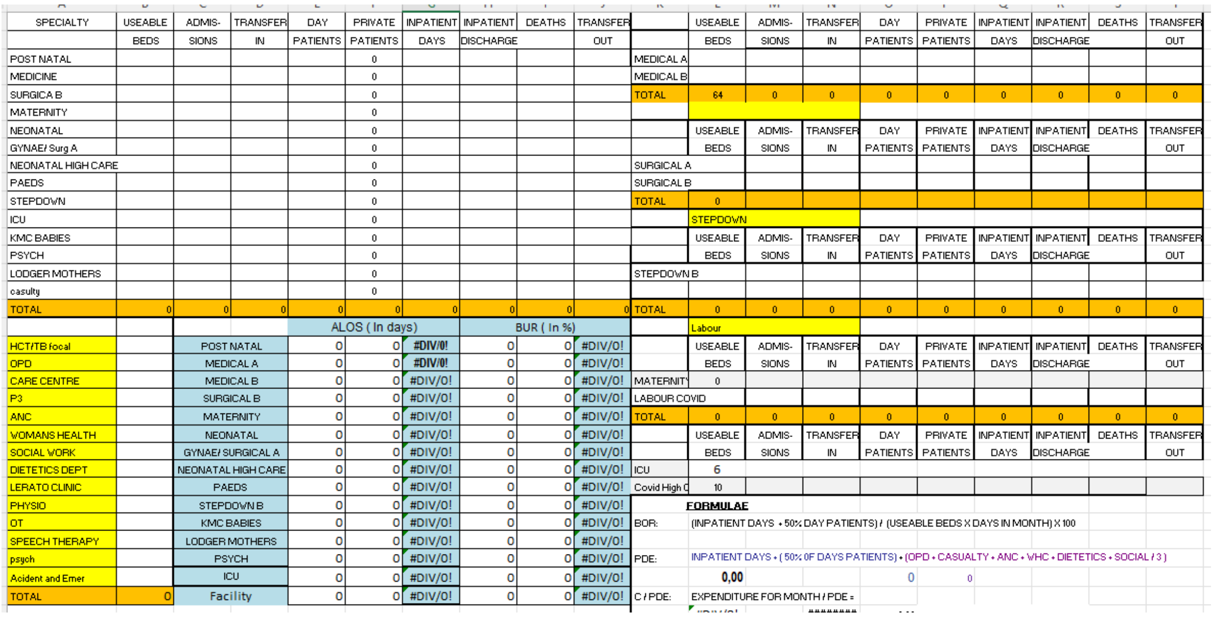
The TPH21 documents can be collected every morning (and at other times during the day) to be captured into spreadsheets. Managers can receive bed occupancy information either daily or monthly via scheduled reports.

> *Oh, this information that we see when a daily basis and then there's information that we receive on a monthly basis. [Participant: A13]*

Participants A13 and A16 referred to the bed occupancy information captured by the ward clerks every weeknight (ward clerks do not work on weekends). The TPH21 document is then sent to the data capturers, who enter the information onto spreadsheets. Some of these spreadsheets differ between facilities:

So, we've literally created like an Excel document is (sic) *that's the one we're using as our throughput to calculate to inputs whatever numbers and then it gives us the percentage of the bed for each unit and then also as a facility altogether so you would get it. [Participant: A16]*

A hospital created a custom spreadsheet to track daily updates to bed occupancy. Such spreadsheets serve as intermediate storage of the information between the TPH21 documents and the DHIS reports. **Figure 53** displays a screenshot of the throughput *Excel* spreadsheet.



SPECIALTY	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
POST NATAL					0				
MEDICINE					0				
SURGICA B					0				
MATERNITY					0				
NEONATAL					0				
GYNAE/ Surg A					0				
NEONATAL HIGH CARE					0				
PAEDS					0				
STEPDOWN					0				
ICU					0				
KMC BABIES					0				
PSYCH					0				
LODGER MOTHERS					0				
casulty					0				
TOTAL	0	0	0	0	0	0	0	0	0

			ALOS (In days)			BUR (In %)		
HCT/TB focal		POST NATAL	0	0	#DIV/0!	0	0	#DIV/0!
OPD		MEDICAL A	0	0	#DIV/0!	0	0	#DIV/0!
CARE CENTRE		MEDICAL B	0	0	#DIV/0!	0	0	#DIV/0!
P3		SURGICAL B	0	0	#DIV/0!	0	0	#DIV/0!
ANC		MATERNITY	0	0	#DIV/0!	0	0	#DIV/0!
WOMANS HEALTH		NEONATAL	0	0	#DIV/0!	0	0	#DIV/0!
SOCIAL WORK		GYNAE/ SURGICAL A	0	0	#DIV/0!	0	0	#DIV/0!
DIETETICS DEPT		NEONATAL HIGH CARE	0	0	#DIV/0!	0	0	#DIV/0!
LERATO CLINIC		PAEDS	0	0	#DIV/0!	0	0	#DIV/0!
PHYSIO		STEPDOWN B	0	0	#DIV/0!	0	0	#DIV/0!
OT		KMC BABIES	0	0	#DIV/0!	0	0	#DIV/0!
SPEECH THERAPY		LODGER MOTHERS	0	0	#DIV/0!	0	0	#DIV/0!
psych		PSYCH	0	0	#DIV/0!	0	0	#DIV/0!
Acident and Emer		ICU	0	0	#DIV/0!	0	0	#DIV/0!
TOTAL	0	Facility	0	0	#DIV/0!	0	0	#DIV/0!

	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
MEDICAL A									
MEDICAL B									
TOTAL	64	0	0	0	0	0	0	0	0
	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
SURGICAL A									
SURGICAL B									
TOTAL	0								
	STEPDOWN								
	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
STEPDOWN B									
TOTAL	0	0	0	0	0	0	0	0	0
	Labour								
	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
MATERNITY	0								
LABOUR COVID									
TOTAL	0	0	0	0	0	0	0	0	0
	USEABLE BEDS	ADMIS-SIONS	TRANSFER IN	DAY PATIENTS	PRIVATE PATIENTS	INPATIENT DAYS	INPATIENT DISCHARGE	DEATHS	TRANSFER OUT
ICU	6								
Covid High C	10								

FORMULAE

BOR: (INPATIENT DAYS + 50% DAY PATIENTS) / (USEABLE BEDS X DAYS IN MONTH) X 100

PDE: INPATIENT DAYS + (50% 0F DAYS PATIENTS) + (OPD + CASUALTY + ANC + WHC + DIETETICS + SOCIAL / 3)

0,00 0 0

C / PDE: EXPENDITURE FOR MONTH / PDE =

Figure 53. Sample throughput spreadsheet used by a hospital

The information captured on the throughput spreadsheet is entered into the DHIS, which is then used for monthly reporting. Crucially, the data must be captured correctly, and the relevant totals must be calculated correctly. Data managers, risk managers or health information officers assist with this data validation process. These roles seem to differ between the hospitals; however, there seems to be consistency regarding the validation of the data.

Now if the data is accurate and safe to send now to national Provincial Office has the right to then sign off the data through the National Office. [Participant: A4]

Different levels of checks are undertaken to ensure the data are accurate and valid before being uploaded to the DHIS. A participant noted that mistakes can occur but they can be corrected. **Figure 54** presents the fourth sub-network relating to the Reports (scheduled or ad hoc) network.

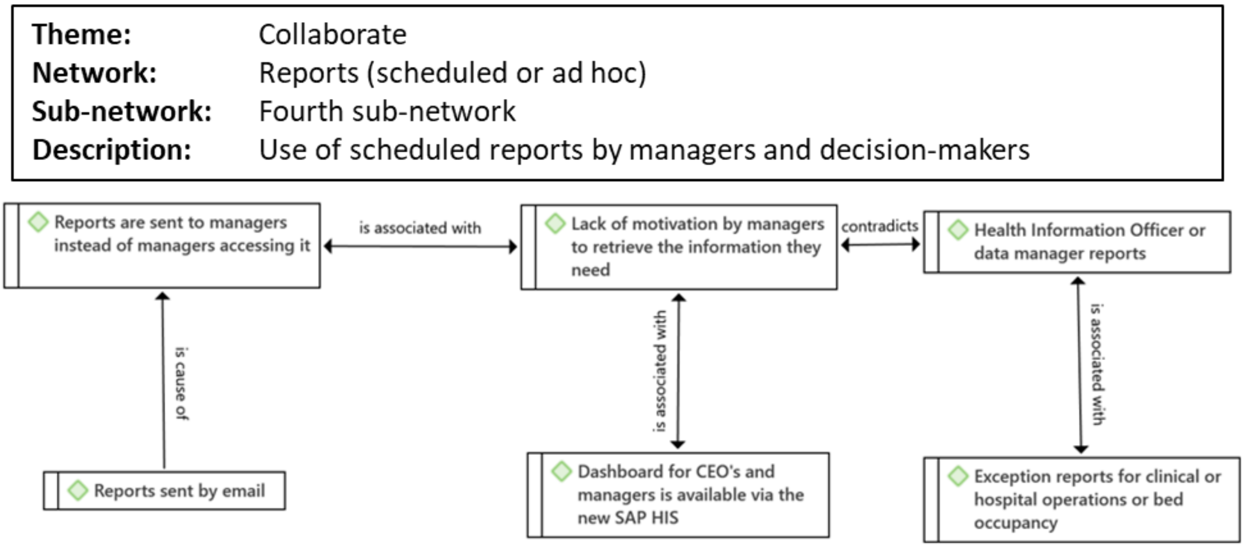


Figure 54. The fourth sub-network relating to the Reports (scheduled or ad hoc) network

The compilation of monthly reports is a team effort; nevertheless, the Data Manager or the Health Information Officer is responsible for ensuring the monthly reports are compiled correctly. In some cases, exception reports can be created. In some scenarios, there are unusually high numbers of admissions to the hospitals, which could prompt the creation of exception reports. Unusually high numbers could be a sign of a pandemic, but this scenario was not probed further as it would have deviated from the current research.

> *And you know so that I'm able to then you know check that against the exceptions then the norms and see how we are doing as an institution. [Participant: A15]*

It was noted that the monthly reports are sent to the relevant managers; the managers themselves do not access the reports. This phenomenon could be linked to the Communicate theme, whereby information is shared with groups of stakeholders instead of the relevant stakeholders accessing the reports.

> *What normally happens, I would get a report from the unit heads so I would get a report from the head of clinical and also get a report from the head of nurses to say, based on our hospital, this is how many people we have received. [Participant: A17]*

> *So normally I inform the management on a monthly basis on the reports. [Participant: A4]*

Bed occupancy information changes daily, yet monthly reports are emphasised even though daily figures are available; however, the daily bed occupancy figures might not be digitised at the point when it is needed. The translation of paper-based information into digital format (*Excel*) and then into DHIS requires collaboration among the relevant data management team members and nursing staff. Once this information reaches the district and provincial managers, it is used for strategic and long-term purposes. At this level, cooperation between the stakeholders is needed. Though admissions and discharges are captured on SAP HIS, the lack of connectivity between SAP HIS and other systems, such as EMS, results in some stakeholders lacking updated information.

4.12.2.2 Stakeholder Collaboration

The codes relating to the Stakeholder Collaboration network is presented in **Figure 55**.

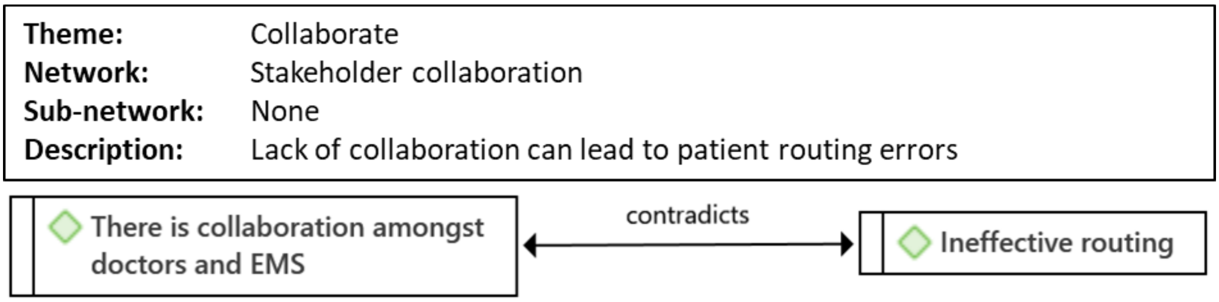


Figure 55. The Stakeholder Collaboration network

Ambulance crews must communicate with doctors in the emergency department during patient transport. The ambulance crews hand over patients with the appropriate documentation (TPH99) to the receiving doctors upon arrival at the emergency department. Doctors also communicate with EMS back-end staff and ambulance crews to transfer patients to other facilities (step-down facilities or more specialised facilities). To ensure a smooth patient handover, the relevant teams must collaborate.

> *EMS and the clinicians like every they are like a partners, they work together. [Participant: A5]*

Participant A5 noted the close relationship between EMS and hospital staff during the patient handover process. However, some participants noted that there could be issues with patient routing during ambulance diverts, which could be due to fragmented access to information. This aspect was discussed in the Connect, Communicate and Combine themes.

4.12.3 Interpretation of this Theme

The Collaborate theme considered how the various stakeholder groups (hospital data management, emergency and EMS teams) work together to promote positive patient outcomes. Petschack et al. (2023) argue that a good doctor–paramedic collaborative relationship can optimise patient routing. The data management teams compile data which informs medium to long-term decisions, whereas emergency and EMS teams collaborate to ensure positive patient outcomes in real-time. The study observed that this theme also has links with the Communicate theme since collaboration implies communication among stakeholders.

4.12.4 Impact on the Design Model for a Live Healthcare Console Version 0.1

The Design Model for a Live Healthcare Console version 0.1 indirectly represents groups of stakeholders, such as healthcare professionals and administrators; however, the interview process aided in identifying more detailed stakeholder groups, such as data managers and health information officers. Since a strong collaborative relationship among various roles within the healthcare system has been identified, adding these roles to the Design Model for a Live Healthcare Console version 0.2 would enrich the model.

4.13 Theme: Cooperate → Employing Technology to Encourage Cooperation Among People

The Cooperate theme considers a longer-term view compared to the Collaborate theme, which focuses on day-to-day or case-by-case collaboration among healthcare workers. This theme focuses on how stakeholders can work towards a long-term goal while considering the patients' short-term needs. Collaboration can exist within teams, across healthcare facilities and at various levels, and cooperation is key to balancing scarce resources in the constrained healthcare system.

4.13.1 Arriving at this Theme

The Cooperate theme comprises four networks, as described below.

- Decision-Making – Stakeholders at a provincial level must work together to ensure long-term goals are met. This includes cooperating with other provinces to share experiences. Short-term goals such as immediate patient care for serious conditions like stroke or cardiac arrest require stakeholders to work together to solve the immediate need. Stakeholders must also consider how to optimise short-term processes to achieve long-term objectives.
- Feasibility Assessment – Cost- and time-saving initiatives coincidentally consume resources such as time and finance to implement. The potential benefits of new projects should be weighed against the costs of the project itself and long-term maintenance costs. The impact on the stakeholders must also be considered since user adoption of a system can contribute to the success of the project. Resistance to using technology (discussed in the Contain theme) could also be due to a lack of user training.
- Specialised Needs – In some cases, patients require specialised needs, including oxygen tanks during transport. Such scenarios require the coordination of additional resources and cooperation between various teams to ensure critical resources are restocked accordingly.

- Stakeholder Accountability – Some participants echoed their concerns regarding stakeholder accountability. Some felt that better decisions could be taken if there was more accountability. Promoting accountability is a function of cooperation between the relevant stakeholders.

4.13.2 Components of this Theme

The Cooperate theme is composed of four networks. The decision-making network comprised two sub-networks, which were formed from the association between 17 codes. The Feasibility Assessment network contains seven codes, the Specialised Needs network has three codes, and the Stakeholder Accountability network comprises two sub-networks formed from 14 codes. The codes are presented in **Table 34**.

Table 34. Components of the Cooperate theme

Decision-Making (17 codes)
Advancements in other provinces, such as the Western Cape, and other countries
Chief Medical Officer or MMO decision – diversion
Chief Medical Officer or MMO decision-making
Clinical manager escalation
EMS does not always need to inform a hospital of their arrival T3 except during a time-sensitive condition such as a stroke.
EMS has to triage or decide on the level of hospital to which to deliver the patient. L1 to L3, whereby L3 is for the most severe conditions.
Hospital occupancy rules
Information supports resource planning.
Patient diversion
Patient transfer
Patient transfer works on a first-come basis and not necessarily on triage. This can waste time and compromise patient care.
Patients can be admitted after visiting the outpatient unit or clinic based on their condition.
Patients can be transported to a clinic or hospital depending on the severity or condition.
Patients must sometimes remain overnight in the emergency department (ED) due to their condition or a lack of beds in wards.
Patients should be educated on what types of emergencies require an ambulance or which level of hospital or clinic to visit.
Stakeholder involvement
Wards can reach maximum capacity.
Feasibility Assessment (seven codes)
Failed cost-saving initiative
Failed project
Gauteng's new SAP HIS

High cost of implementing technology
Lack of progress in Gauteng
New projects
Wasteful expenditure
Specialised needs (three codes)
Patient-to-facility mismatch
Patients might require specialised beds
Routing patients to the correct facility
Stakeholder accountability (14 codes)
Accurate information can promote accountability among staff.
Emergency departments are open to walk-in patients, even on divert. There is a threshold for them.
Lack of accountability among staff
Patients can be transferred multiple times because of a lack of capacity information or due to circumstances.
Patients cannot be turned away or refused emergency medical care.
Patient care
Patient transfer can be a manual process with limited information.
Patients are triaged as P1, P2 or P3 in the emergency department, depending on their condition or severity.
Real-time systems can promote patient care.
The availability of equipment, such as an MRI, should also be available to other facilities without an MRI.
There is a link between accurate information and the public's confidence and perception towards the healthcare system.
There is a link between performance information, risk management and organisational goals.
There should be an end-to-end process from a call being logged to fetching a patient and handing them over to a doctor at a hospital. Currently, the paper-based system can be compromised.
Walk-in emergency patients are at risk of arriving during a divert, thereby compromising their medical care.

4.13.2.1 Decision-Making

Figure 56 presents the first sub-network of the Decision-Making network.

Theme:	Cooperate
Network:	Decision-making
Sub-network:	First sub-network
Description:	Real-time information is used for key decision-making

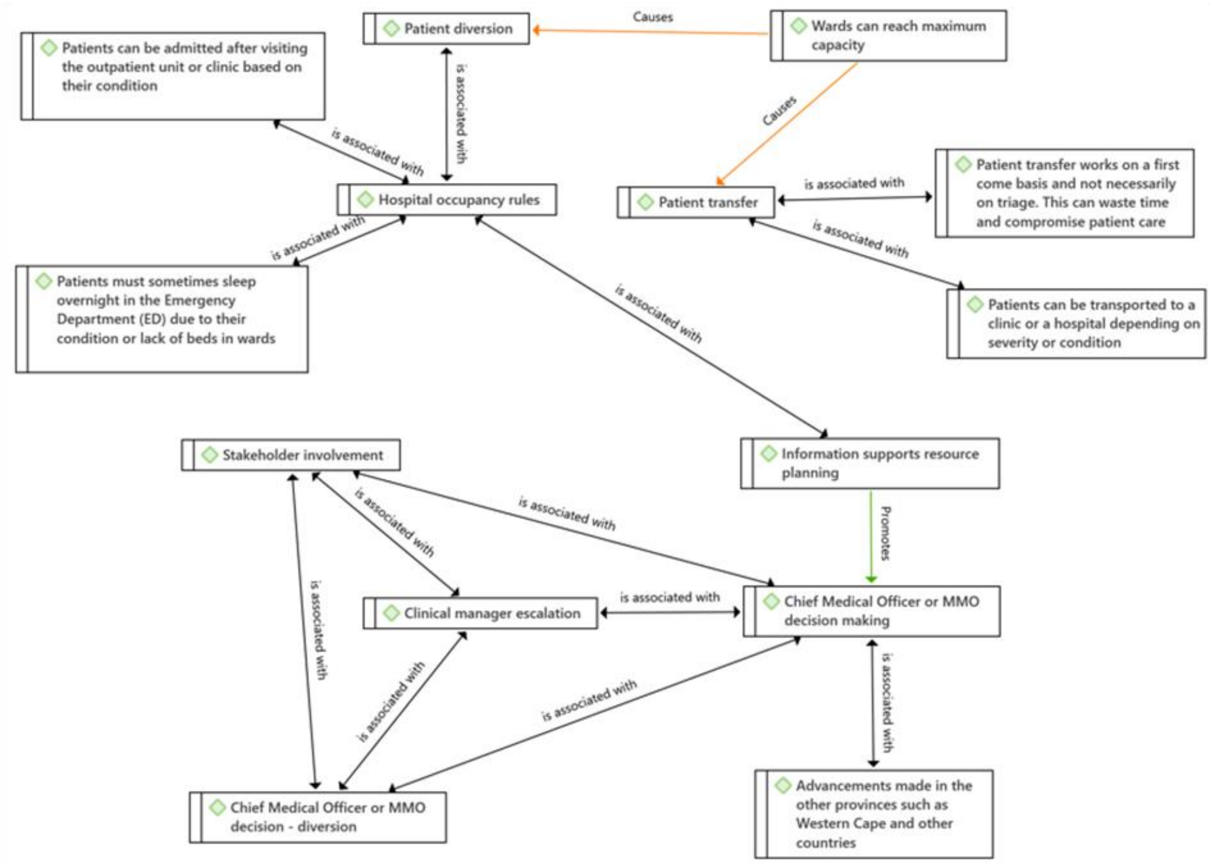


Figure 56. The first sub-network relating to the Decision-Making network

The MMO has a critical decision-making role in the district of which they are in charge for a particular shift. One of the key decisions an MMO makes (discussed in the Communicate theme) is whether to place a hospital on ambulance divert. To make this decision, the MMO requires quality data from trustworthy sources.

> *That's on call that day or that night, and that manager then calls the MMO, which is the person who sort of manages all the hospitals in the region… So there's a lot a number of decisions being taken each step of the way. [Participant: A9]*

> *MMO, the person that the medical doctor, who is the coordinating the provincial movement of patients and EMS and ambulances. [Participant: A15]*

> *Remember that you have MMO on calls like Managing Medical Officers that are on a daily basis. These guys are the CEOs of the hospitals. So there are five of them. So each and every day and night we have a designated MMO. Then if the hospital is on divert for some other reason, if they are full for a P1 or it's just a maternity case they call the MMO on call, then MMO, we have a phone here[in]*

where I'm working. There's a phone that is actually designated for those guys because we do not, it's only them who knows that number because we wouldn't want them to call us and then they will find out that our line is engaged. [Participant: A21]

The participants described MMOs as senior doctors who manage the ambulance divert process within a district. Some participants referred to the MMO as the CEO. However, as explained in **Section 4.10.2.1**, the MMO and CEO are two separate roles. As described by the participants, an MMO has the ultimate responsibility to determine whether to place a hospital on ambulance divert. This decision requires cognisance of the statuses of other nearby hospitals.

Nevertheless, the role of the patient as a walk-in must not be set aside. As mentioned in **Section 4.10**, diverts do not apply to walk-in patients. Since most patients are not trained in medicine, they might not understand the severity of their condition and could visit a facility that is either categorised as higher or lower than the type of facility they require.

They can then bypass the clinic and go to the big hospital in the area. So whether it be a tertiary hospital like an education hospital, where there's just one of the big hospitals in the area. [Participant: A19]

A patient might have a condition that could be treated by a clinic but due to proximity, they might travel to a facility that is closer to them without realising that the facility is a higher-level facility that would refer the patient elsewhere to conserve resources. Such situations can burden the higher-level facility. Since patients play an important role in their own health and can decide which facility to visit, the concept of self-triage might need to be considered. To introduce such an idea into the healthcare system would require significant cooperation among the various healthcare stakeholders and patients. The second sub-network introduces the concept of patient involvement in healthcare decision-making and is presented in **Figure 57**.

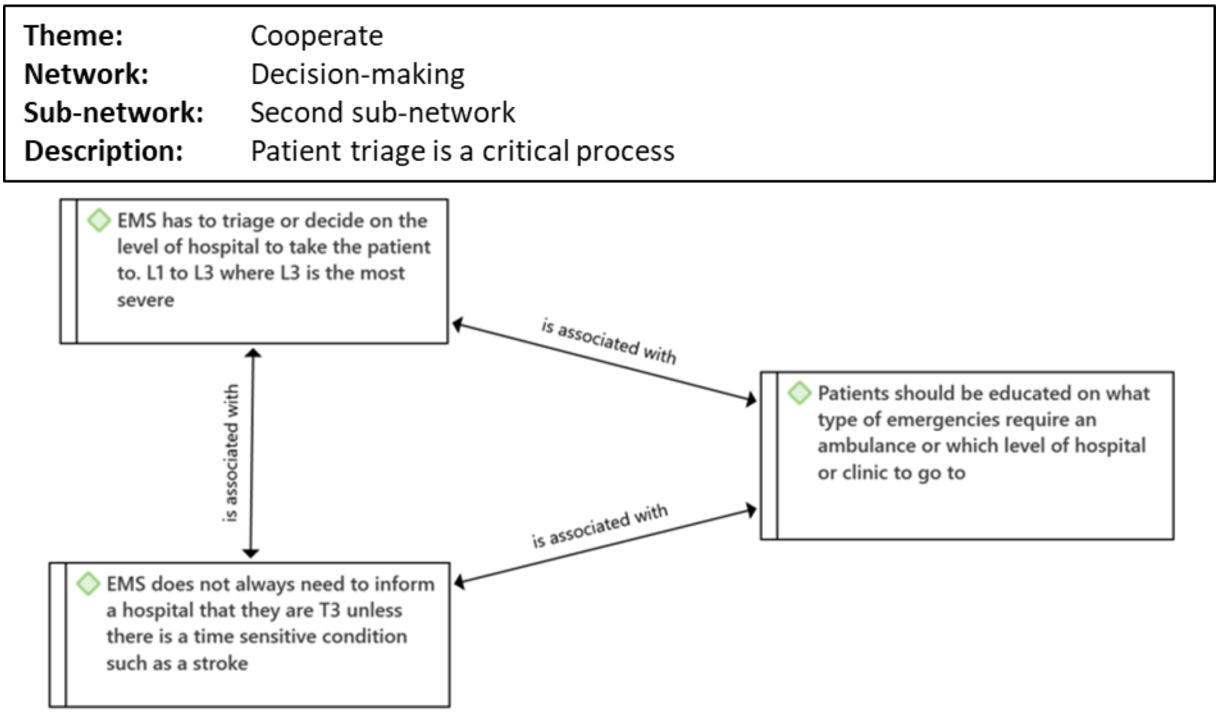


Figure 57. The second sub-network relating to the Decision-Making network

Patient decision-making does not always result in optimum outcomes. Thus, some participants suggested educating patients on following the correct procedures when requesting medical assistance. This could be regarded as a long-term objective.

> *And strategies whereby we can teach our people that does this and emergency that needs and to be transported by an ambulance to the hospital or this kind of emergencies, we can try to start at your local clinic because remember, if the clinics is that OK this ailment or this condition warrant for a hospital admission, then they can make a decision there and then call for a transportation to the hospital. [Participant: A25]*

Participants alluded to the concept of self-triage (discussed above), speaking to how patients could be educated on the different facility levels and what type of conditions require an ambulance versus using their own transport. Decision-making, as presented in this network, occurs at several levels. The stakeholders involved include healthcare professionals, managers, EMS and patients.

4.13.2.2 Feasibility Assessment

Figure 58 presents the codes related to the Feasibility Assessment network.

Theme: Cooperate
Network: Feasibility assessment
Sub-network: None
Description: New systems can be financially wasteful if not implemented correctly

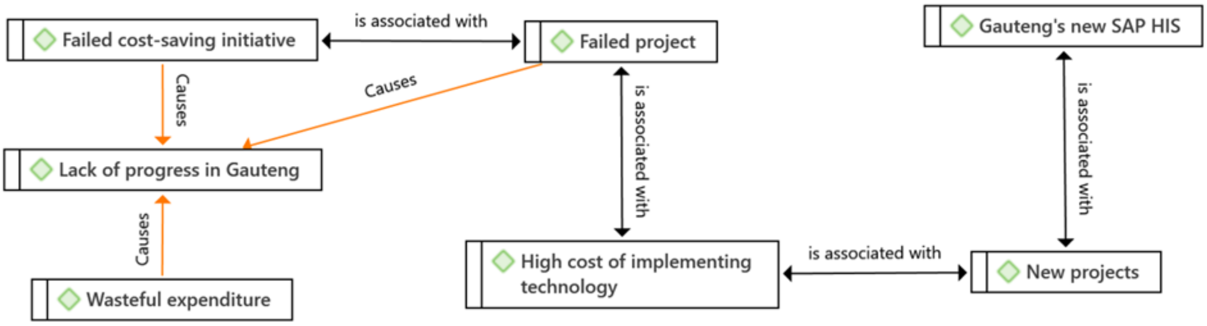


Figure 58. The Feasibility Assessment network

Digital health interventions consume resources such as finances and time. The participants mentioned recently implemented projects such as Gauteng's new HIS. Though most participants praised the new system, some noted a lack of connectivity to other key systems. Decision-making related to new projects and how to embed systems into a landscape requires collaboration among key stakeholders to ensure long-term objectives are met. The feasibility of implementing a new system needs to be assessed in the beginning stages of a project.

> *But the cost and those issues are huge. [Participant: A2]*

> *I think on the basis that they wanted to do it for the whole province, but that has not come to fruition. [Participant: A13]*

The participants noted the high costs of implementing projects, especially those not meeting all the desired objectives. The participants also noted advancements made in the Western Cape and some suggested consultation with Western Cape project leaders for the appropriate lessons to be shared. Such consultation would imply further cooperation between provinces.

> *So I know that there's been developments in Gauteng, which are slowly trickling through to all of the hospitals in terms of standardising a single hospital number per patient so that you get continuity of care between the hospitals having worked in the Western Cape before where that system is already in place. [A10]*

> *Again, having seen the Western Cape, it's easier to then formulate systems such as digital discharge summary set then get uploaded from the hospital side and then the clinics can access it on their side to see what was done in the hospital and also in terms of pharmacy services. [Participant: A10]*

> *And I think that some of the other provinces have implemented a digital system from the EMS perspective. [Participant: A19]*

The participants suggested consulting other provinces' experiences, as well as the feasibility of existing systems, before initiating new projects. Such consultation could reduce the possibility of failed projects, consequently protecting scarce resources such as finances, time and the availability of key stakeholders.

4.13.2.3 Specialised Needs

Figure 59 presents the Specialised Needs network.

Theme:	Cooperate
Network:	Specialised needs
Sub-network:	None
Description:	Specialised patient needs can complicate routing

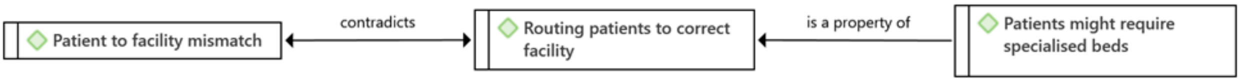


Figure 59. The Specialised Needs network.

At the inception of this research, the study assumed that beds in the wards and emergency departments were identical; instead, some participants stated that the beds in certain wards, such as the emergency department, differ to facilitate specialised medical procedures like resuscitation. This difference adds a further layer of complexity to reporting on available beds within certain departments. It also complicates cooperation between stakeholders such as emergency doctors and EMS.

> *General beds, high-care beds as well as ICU beds. [Participant: A8]*

> *But when our resuscitation beds become fully occupied or 100% occupied and there's no additional space to put any of these critically injured patients. [Participant: A9]*

Furthermore, there are different bed types within the emergency departments, which would consequently require further classification in terms of hospital bed occupancy. In some situations, beds are available in the emergency department; however, those beds might not be appropriate for the treatment required for the patient who has arrived.

Patient-to-facility mismatches arise when a patient arrives as a walk-in or is transported to the incorrect level hospital. This situation could be due to a communication breakdown between stakeholders, which can threaten resource availability.

> *You don't want a district, the patient to end up in a tertiary hospital just because there's a bed. [Participant: A2]*

> *They're so they have a fear of not being able to cope and if somebody unsolicitally sends a patient to your department because you've got a bed, but it's not the right*

type of patient, you will be full of the wrong patients and what is sitting at a District Hospital should be staying at the District Hospital and what should come to a tertiary hospital. And that's often a problem between administrators and clinicians. [Participant: A2]

Scarce resources require patients to seek assistance from a facility that matches their condition. If patients seek assistance from a higher-level facility, this can cause issues with load-balancing resources, as discussed in the Communicate theme. Hence, a lack of cooperation between certain stakeholder groups could result in incorrect patient routing, which could, in turn, result in patient rerouting, thereby again adding to issues with the load-balancing of resources.

Yes. And of course it is for the sake of the patient because now I have to go up and down with the patient. He didn't tell us that that specialist is not there. We have to take the patient again from that hospital, go to another one and it's not good for the patient. [Participant: A22]

Some participants noted that communication breakdowns or a lack of communication can lead to situations whereby patients are transferred multiple times before reaching the appropriate facility. This concept leads to the Stakeholder Accountability network, which is discussed in **Section 4.13.2.4**.

4.13.2.4 Stakeholder Accountability

Figure 60 presents the first sub-network relating to the Stakeholder Accountability network.

Theme:	Cooperate
Network:	Stakeholder accountability
Sub-network:	First sub-network
Description:	Increased stakeholder accountability can lead to better patient care

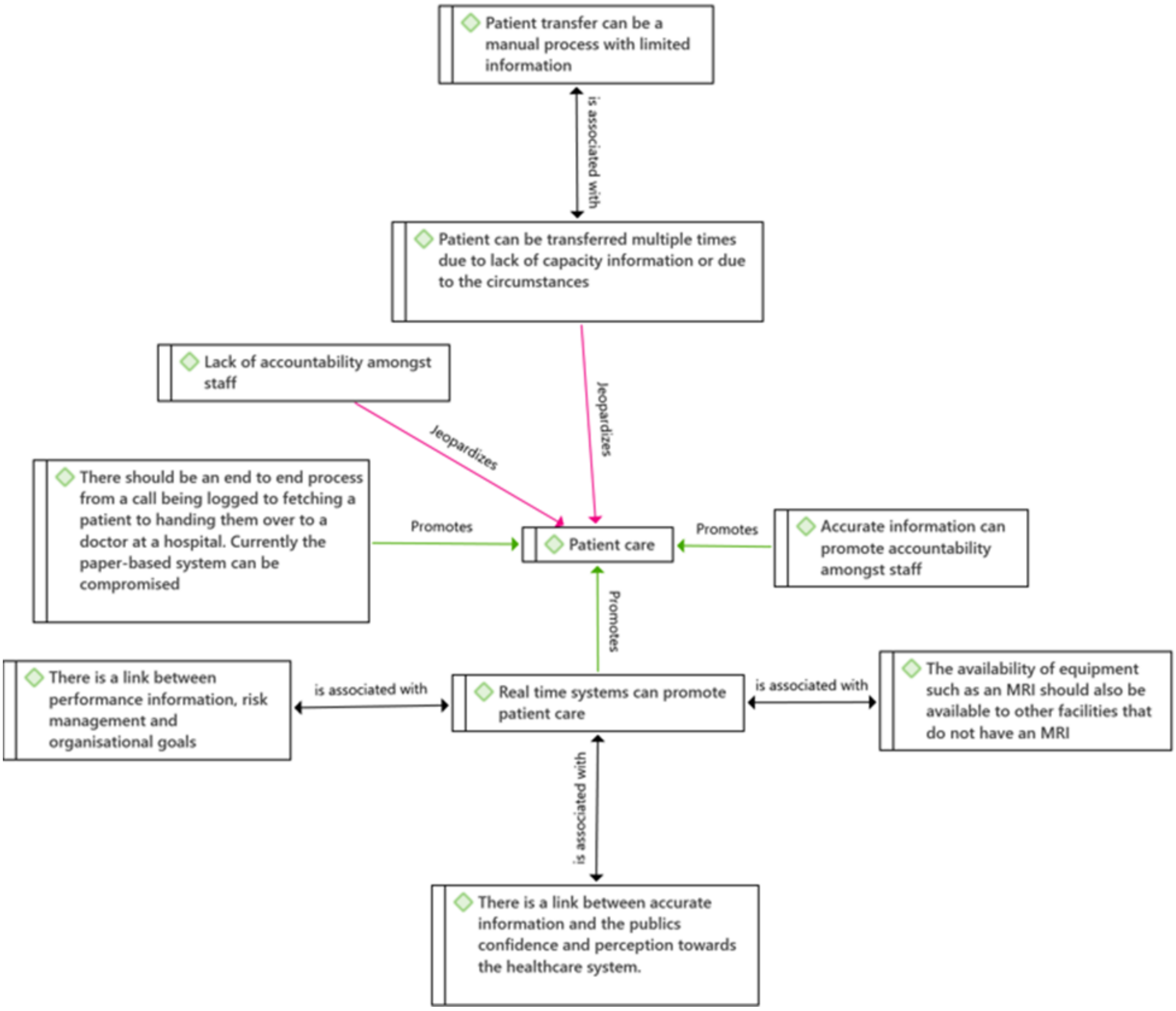


Figure 60. The first sub-network of the Stakeholder Accountability network

Cooperation between the relevant teams is key to promoting positive patient outcomes; however, in some cases, sub-optimal decisions can have a negative effect.

> *Sometimes the system is not flawless and patients will come with the emergency medical services to a facility that is on divert and then it would be the doctor's role to ensure that the patient is stable, perform any emergency intervention. [Participant: A10]*

In some scenarios, a patient arrives by ambulance at a hospital that is on ambulance divert, which could be the result of a breakdown in communication (Communicate theme) or a lack of shared information (Combine theme). It could also be due to human error, e.g., if a person does not keep up to date with their messages. However, one could argue that this scenario is not a case of human error but rather one of information overload due to receiving copious numbers of messages.

> *Despite regular updates on groups that say this is the place on they would still tend to ignore those diverts when it suits them. [Participant: Anonymised]*

Some participants believed human error could be owing to misrouting patients, which, in turn, calls for accountability among key stakeholders. **Figure 61** presents the second sub-network relating to the Stakeholder Accountability network.

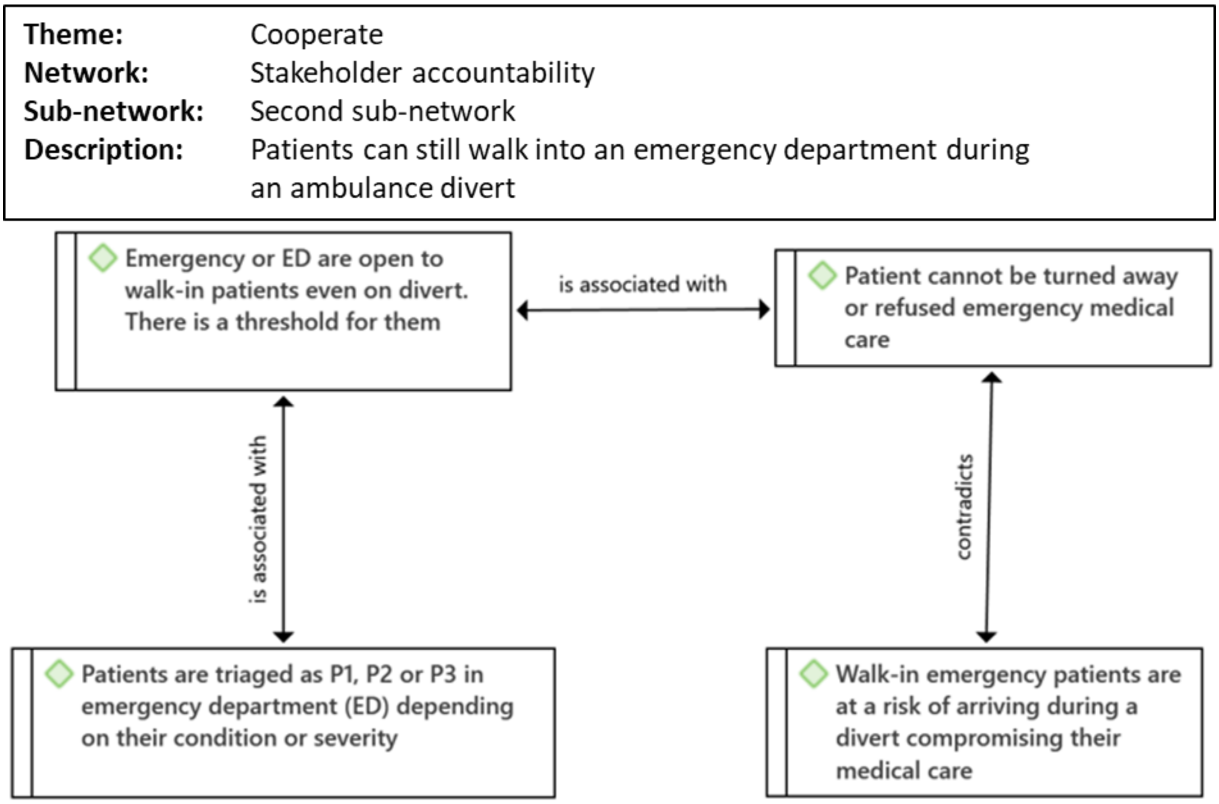


Figure 61. The second sub-network of the Stakeholder Accountability network

The participants described the ambulance divert process as necessary to ensure the load-balancing of resources (Communicate theme) and, ultimately, promote positive patient outcomes. However, the divert process requires different layers of validation before the divert can be approved (Collaborate theme). In this process, the MMO seems to take accountability for correctly approving a divert request. The patient triage process is a trusted method to ensure the patient receives the correct level of care.

> *You see? So once they have triaged the patient and they see that guy is a P3. They can be able to give a second opinion to say you are a P3, you would say we are operating at full capacity. Can you maybe at least go to the nearest clinic so that you can be help* (sic) *faster other than waiting here for longer? So I think it would also be helpful to the staff. [Participant: A12]*

The stakeholder responsible for the triage is also responsible for making the correct decisions relating to the care of patients based on the limited resources available.

4.13.3 Interpretation of this Theme

Cooperative strategies between various healthcare levels aided in the integration of primary-level facilities in China (Dong et al., 2023). Participants in this research highlighted the importance of cooperation among healthcare stakeholders. Some described implemented measures such as triaging and approving ambulance diverts. These measures can potentially support accountability, which can affect patient care positively. Cooperation between healthcare professionals, policymakers and the public is needed to ensure meeting long-term objectives. In such cases, the feasibility of certain initiatives should have been determined prior to embarking on new projects, which consume critical resources such as finances, time and the availability of key stakeholders.

4.13.4 Impact on the Design Model for a Live Healthcare Console Version 0.1

The Design Model for a Live Healthcare Console version 0.1 is not intended to associate roles such as those assigned in a RACI (responsible, accountable, consulted and informed)[8] matrix, which can be used as a project management technique (De Moura et al., 2021). However, the Stakeholder Accountability sub-network introduced the idea of accountability. Since data managers or health information officers are tasked with ensuring bed occupancy data are correctly captured and uploaded to the DHIS, this role could be highlighted as displaying accountability. The other three roles of the RACI matrix were not considered any further. Supplementing the role list with the concept of accountability also serves to highlight the importance of certain roles.

4.14 Summary of Chapter 4

This chapter began with a presentation of the steps followed during the ethics application process. The interview process and research instrument were then explained in detail. During the data collection process, the researcher conducted 31 semi-structured interviews and analysed the interview transcripts qualitatively using three cycles of coding. The first cycle led to 214 codes associated with each other to form networks or sub-networks during the second cycle of coding. During the third cycle of coding, six themes were identified using the networks. Each theme had an impact on the Design Model for a Live Healthcare Console version 0.1. In **Chapter 5**, the theoretical model is developed and the Design Model for a Live Healthcare Console version 0.1 is improved based on the six themes.

[8]Responsible – Person responsible for executing a task.
Accountable – Person who is ultimately in charge of ensuring that the task is completed.
Consulted – Person who can provide further insights into the completion of the task.
Informed – Person who needs to be communicated of the task status.

Chapter 5: Theoretical Development and Discussion

This chapter presents the theoretical conjecture supported by the theoretical model. This is followed by a presentation of the Design Model for a Live Healthcare Console version 0.2 and then version 1.0 (final version). Thereafter, the chapter discusses the evolution of the three model versions (0.1, 0.2 and 1.0) and concludes by answering the research questions. **Figure 62** illustrates the structure of this chapter.

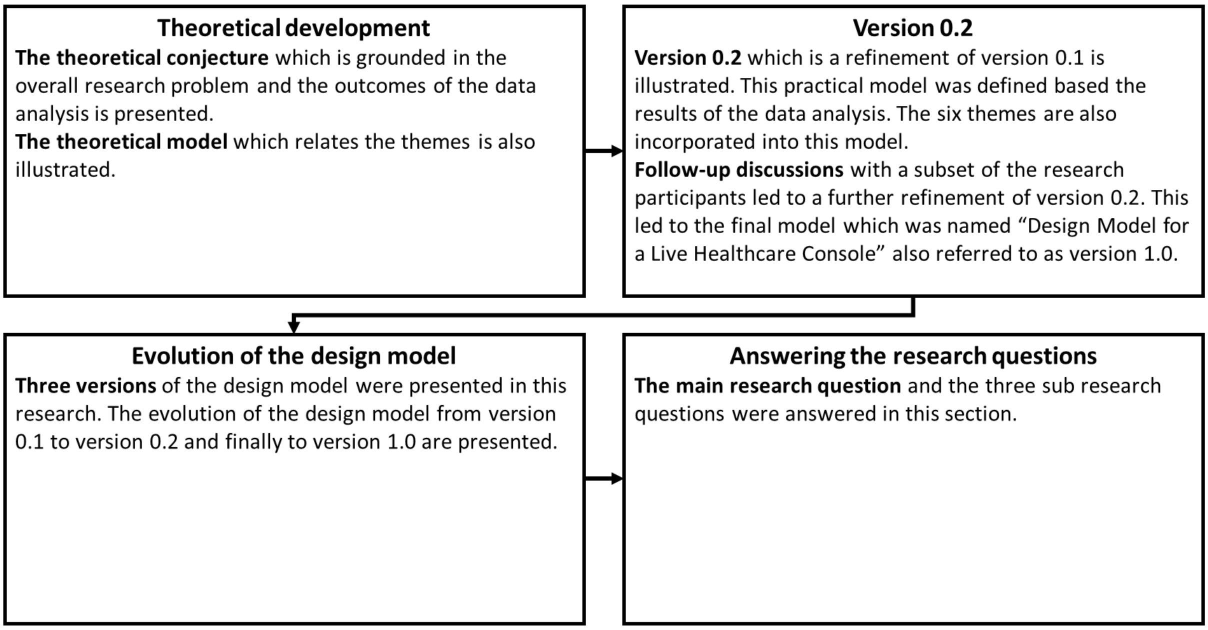


Figure 62. Structure of Chapter 5

5.1 Theoretical Development

The theoretical conjecture is a synergy of the outcomes of the literature review and the results of the data analysis. The conjecture describes the challenges and opportunities related to the public healthcare system in South Africa. These challenges and opportunities were identified during the literature review, which was conducted in three phases. The outcomes of the literature review were then merged with the six themes identified through an interpretive analysis of 31 semi-structured interviews with key stakeholders selected using purposeful and snowball sampling techniques. The theoretical conjecture is presented below.

> *South Africa’s resource-constrained public healthcare system demands daily operational resource optimisation and load-balancing to support the delivery of appropriate healthcare services. The aforementioned are essential to achieving long-term strategic objectives, such as offering the best value to patients and reducing the effects of burdens which arise from diseases and violent crimes, which are prevalent in South Africa. Reducing the physical gap between patients and the healthcare services they need is one way to achieve these objectives, which calls for optimisation of patient transport to appropriate healthcare facilities.*

The present fragmented public healthcare technology landscape could benefit from connecting people to real-time information first by integrating systems such as healthcare facilities and EMS and then combining the relevant information such as hospital bed occupancy and ambulance diverts. Such steps then support decision-making at various levels, such as within the healthcare facilities as well as at the district, provincial and national levels. Once people are connected to information, they can leverage it to promote collaboration among healthcare teams such as healthcare facilities and EMS. This collaboration is critical, particularly within the healthcare system, where consultation across various healthcare teams is essential to making life-and-death decisions.

On the other hand, connected systems with multiple entry points have an increased likelihood of attracting the attention of cybercriminals. Therefore, sensitive healthcare records and strategic healthcare information must be adequately safeguarded. By effectively containing cybersecurity threats, sensitive information can be secured, and people can access information and services with minimal disruption. This promotes the information integrity of the healthcare ecosystem.

Strengthening communication mechanisms by adding information access levels supports meaningful and targeted communication to the right stakeholders. Therefore, effective communication among people and systems would precipitate a favourable information flow, allowing for more informed decision-making. Since patients are the focus of the healthcare system, their role in decision-making should also be considered. Communicating with patients openly and transparently subsequently empowers them to make decisions related to their health.

This human collaboration, supported by the effective and responsible use of technology, encourages long-term cooperation, which could lead to achieving South Africa's long-term strategic healthcare objectives.

The theoretical conjecture is expressed as a theoretical model in **Figure 63**.

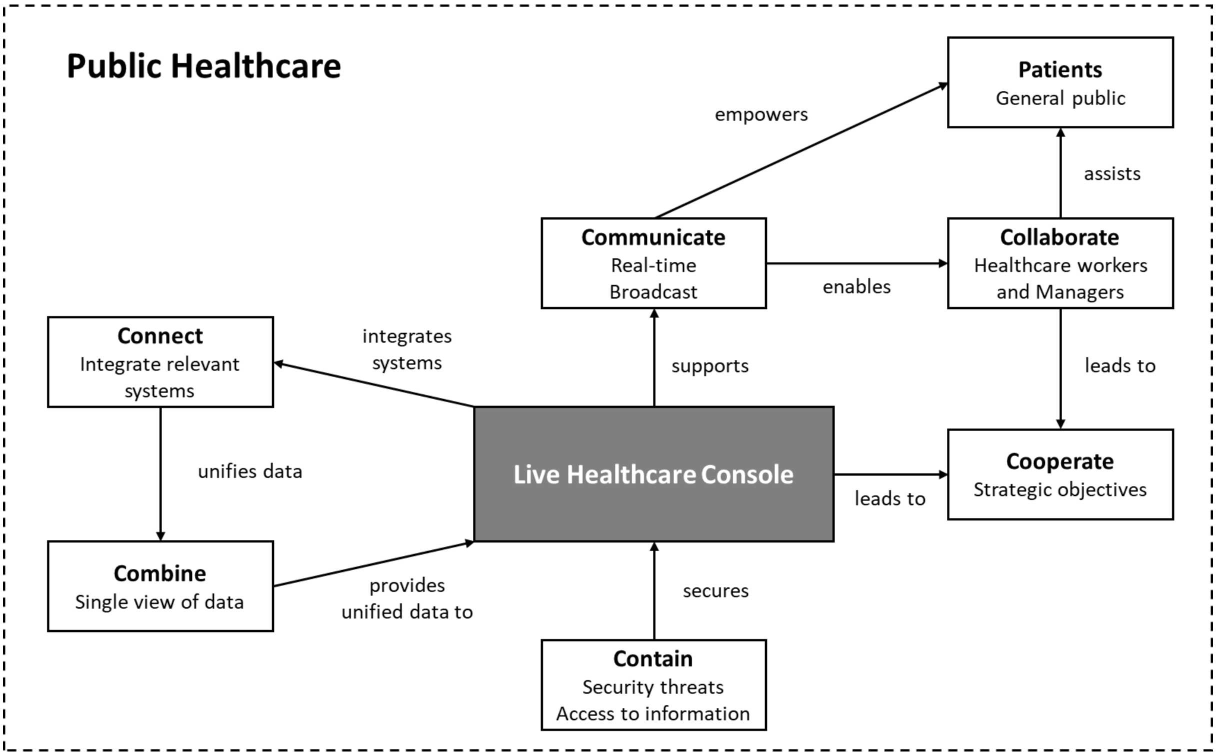


Figure 63. Illustration of the theoretical model

The illustration of the theoretical model demonstrates how the Live Healthcare Console could be used to connect the relevant digital health systems in a way that combines the appropriate datasets into a single or unified view. The Live Healthcare Console can share the unified data with the appropriate stakeholders based on agreed data governance principles to ensure precise and targeted communication. Effective communication can empower patients (identified as key stakeholders) to make informed decisions relating to their health. Communicating quality data with key stakeholders such as healthcare professionals and managers leads to effective collaboration among healthcare teams. Collaboration, in turn, contributes to positive patient outcomes. In the long term, the Live Healthcare Console can support strategic objectives by enabling cooperation among key stakeholders. The rise in cybersecurity threats must be considered, especially within the healthcare context; hence, the Live Healthcare Console must contain security threats that would safeguard content stored on the system. **Section 5.2** presents and discusses the Design Model for a Live Healthcare Console version 0.2, a practical application of the theoretical development.

5.2 Design Model for a Live Healthcare Console Version 0.2

Chapter 4 introduced and discussed the six themes identified during the data analysis phase. The Design Model for a Live Healthcare Console version 0.1 was created based on insights gained from a review of academic literature. In this section, version 0.1 is updated based on the insights gained from the six themes to formulate the Design Model for a Live Healthcare Console version 0.2.

Below is a summation of the improvements made to formulate the Design Model for a Live Healthcare Console version 0.2:

- Connect – Incorporate EMS and a potential dataset such as ambulance diverts.
- Communicate – Advance the representation of broadcast communication.
- Combine – Incorporate the EMS dispatch system as a subsystem.
- Contain – Include secured endpoints for all systems.
- Collaborate – Complement the stakeholder list with specialised stakeholder groups.
- Cooperate – Highlight accountability for specialised stakeholder groups.

The improvements were applied to version 0.1 to formulate the Design Model for a Live Healthcare Console version 0.2, presented in **Figure 64**.

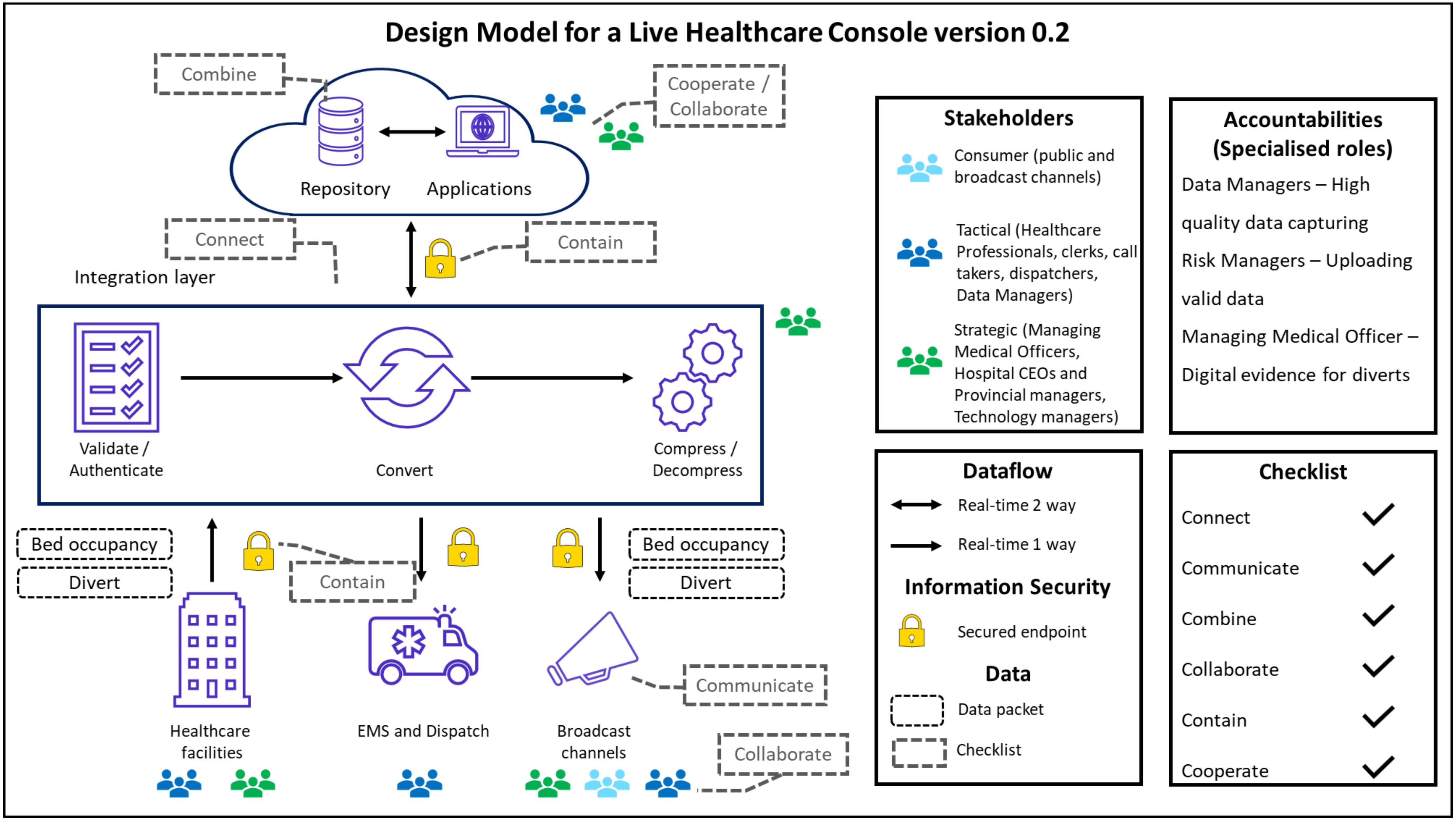


Figure 64. Design Model for a Live Healthcare Console version 0.2

The Design Model for a Live Healthcare Console version 0.2, illustrated in **Figure 64**, is an improvement of the Design Model for a Live Healthcare Console version 0.1. The stakeholder list has been updated to include the roles identified during the interviews and the accountabilities of specialised roles. Key data packets, such as bed occupancy and ambulance diverts, have been included as outgoing messages from healthcare facilities and incoming messages to EMS and broadcast channels. Healthcare facilities have been divided into different systems as the data analysis revealed that these systems work on different platforms. Secured endpoints have been included to deter unwanted access. Due to the importance of broadcast messaging, broadcast channels have been included as a separate system.

5.3 Testing the Design Model for a Live Healthcare Console Version 0.2 with Participants

The researcher discussed the Design Model for a Live Healthcare Console version 0.2 and the theoretical model with a subset of the original participants to confirm whether these models could contribute to alleviating the problems identified during this research. Four participants agreed to a follow-up discussion. The follow-up interviews allowed the interviewer and the participant to discuss or reflect on the original interview (Holter et al., 2019). However, it would be inaccurate to describe the four follow-up discussions as interviews, as there were no prepared questions, and none of the original interview questions were revisited. The follow-up discussions conducted online using MS *Teams* were not recorded or transcribed, and the researcher observed that the participants were more relaxed compared to the original interviews. Two participants switched on their cameras because they wanted the feeling of meeting their interviewer. They initiated the discussions and were eager to learn about the new models that had been developed. Therefore, the discussions could be considered participant-led, which allowed the participants to speak freely (Hancock & Foster, 2019).

The Design Model for a Live Healthcare Console version 0.2 and the theoretical model were shared on-screen and described to the participants. Two participants agreed that the models could form the basis for contributing to solving current issues and potential challenges that may arise from implementing the NHI. They did not have any further comments. The other two participants were eager to know the details of the datasets to be shared and how the data would be protected. Though the hospital bed occupancy and ambulance divert data packets were represented in the Design Model for a Live Healthcare Console version 0.2, the study uncovered that the data packets were not necessarily governed by access control, even though access levels were noted in **Chapter 4**. This research only proposed the sharing and potential protection of these datasets but did not delve into the access control aspects. Therefore, the researcher agreed that the design model would be refined to include access control on the two data packets. The final version of the design model was then renamed Design Model for a Live Healthcare Console version 1.0 and is presented in **Figure 65**. The participants agreed with the theoretical model and thus did not propose any changes.

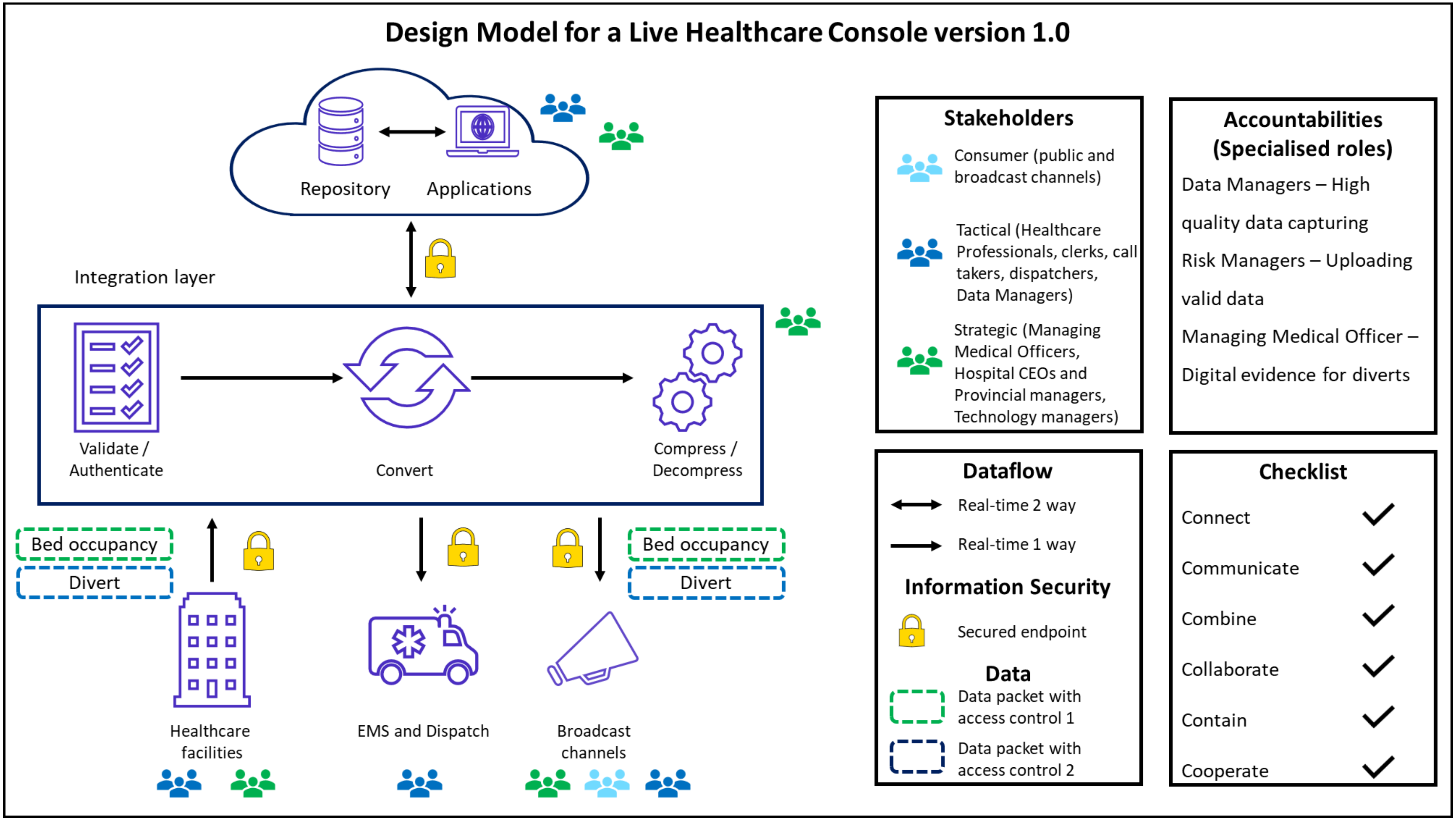


Figure 65. Design Model for a Live Healthcare Console version 1.0

5.4 The Evolution of the Design Model for a Live Healthcare Console

The Design Model for a Live Healthcare Console (version 1.0) was created using an iterative approach. Each of the three versions was influenced by different inputs. Version 0.1 was chiefly influenced by the outputs of the literature review. This fed into version 0.2, which was guided by the analysis of the stakeholder interviews. Version 0.2 was tested with a subset of the original stakeholder participant group. The inputs from the follow-up sessions led to the development of the final model, version 1.0. **Table 35** presents the inputs, strengths and limitations of each model version.

Table 35. The evolution of the Design Model for a Live Healthcare Console

Model version	Inputs	Strengths	Limited by
Version 0.1	• Batho Pele Principles • Five evaluated models • Department of Health aims	• Illustrates combining data from various sources into a single repository. • Collaboration among key stakeholders, such as consumers, tactical personnel and strategic managers, is represented. • Connecting existing systems is illustrated through the integration layer. • Communication is illustrated through consuming systems.	• Information security is not represented. • Consuming systems do not depict key systems such as EMS and dispatch. • Broadcast communication is not adequately represented. • Key data packets, such as bed occupancy and ambulance diverts, are not represented. • Cooperation among key stakeholder groups is not represented. • Stakeholder groups are illustrated. However, there are no accountabilities for certain critical healthcare roles.
Version 0.2	• Version 0.1 • Stakeholder interviews	• Information security is represented at key data entry points.	• Access control or data sensitivity levels are not represented for the bed occupancy and ambulance diverts data packets.

		• Consuming systems have been split into EMS and dispatch as well as broadcast channels. • Cooperation between tactical and strategic stakeholder groups has been illustrated. • Key data packets, such as bed occupancy and ambulance diverts, are represented. • Stakeholder accountabilities have been represented for specialised roles.	
Version 1.0	• Version 0.2 • Stakeholder follow-up discussions	• Access control levels for the bed occupancy and ambulance diverts data packets are represented.	No limitations for this version of the model were noted; however, this could form the basis for future research.

5.5 Answering the Research Questions

Section 1.5 introduced the main research question (RQ). This question asked: "How can digital health interventions in the form of a Live Healthcare Console support public healthcare management?". The study first had to construct sub-questions (SQ) that would contribute to answering the RQ. SQ1 asked: "How can a Live Healthcare Console support the key stakeholders in their tactical and strategic functions?". SQ2 asked: "What are the key elements needed for the design of a Live Healthcare Console?" and SQ3 asked: "What influences the effectiveness of a Live Healthcare Console within the public healthcare system?". The six themes identified and discussed in **Chapter 4**, together with the literature review outcome, contributed to answering each research question.

- Answer to SQ1 – Tactical (daily) and strategic (long-term) objectives can be achieved by key stakeholders using connected systems that share real-time or near-real-time information. Connected systems, such as a Live Healthcare Console, can also enhance communication between stakeholders, who can share quality information relating to immediate patient care. Communication and sharing of information support cooperation between key decision-makers, which is essential to achieve strategic objectives. Load-balancing, a critical function of hospital managers and MMOs, can be achieved by using the centralised (graphical) view of the Live Healthcare Console that alerts decision-makers about congestions in real-time and allows them to reallocate resources appropriately.
- Answer to SQ2 – The design of a Live Healthcare Console requires the inclusion of the appropriate key stakeholders, which ensures that all unique perspectives, such as strategic, tactical and consumption, can be accommodated. The appropriate processes, such as admissions, discharges, transportation, transfers and ambulance diverts, must also be incorporated into the design. The design of a Live Healthcare Console must further include the optimal use of existing systems while considering infrastructure-related constraints.
- Answer to SQ3 – The effectiveness of a Live Healthcare Console is influenced first by its ability to connect to systems that can share quality information in real-time. Second, it is influenced by the ability of key stakeholders and appropriate third-party systems to access information relevant to them. Lastly, the Live Healthcare Console is influenced by its ability to contain security threats to ensure the availability of information is uncompromised.

Accordingly, the answers to SQ1, SQ2 and SQ3 led to answering the RQ.

- Answer to RQ – In a resource-constrained public healthcare system, the Live Healthcare Console can serve as the "nervous system" for healthcare resource management from a healthcare facility to the district and provincial levels. Contextualised healthcare information from existing healthcare systems can be communicated in real-time with healthcare managers, who can evaluate the information to inform critical decision-making. This human–technology decision-making approach supports the effective load-balancing of scarce healthcare resources.

5.6 Summary of Chapter 5

This chapter presented the theoretical and practical development. The theoretical model, together with the Design Model for a Live Healthcare Console version 0.2, was tested with a subset of the original participants. The four participants who attended the follow-up discussions did not highlight any proposed changes to the theoretical model. They expressed their satisfaction with the Design Model for a Live Healthcare Console version 0.2 but added that specific access levels could be added to the hospital bed occupancy and ambulance diverts data packets. These suggestions were considered, resulting in the final version of the model. **Table 35** contains an explanation of the evolution of the three versions of the model. The three research sub-questions were then answered, which led to answering the main research question. **Chapter 6** presents the final commentary regarding this research.

Chapter 6: Conclusion

This chapter provides a reflection on the research process. It includes an audit of the research, the techniques used to ensure academic integrity (research rigour), and presents the research contributions, possibilities for future research and the researcher's reflections. Reflexivity in information systems research is an approach that allows researchers to share their knowledge based on their experiences. These can include extracts or insights from personal notes (Moonsamy & Singh, 2024a). Thus, the chapter concludes with some of the researcher's reflective accounts of this research. **Figure 66** illustrates the structure of **Chapter 6**.

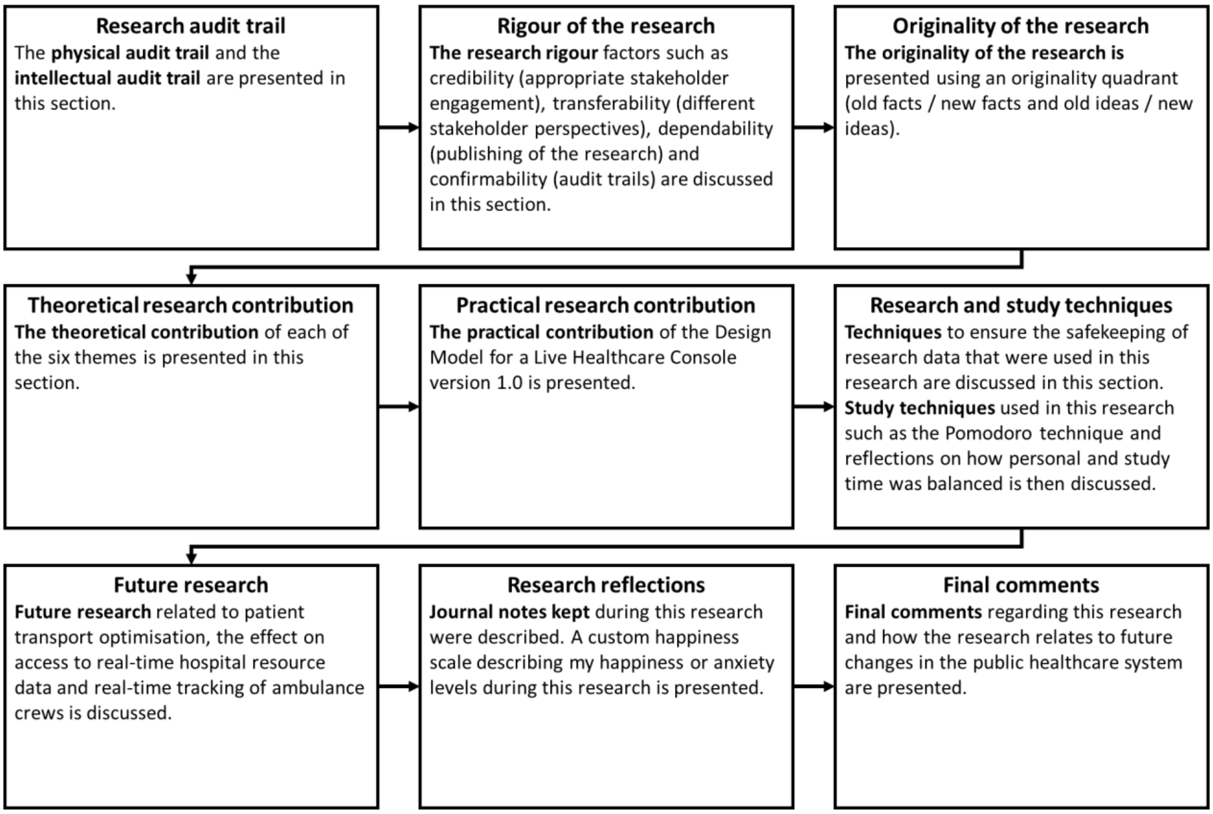


Figure 66. Structure of Chapter 6

6.1 Research Audit Trail

Carcary (2021) argues that trustworthiness in research could be achieved by presenting a research audit trail. The research audit trail could comprise two parts: a physical audit trail and an intellectual audit trail. The physical audit trail could be regarded as a checklist or an event log, whereas the intellectual audit trail could be considered as the philosophical approach. **Table 36** presents the physical audit trail and is an adaptation of Carcary (2021).

Table 36. The physical audit trail of this research

Item	Notes
Research problem	The research problem was identified and defined during the research proposal phase. Following the acceptance of the research proposal, the research problem was interrogated by the appropriate ethics review committee (CAES HREC). The research problem was substantiated by literature in the academic domain as well as in the media.
Literature review	An extensive literature review consisting of three phases was conducted. Setting the scene – This phase confirmed challenges and opportunities using recent events found in digital newspaper media. The challenges and opportunities were then confirmed using academic literature. Technology architecture development – This phase investigated the Department of Health's architectural design model. Insufficiencies were identified in the Department of Health's proposed Federated Health Information Architecture model, along with recommendations related to the identified insufficiencies. Existing healthcare design models – This phase confirmed the need to develop a new design model because existing models, though appropriate within their contexts, are not suitable for the South African public healthcare system.
Research methodology	The selection of a qualitative approach for this study was supported by other similar research projects reported in academic literature. The research methodology was also examined and approved by the CAES HREC.
Sample selection	The insights gained from the research participants were multifaceted, i.e., insights into the technology architecture, systems, processes, reporting and strategy. These were necessary to ensure the results encompass various aspects of the public healthcare system, which was achieved through the careful selection of appropriate stakeholders within the public healthcare system.
Ethical clearance	Ethical clearance was granted by an HREC-recognised committee, CAES HREC. Further clearance was approved by the NHRD and at an individual district level. The participating hospitals also provided written consent before conducting interviews with key stakeholders.
Data collection	All participant data were collected using semi-structured interviews, an approach used in similar research projects. All interviews were conducted online using MS *Teams*. This approach proved flexible (some participants asked to reschedule) and reliable. All meeting

	recordings and transcriptions were automatically created, and no data were lost. Several participants stated they preferred online meetings due to their flexibility. Some confirmed that meeting rooms or quiet areas where meetings could be conducted in person were not easily accessible at their place of work.
Data analysis	An interpretive analysis of interview transcripts was conducted using three cycles of coding. This analysis revealed six relevant themes supported by the concepts identified during the literature review.
Research artefact	The design model and theoretical models were tested with a subset of the original participant group. Follow-up discussions with four participants highlighted one change to the design model, which subsequently led its refinement. The theoretical model remained unchanged as the four participants did not have further comments or suggestions.
Use of artificial intelligence tools	**Section 2.1.2** highlighted how AI coding was used to supplement human-centred coding during the literature review. Apart from this, no AI was used to generate any text or ideas in this research and thesis.

Source: Adapted from Carcary (2021)

Table 37 presents the intellectual audit trail adapted from Carcary (2021).

Table 37. The intellectual audit trail of this research

Item	Notes
Philosophical stance	The interpretive paradigm states that multiple realities can exist and that these realities must be interpreted. Interviewing various stakeholder groups (strategic, tactical and operational) with up to 15 different job roles provided multiple realities. These provided unique and sometimes opposing viewpoints, which uplifted the conversations with participants. The suggestions from academic literature on the philosophical stance were confirmed by the experiences of this research.
Alternatives for data collection	The use of a questionnaire was considered as a data collection instrument; however, this method was not adopted since the contribution to this research called for one-on-one interactions with the participants. Several comments and, consequently, follow-up questions could not have been contemplated using a questionnaire.
Alternatives for data analysis	The choice of the interpretivist paradigm led to the data collection strategy, which then informed the strategy for the data analysis. Content analysis using multiple coding cycles has proven effective

	in similar studies and the present study. No alternatives were considered for the data analysis.
Interpretation of evidence	The interpretation of different realities, especially between hospital and EMS staff, led to ideas that could promote various aspects, such as communication. Therefore, another data collection or analysis strategy would not have provided a sufficiently rich dataset.

Source: Adapted from Carcary (2021)

6.2 Research Rigour

Section 3.8 discussed four trustworthiness factors. The rigour of this research is categorised and described according to these factors and presented below.

Credibility:

- Environmental triangulation was considered during this research: Data were collected from four of the five health research districts in Gauteng, which ensured perspectives were obtained from multiple environments.
- Data were collected from hospitals and EMS staff. These organisations share the same goals but approach healthcare from different perspectives.
- Various stakeholder types were interviewed: Fifteen different participant role types were interviewed, which provided additional perspectives on the healthcare system.

Transferability:

- Data were collected from multiple districts and hospitals: The healthcare processes (admissions, discharges and patient transport) followed by each hospital and district differed (even if slightly), leading to multiple perspectives on these processes.

Dependability:

- Presenting this research: Parts of this research were presented at an international health informatics conference.
- Publishing parts of this research: Parts of this research were published in two peer-reviewed journal articles, one peer-reviewed book chapter and one conference proceeding (in-press) (Moonsamy & Singh, 2024e, 2024c, 2024b, 2024d).
- Academic standards: The data analysis was confirmed as meeting academic standards by a full professor and lecturer at the University of South Africa.

Confirmability:

- Reducing the contamination of data collection: All interviews were conducted online via MS *Teams*. Since no data were collected at the participants' places of work, there was a reduced possibility of data contamination.
- The use of a research audit trail: The research audit trail confirms the steps taken to ensure research rigour and confirmability.

Appendix 8.25 contains a sample interview transcript.

6.3 Originality of the Research Contribution

Alajami (2020) suggests that four criteria groups can be used to determine the originality of research, namely new facts, old facts, new ideas and old ideas. **Figure 67** represents these criteria groups as a quadrant. Research containing either or both new facts and new ideas is considered original. Therefore, quadrant four represents unoriginal research and quadrant one represents original research.

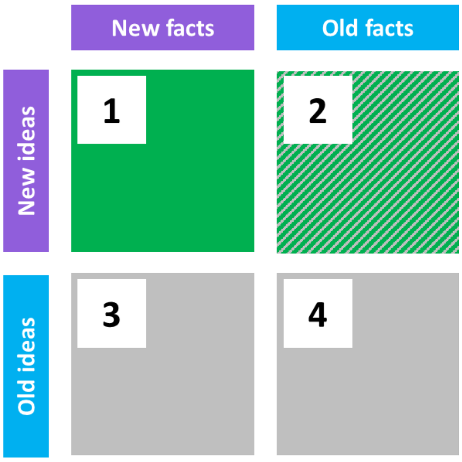


Figure 67. Research originality quadrant

The six themes identified during this research represent new facts within the context of this research and are also reflected in the theoretical model. The practical model is a new idea built on existing theory, learnings from previous models and new facts (themes). Therefore, this research fits into quadrants one and two, which suggests that this research and its contributions are original, as emphasised in **Figure 67**.

6.4 Theoretical Research Contribution

The theoretical contribution of this research, consisting of outputs, such as the theoretical conjecture and the theoretical model, were formulated while considering the management of the public healthcare system. The six themes could be utilised when implementing digital health systems for public healthcare in South Africa. The themes could be applied as a checklist or as project objectives. **Table 38** presents the theoretical uses of this research.

Table 38. Theoretical contribution of the six themes

Theme	Project objectives	Checklist
Connect – Connecting people to information	People should be able to connect to (real-time) information that they require to perform their job function. People should access the same version of the information.	Are people able to connect to the same version of the information?
Communicate – Strengthening communication among people	People should be able to communicate without delay or interruption.	Can people communicate in real-time and share the latest version of information?
Combine – Combining relevant information to support decision-making	People and systems should have access to the same version of information across all systems.	Is the version of information stored on different systems identical?
Contain – Containing security threats such that people can access information with minimal disruption	Cybersecurity threats to the digital healthcare system and information should be contained.	Are appropriate measures in place to protect systems and information?
Collaborate – Leveraging real-time information to promote collaboration among people	People should be able to leverage the benefits of digital health systems to collaborate on cases they are working on.	Are people working on a common case able to collaborate using digital health system technology?
Cooperate – Employing technology to encourage cooperation among people	Long-term cooperation can be supported by connected systems to provide real-time information. Historical data can be provided by using reports.	Can people access strategic information required for long-term cooperation?

In addition to the theoretical uses of the six themes, the relationships between them can be used in appropriate situations.

6.5 Practical Research Contribution

The outcomes of the literature review and the results of the data analysis led to the identification of six themes. These themes were used to revise the Design Model for a Live Healthcare Console version 0.1 to formulate the Design Model for a Live Healthcare Console version 0.2. Testing version 0.2 with a subset of the research participants resulted in refining the Design Model for a Live Healthcare Console version 0.2 to formulate the Design Model for a Live Healthcare Console version 1.0, which is the final model version for this research. The practical implications of research refer to the ability of the research outputs to contribute towards solving real-world problems (Elsevier, 2024). The practical model was continuously refined throughout this research to ensure that it could be contextually applied towards public healthcare system management in South Africa. Therefore, the practical model contains public healthcare system perspectives from technology experts, healthcare professionals and healthcare facility managers. This was merged with relevant technology trends (identified during the literature review) to make the model as practical and implementable as possible. Hence, the practical implication of this research is the design model, which could be used as a blueprint for designing the Live Healthcare Console for Gauteng, South Africa.

6.6 Research and Study Techniques

The following methods were effective in ensuring the information collected during this research was safely stored and backed up. Study techniques are also shared.

- Daily backups of working documents were generated. The current date was appended to the filename. If a file became corrupted, only one day's work (at most) would be lost.
- All research files were fully backed up weekly. An easy approach was to compress (zip) all files into one and upload this to the university's cloud service. Daily backups were also stored both on the cloud and locally.
- Since the *ATLAS.ti* desktop version was employed, the project file was uploaded to the *ATLAS.ti* cloud regularly. A downloaded copy of the project file was added to the weekly backup.
- All images (custom or downloaded) were stored in a single location. They were also pasted into a single designer software file such as MS *PowerPoint*. Although the file became very large as images (sometimes with multiple versions) were added, this ensured that the images could be found in one place. The image file was included in the weekly backup.
- I kept two research journals, one digital and one written, for the duration of the research project. These journals served as a reflection of my thoughts and feelings throughout the

project. They also served as motivation during difficult times and as a personal project plan.

- The Pomodoro Technique can be very effective when used correctly. During study times, I would try to limit distractions by moving my phone or other unnecessary devices out of reach.
- On days when my children wanted to be close to me while I worked on my research, I would make a fort for them (with their toys inside) under my study desk. Unfortunately, this method resulted in approximately 80% loss of research productivity.

6.7 Future Research

The following projects have been identified for future research.

- Patient transport notes were analysed by Van Straten et al. (2017) to determine whether patients visited the appropriate facilities. New research could be conducted to determine the effectiveness of patient transport when using real-time data (from the Live Healthcare Console). This would include the use of ambulance divert and hospital bed occupancy data.
- A participant mentioned that the availability of a specialist healthcare practitioner could also impact patient routing. Effectively supplementing the Live Healthcare Console dataset with the availability of specialist healthcare practitioners should be investigated.
- Real-time tracking of ambulance crews by emergency staff could be researched to determine whether this might have an impact on patient arrival preparation.
- Perspectives on change management relating to the introduction of a Live Healthcare Console into the public healthcare system should be investigated due to the potential impact on people related processes.

6.8 Reflections on the Research Process

The completion of this research required collaboration between my supervisor and I to achieve short-term objectives like compiling the interview questions. However, the long-term objectives, such as submitting ethics applications, required cooperation to ensure the task deadlines and submission dates were aligned. I documented short-term and long-term goals, together with general reflections in two research journals, discussed in **Section 6.8.1**.

6.8.1 Journal Notes

Two types of journals were kept during this research. A handwritten journal contained a task list, which was usually illegible as it would be consumed by doodling by the end of the study session. **Appendix 8.26** contains some of the informal notes. A digital journal was used to document my deeper thoughts, concerns and ideas. This journal contained 74 entries and was documented whenever I remembered to add an entry. I used a customised (self-created) rating scale to judge my level of happiness or stress during each journal entry. The ratings were also colour-coded. A standard RAG colour or Red-Amber-Green status was combined with purple for feeling inspired and blue for confusion (or feeling blue). **Table 39** presents the rating scale.

Table 39. Self-created happiness rating scale

Rating	Description	Score
Happy	Feeling happy about the progress reported.	3
Meh	Neither happy nor sad.	1
Sad	Feelings of sadness or unhappiness. Could be related to a lack of progress or processes out of my control.	-1
Inspired	Moments of extreme happiness. This could be due to the completion of a milestone task or if I came up with a new inspiring idea.	5
Confused	These were days when ideas would not convert to words or when processes, such as obtaining ethical clearance, would end in a deadlock.	0

Feelings of inspiration and sadness were regarded as outliers since they did not arise too often (frequencies deliberately not reported); therefore, they were excluded from the overall rating score. This resulted in an average score of 2.4 out of 3, which is 80%. Based on the overall rating score of 80% and other (undocumented) factors, it can be concluded that this research was an overall enjoyable experience mixed with moments of extreme inspiration and unease.

6.8.2 A Conversation Between my Supervisor and I

The following short conversation between my supervisor and I provides a glimpse into some of our interactions during this research project.

Prof Singh: *Hello Wesley!*

Wesley: *Hi Prof.*

Prof Singh: *Are you busy?*

Wesley: *Err, yes [wonders what's going on]*

Prof Singh: *I saw this call for papers.*

Wesley: *[I wonder where he is going with this]*

Prof Singh: *Wesley, are you still there?*

Wesley: *Yes, yes, I think my internet dropped for a second.*

Prof Singh: *Ok then, I'm sending you this call for papers. It's very relevant to your PhD!*

Wesley: *Ok [Wonders where's the time for this!]*

Prof Singh: *Send me a draft by the end of the week. You don't have much time, the abstract is due soon.*

Wesley: *OK. [Doesn't sleep for the rest of the week]*

6.9 Final Comments on this Research

South Africa has taken important steps towards promoting effective management within the public healthcare system. The introduction of the NHI will impact public healthcare processes. Such impacts should not be ignored, as they could potentially cause disruption. Though this research considered lessons from the past, current situations and future implications, the research itself cannot be considered to be concluded.

The limitations of this research, such as a geographic boundary (Gauteng only), and ideas for future research, such as utilising patient transfer information to optimise patient transport, have been provided so that future researchers might continue with this work.

The theoretical and practical models formulated during this research can be implemented as they are or could be further refined by future researchers to suit an ever-changing world. This view is supported by Checkland (1999):

> *Obviously the work is not finished, and can never be finished. There are no absolute positions to be reached in the attempt by men to understand the world in which they find themselves: new experience may in the future refute present conjectures. So the work itself must be regarded as an on-going system of a particular kind: A learning system which will continue to develop ideas, to test them out in practice, and to learn from the experience gained.* (Checkland, 1999)

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Appendices

8.1 Turnitin Report Summary

21% Overall Similarity

Top sources found in the following databases:

- 17% Internet database
- 10% Publications database
- Crossref database
- Crossref Posted Content database
- 10% Submitted Works database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	sajim.co.za Internet	6%
2	jhia-online.org Internet	2%
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4	uir.unisa.ac.za Internet	<1%
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6	digitalcommons.liberty.edu Internet	<1%
7	etd.uwc.ac.za Internet	<1%
8	ijssrr.com Internet	<1%

8.2 Editing Certificate

Certificate of Editing

Digital Health: A Live Healthcare Console for Public Health in Gauteng, South Africa

Doctor of Philosophy in Information Systems

Wesley Moonsamy

Edited for English language usage:

- Proofreading for mechanical errors such as spelling, punctuation, grammar.
- Copy-editing that includes commenting on, but not correcting, structure, organisation and logical flow of content, basic formatting, eliminating unnecessary repetition.
- Checking citation style is correct and punctuating as needed.
- Commenting on suspected plagiarism and missing sources.
- Returning the document with track changes for the author to accept.

I confirm that I have met the above standards of editing and professional ethical practice. The content of the work edited remains that of the student.

Lorinda Gerber
15th of May 2024

Note: I am not accountable for any changes made to this document subsequent to my edit.

Copy-Editing

Professional EDITORS Guild

+27 72 125 9475
loredit.ele80@gmail.com

8.3 CAES Full Approval

UNISA university of south africa

College of Agriculture and Environmental Sciences_Health REC

NHREC Registration # : REC-170616-051
Ref #: 2023/CAES_HREC/585
Name: Mr Wesley Moonsamy
Student #: 41179609

Date: 23/06/2023

Dear: Mr Wesley Moonsamy

Decision: Ethics Approval from 21/06/2023 to 30/06/2028
Subject to submission of yearly progress reports
Due date for first progress report: 30 June 2024

Researcher: Mr Wesley Moonsamy

Supervisor: Professor Shawren Singh

Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals

Qualification: PhD Information Systems

Thank you for the application for research ethics clearance by the College of Agriculture and Environmental Sciences_Health REC for the above mentioned research study. Ethics approval is granted for five years, subject to submission of yearly progress reports.
Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.

Due date for next progress report: 30 June 2024

The progress report form can be downloaded from the college ethics webpage:

https://www.unisa.ac.za/sites/corporate/default/Colleges/Agriculture-&-Environmental-Sciences/Research/Research-Ethics

The **low risk application** was **reviewed** by College of Agriculture and Environmental Sciences_Health REC on 21 June 2023 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College of Agriculture and Environmental Sciences_HealthREC.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

8.4 Ekurhuleni Research Committee Approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

STEVE BIKO ACADEMIC HOSPITAL

Enquiries: Dr JS Mangwane
Tel No: +2712 3452018
Fax No: +2712 354 2151
E-mail: joseph.mangwane@gauteng.gov.za

For attention: Wesley Moonsamy

NHRD Ref Number: GP_202306_007

Re: REQUEST FOR PERMISION TO CONDUCT RESEARCH AT STEVE BIKO ACADEMIC HOSPITAL

TITLE: Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals

Permission is hereby granted for the above-mentioned research to be conducted at Steve Biko Academic Hospital. This is done in accordance to the "Promotion of access to information act No 2 of 2000".

Please note that in addition to receiving approval from Hospital Research Committee, the researcher is expected to seek permission from all relevant department. Furthermore, collection of data and consent for participation remain the responsibility of the researcher.

The hospital will not incur extra cost as a result of the research being conducted within the hospital.

You are also required to submit your final report or summary of your findings and recommendations to the office of the CEO.

STATUS OF APPLICATION: Approved

Date: 2023-06-11

____

Dr. J S. Mangwane
Manager: Medical Service

8.5 Johannesburg Research Committee Approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Joburg
a world class African city

Research Committee of Johannesburg Health District

Enquiries: Prof S. Moosa |researchjoburg@gmail.com

DATE: 01 JULY 2023

ATT: Mr Wesley Moonsamy

Dear Sir

STUDY TITLE: Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals

NHRD REF. NO.: GP_202306_007

OFFICIAL APPROVAL

The District Research Committee has reviewed your application. This letter serves as a final approval letter for this study.

The following conditions must be observed:

- The facilities in which the research will be conducted are listed below
- These facilities will be visited from: 2023/07/05 to 2025/07/01
- Participants' rights and confidentiality will be maintained all the time.
- Neither the District nor the facility will incur any additional cost for this study.
- No resources (Financial, material, and human resources) from the above facilities will be used for the study.
- The study will comply with Publicly Financed Research and Development Act, 2008 (Act 51 of 2008) and its related Regulations.
- You will submit a copy (electronic and hard copy) of your final report. In addition, you will submit an annual progress report to the District Research Committee.
- If this is academic research, then your supervisor and the University will ensure that these reports are being submitted timeously to the District Research Committee.
- The district must be acknowledged in all the reports/publications generated from the research and a copy of these reports/publications must be submitted to the District Research Committee.
- You will liaise with the manager/s listed below as relevant before initiating the study.

8.6 Sedibeng Research Committee Approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Sedibeng District Health Services
Enquiries: Ms. N. Tuswa
Tel: 016 950 6255
Email: Nomonde.Tuswa@gauteng.gov.za

Mr. Wesley Moonsamy
University of South Africa (UNISA)
28 Pioneer Avenue
Florida Park, 1709

Dear Mr. Moonsamy

RE: A DESIGN MODEL FOR A HOSPITAL CAPACITY DASHBOARD (HCD) IN GAUTENG, SOUTH AFRICA

Please be informed that permission has been granted for you to carry out the above-mentioned research at Heidelberg and Kopanong District Hospitals mentioned on your request proposal. It is noted that you have already obtained Provincial Ethics Committee as well as Research Ethics Clearance from UNISA.

Kindly note that a copy of the report on the findings (especially) that concerns Sedibeng District Health Services should be submitted to the Chief Director's office at the completion of the study.

This permission is also subject to the conditions stated in the protocol and any change in design and methodology must be communicated to the Chief Director.

We wish you success in your research endeavours.

Recommended / Not recommended / Recommended as amended

Prof. OB Omole
Chairperson: Sedibeng District Research Committee
Date: 26/10/2023

Approved / Not approved / Approved as amended

Ms. M.A. Madolo
Acting Chief Director: Sedibeng District Health Services
Gauteng Health Department
Date: 01/11/2023

NHRD REF: GP_202306_007

Sedibeng DHS, Cnr Frikkie Meyer & Pasteur Blvd, Private Bag X 023, Vanderbijlpark

8.7 Tshwane Research Committee Approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr. Manei Letebele-Hartell
Tel: +27 12 451 9036
E-mail: Troy.Mashabela@gauteng.gov.za

TSHWANE RESEARCH COMMITTEE: CLEARANCE CERTIFICATE

DATE ISSUED: 07/07/2023
PROJECT NUMBER: 36/2023
NHRD REFERENCE NUMBER: GP_202306_007

TOPIC: Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals

Name of the Lead Researcher:	Mr Wesley Moonsamy
Name of the Supervisor:	Prof. Shawren Singh
Facilities:	Tshwane District Hospital
Name of the Department:	UNISA

NB: THIS OFFICE REQUEST A FULL REPORT ON THE OUTCOME OF THE RESEARCH DONE AND

NOTE THAT RESUBMISSION OF THE PROTOCOL BY RESEARCHER(S) IS REQUIRED IF THERE IS DEPARTURE FROM THE PROTOCOL PROCEDURES AS APPROVED BY THE COMMITTEE.

DECISION OF THE COMMITTEE: APPROVED

....
Dr. Manei Letebele-Hartell
Chairperson: Tshwane Research Committee

Date 07/07/2023

....
Mr. Mothomone Pitsi
Chief Director: Tshwane District Health

Date: 2023-07-17

8.8 West Rand Research Committee Approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

WEST RAND DISTRICT
FAMILY MEDICINE
Dr. E.E.WENEGIEME
Telephone: (011) 9516219
Cell: 0783993190
0674196257
wenegiemeegbert@gmail.com
Wenegieme.egbert@gauteng.gov.za

Date: 06 July 2023

PI Name and Surname: Mr. Wesley Moonsamy

NHRD REF NO: GP_202306_007

Title Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals.

Protocol: I have studied the protocol and it is well articulated. Sample size will not impact service delivery.

The location where the study will be conducted: West Rand District Health

Facilities Requirements:

1. There will not be an additional load on nursing staff, e.g. asking them to recruit patients for study
2. Support services e.g. administration staff including clerks, and reception staff will not be part of facilitating this study (IT Specialist)
3. Consumables e.g. swabs and gloves will not be used in these facilities
4. Laboratory tests will not be done in the above-mentioned facilities
5. Equipment's e.g. BP cuffs belonging to these facilities will not be used
6. Space (office space/counselling cubicles) of these facilities will not be used but the location of the interview will be negotiated according to the interviewee's preferences may be hospital offices at a time convenient for the interviewee
7. Communication e.g. announcements, and handing out leaflets will not be undertaken in these facilities (Survey Questionnaire)
8. Dates, days of the week, and times you wish to access the facilities should not be determined by the researcher without knowledge of the facilities
9. There will be no additional OPD visits for this study
10. Admission of patients will not be part of this study

Ethics: Provinsional Approval granted by HREC as provided by the researcher

Funding Source: Researcher

Take note that you will need to share your findings and recommendations with the facilities to assist with future clinical policies.

We wish you well during this project. For any additional information, feel free to contact our department.

Regards.

PP

Dr Wenegieme (DRC WRD)

8.9 EMS Research Committee Approval

GAUTENG PROVINCE

HEALTH
REPUBLIC OF SOUTH AFRICA

Mr. W Moonsamy

College of Science, Engineering and Technology, University of South Africa

31 October 2023

SUBJECT: APPLICATION TO CONDUCT RESEARCH

Dear Mr. Moonsamy

Thank you for your application requesting permission to conduct research with Gauteng EMS employees as potential participants in your study. We have reviewed your proposal "*A design model for a Hospital Capacity Dashboard (HCD) in Gauteng, South Africa*" and are happy to approve your request.

Please share your final study findings with us so that we can include it in our future decision making processes regarding the application of electronic health data.

Please note that participation by our employees in your study are voluntary. This approval letter is valid for 1 year and will expire on the 31st of October 2024. Please reapply for an extension one month before this date.

Enquiries may be directed to Mr. N Ravhandalala
Telephone : (012) 356 8054
Email : Ndotenda.Ravhandalala@gauteng.go.za

Regards

Mr. Ndotenda Ravhandalala
Principal LCOEC
Gauteng department of Health
Date: 31/10/2023

Page 1 of 1

8.10 NHRD Registration

RESEARCH PROPOSAL DETAILS:
GP_202306_007

Research Committee

GAUTENG HEALTH RESEARCH COMMITTEE

APPLICATION DETAILS

Title of Research Project

Live Healthcare Console (LHC): A design model conceptualized in Gauteng, South Africa for public hospitals

8.11 Top 10 Search Terms

Search term	Category	Number of results
information systems modelling	Information Systems	3 797 372
information systems standards	Information Systems	3 232 230
constructing a model	General	2 353 219
transport system	General	2 225 286
constructing a research model	General	1 755 101
health and technology	eHealth	1 377 879
constructing an information systems model	Information Systems	1 245 673
how to construct an information systems model	Information Systems	1 245 673
model scoring technique	General	736 378
healthcare	eHealth	703 583

8.12 Description of the Batho Pele Principles

Principle	Description
Consultation	Engaging with customers to determine their needs
Service Standards	Offering services that meet customers' expectations
Access	Ensuring that the public has access to services
Courtesy	Treating customers respectfully
Information	Ensuring that information regarding services is readily available
Openness and Transparency	Promoting honesty with customers
Redress	Rectifying customer issues
Best value	Effectively utilising resources to ensure maximum customer benefit
Customer Impact	Ensuring synergy among all other Batho Pele Principles

Source: Adapted from Department of Social Development (2022)

8.13 Evaluation Criteria Considered

Evaluation criteria	Description
Policy and objectives	Determines whether or not the objectives of the new information system have been documented and will promote supporting healthcare services. Compatibility – Will the new information system be compatible with existing systems? Information systems standards – Will the new information system conform to information systems standards.? These standards could include ISO 9241–110 (Hosseini Teshnizi et al., 2021), which refer to usability problems, including insufficient, poor and misleading information (ISO, 2020). Data collection and dissemination, including information processing – Will manual and digital information be treated as private and confidential? Security – Will information be stored safely?
Technical feasibility	This is related to the infrastructure, which comprises technical components (hardware and software) and human capital. Effectiveness – Will the new information system have the intended value? Adequacy – How many of the objectives can be achieved by utilising the available resources?
Financial viability †	What financial investment is required for the new information system, and will this investment align with the perceived benefits?
Political viability	Will the implementation of the new information system have the support of the key decision-makers?

Source: Adapted from Odhiambo-Otieno (2005)

† This criterion was excluded as the study did not incorporate any financial aspects.

8.14 Summary of the Themes and Dimensions According to the HOT-Fit Framework

Theme	Dimensions	Considerations
Technology	System quality	Is the system flexible, reliable, accurate and useful?
	Information quality	Is the information accurate, relevant and useful?
	Service quality	Is the system fast and responsive, and is there sufficient technical support?
Human	System use	How often do the users use the system, and what functions do they use? Are they trained and happy to use the system, or are they reluctant to use it?
	User satisfaction	Do the users enjoy using the system? Is it useful, and does it aid them in decision-making?
Organisation	Structure	What are the hierarchy, management, structure and communication of the organisation?

	Environment	Are there localisation, competition or inter-organisational relationships to consider?

8.15 Description of the Four Main Aims and the Related CSFs

Digital health model aim	Description	Related CSF(s)
Combine	Represents a consolidated repository of hospital occupancy data.	Interoperability
Communicate	Provides real-time data to the relevant stakeholders.	Customer acceptance, stakeholder collaboration, interoperability
Collaborate	Involves the relevant stakeholders in the design and use of the system.	Stakeholder collaboration, interoperability
Connect	Integrates into internal and external systems.	Interoperability

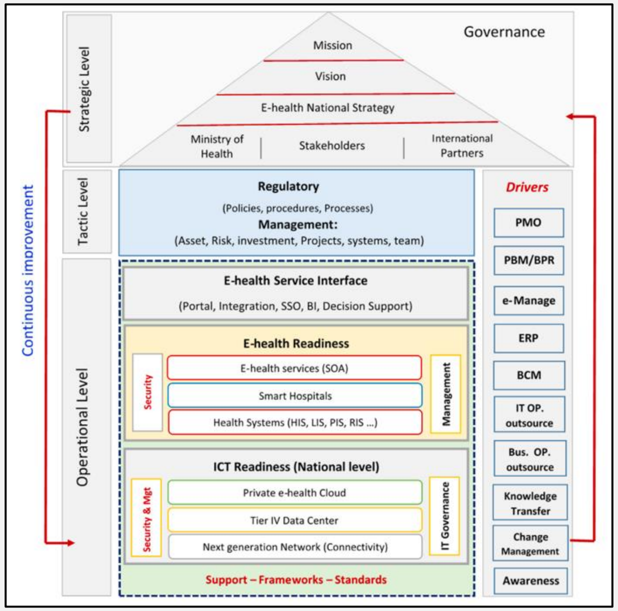
8.16 Definitions of the Evaluation Criteria Used in this Research and their Relevance to the Batho Pele Principles

Evaluation criteria	Related Batho Pele Principle	Rationale	Related digital health model aims
Adequacy	Best value	The effective and optimised use of existing resources.	Combine Communicate Collaborate Connect
Compatibility	Information	Compatibility of systems promotes the availability of accurate information.	Combine Connect
Data handling	Courtesy	Ensuring the safety and privacy of customer information encourages the respectful treatment of customers.	Combine Communicate Connect
	Openness and transparency	Honesty is a key element in treating customer information as private and confidential.	
Effectiveness	Service standards	Systems that meet customer expectations ensure their effectiveness.	Collaborate
Environment	Customer impact	Various systems might need to interact within an environment. This is made possible if there is synergy among the Batho Pele Principles.	Connect
Information quality	Service standards	The accuracy and usefulness of information are vital to ensuring that the system and information meet the customers' expectations.	Combine Communicate Connect
Information systems standards	Access	Access to services includes that of the associated information. The information itself needs to be accurate, and systems must be usable.	Collaborate
	Service standards	Having good information systems standards ensure customer expectations are met.	

	Redress	Customer issues can be dealt with by utilising effective information systems and business processes based on accepted standards.	
Security	Courtesy	Ensuring the safety of customers' information is one of the steps towards treating them respectfully.	Combine Collaborate Connect
	Information	The safe and secure storage of information promotes the availability of information.	
Service quality	Service standards	Reliable systems ensure the customer's expectations are met.	Collaborate
Structure	Consultation	The consultation principle refers to communication with customers, but in this instance, it could refer to communication between key stakeholders within an organisation.	Collaborate
System quality	Information	Useful and reliable systems ensure information is readily available.	Combine Communicate Collaborate
System use	Service standards	Systems frequently used by satisfied customers meet customer expectations.	Collaborate
User satisfaction	Customer impact	For customers to be satisfied with a system, all other principles need to collaborate.	Collaborate

8.17 Model 1 Illustration and Evaluation Scores

Model illustration	Evaluation

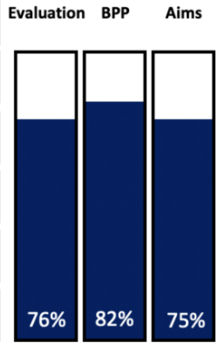


Source: (Al-Sharhan et al., 2019)

Model 1: Evaluation scores

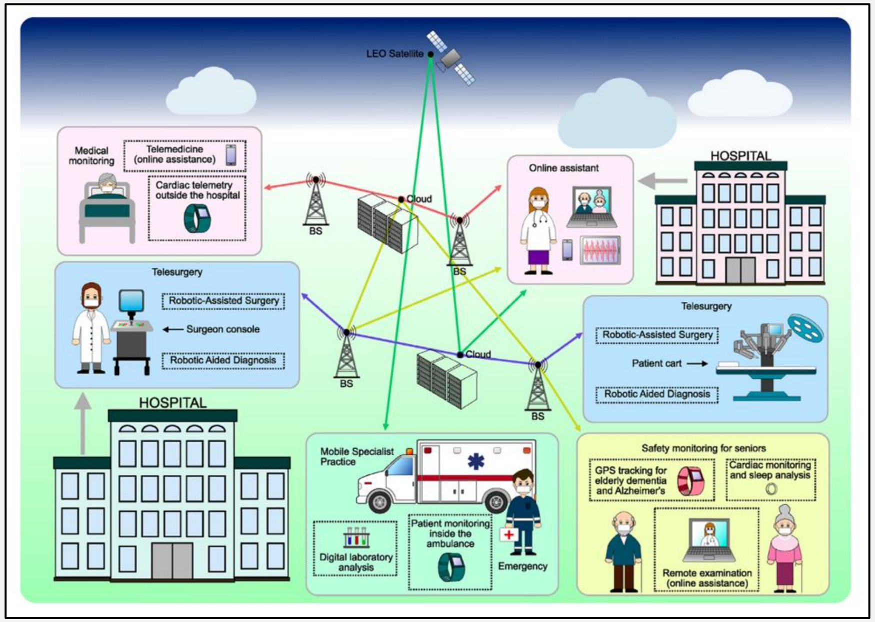
Adequacy (3/4)	Compatibility (1/2)	Data handling (2/3)	Effectiveness (1/1)
Environment (1/1)	Information quality (2/3)	Information systems standards (1/1)	Security (2/3)
Service quality (1/1)	Structure (1/1)	System quality (2/3)	System use (1/1)
User satisfaction (1/1)	**Total score: 19/25**		

BPP scores		Model aims	
Access (1/1)	Best value (3/4)	Combine	
Consultation (1/1)	Courtesy (4/6)	Communicate	
Customer impact (2/2)	Information (7/8)	Collaborate	
Openness and Transparency (2/3)	Service standards (6/7)	Connect	
Redress (1/1)	**Total score: 27/33**	Represented	Not represented



8.18 Model 2 Illustration and Evaluation Scores

Model illustration	Evaluation

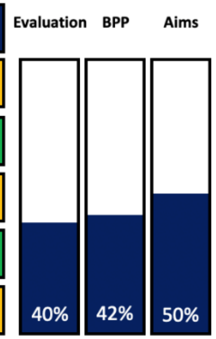


Source: (Alekseeva et al., 2022)

Model 2: Evaluation scores

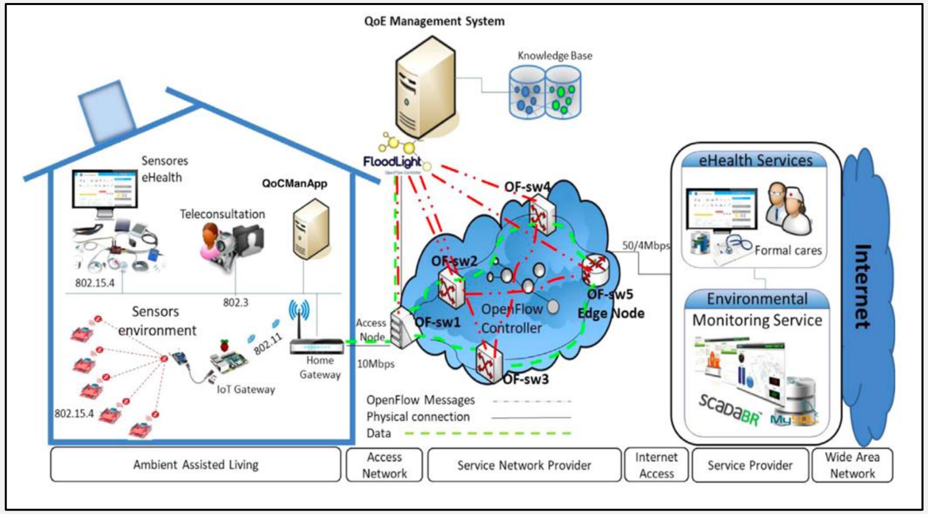
Adequacy (2/4)	Compatibility (1/2)	Data handling (2/3)	Effectiveness (0/1)
Environment (1/1)	Information quality (2/3)	Information systems standards (0/1)	Security (1/3)
Service quality (0/1)	Structure (0/1)	System quality (1/3)	System use (0/1)
User satisfaction (0/1)	Total score: 10/25		

BPP scores		Model aims
Access (0/1)	Best value (2/4)	Combine
Consultation (0/1)	Courtesy (3/6)	Communicate
Customer impact (1/2)	Information (4/8)	Collaborate
Openness and Transparency (2/3)	Service standards (2/7)	Connect
Redress (0/1)	**Total score: 14/33**	Represented / Not represented



8.19 Model 3 Illustration and Evaluation Scores

Model illustration	Evaluation



Source: (Da Silva et al., 2019)

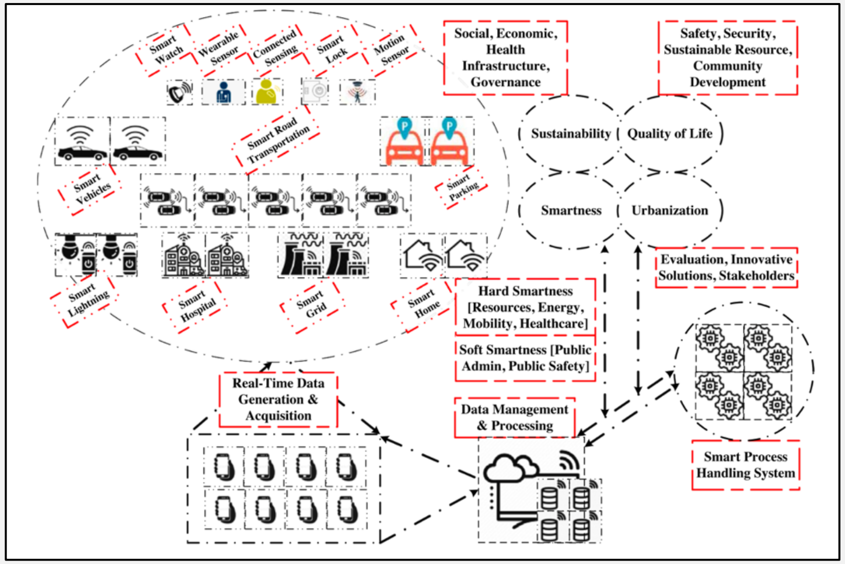
Model 3: Evaluation scores			
Adequacy (3/4)	Compatibility (1/2)	Data handling (2/3)	Effectiveness (1/1)
Environment (1/1)	Information quality (2/3)	Information systems standards (1/1)	Security (2/3)
Service quality (1/1)	Structure (1/1)	System quality (2/3)	System use (1/1)
User satisfaction (1/1)	Total score: 19/25		

BPP scores		Model aims
Access (1/1)	Best value (3/4)	Combine
Consultation (1/1)	Courtesy (4/6)	Communicate
Customer impact (2/2)	Information (7/8)	Collaborate
Openness and Transparency (2/3)	Service standards (6/7)	Connect
Redress (1/1)	**Total score: 27/33**	Represented / Not represented

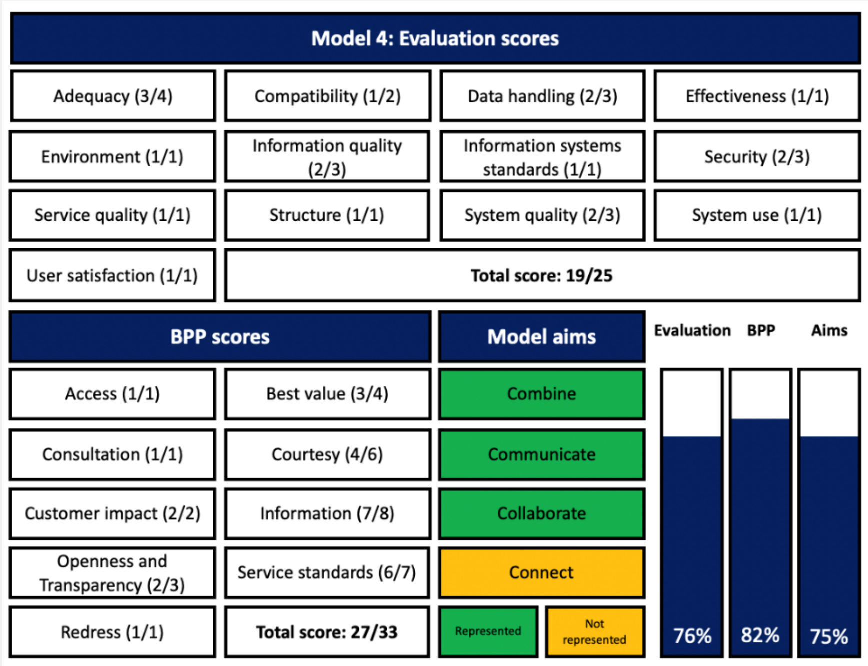
Evaluation	BPP	Aims
76%	82%	75%

8.20 Model 4 Illustration and Evaluation Scores

Model illustration	Evaluation

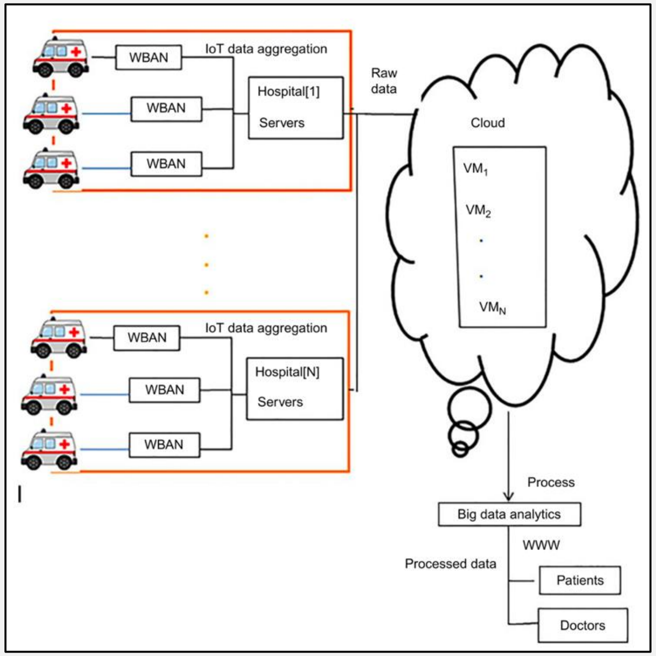


Source: (Deebak et al., 2022)



8.21 Model 5 Illustration and Evaluation Scores

Model illustration	Evaluation



Source: (Dumka & Sah, 2019)

Model 5: Evaluation scores

Adequacy (3/4)	Compatibility (1/2)	Data handling (2/3)	Effectiveness (1/1)
Environment (0/1)	Information quality (2/3)	Information systems standards (1/1)	Security (2/3)
Service quality (1/1)	Structure (1/1)	System quality (3/3)	System use (1/1)
User satisfaction (1/1)	**Total score: 19/25**		

BPP scores		Model aims
Access (1/1)	Best value (3/4)	Combine
Consultation (1/1)	Courtesy (4/6)	Communicate
Customer impact (1/2)	Information (8/8)	Collaborate
Openness and Transparency (2/3)	Service standards (6/7)	Connect
Redress (1/1)	**Total score: 27/33**	Represented / Not represented

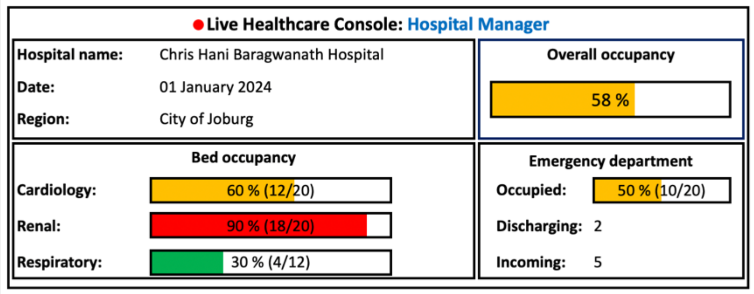
Evaluation	BPP	Aims
76%	82%	75%

8.22 Detailed Model Evaluation Calculation

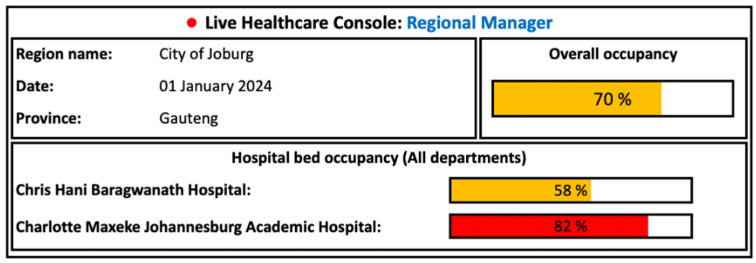
Evaluation criteria	Aims of the model	Model 1	Model 2	Model 3	Model 4	Model 5
Adequacy	Centralised repository	0	0	0	1	1
	Real-time information	1	1	1	1	1
	Stakeholders	1	0	1	1	1
	Integrate	1	1	1	0	0
Compatibility	Centralised repository	0	0	0	1	1
	Integrate	1	1	1	0	0
Data handling	Centralised repository	0	0	0	1	1
	Real-time information	1	1	1	1	1
	Integrate	1	1	1	0	0
Effectiveness	Stakeholders	1	0	1	1	1
Environment	Integrate	1	1	1	0	0
Information quality	Centralised repository	0	0	0	1	1
	Real-time information	1	1	1	1	1
	Integrate	1	1	1	0	0
Information systems standards	Stakeholders	1	0	1	1	1
Security	Centralised repository	0	0	0	1	1
	Stakeholders	1	0	1	1	1
	Integrate	1	1	1	0	0
Service quality	Stakeholders	1	0	1	1	1
Structure	Stakeholders	1	0	1	1	1
System quality	Centralised repository	0	0	0	1	1
	Real-time information	1	1	1	1	1
	Stakeholders	1	0	1	1	1
System use	Stakeholders	1	0	1	1	1
User satisfaction	Stakeholders	1	0	1	1	1
Total		19	10	19	19	19

8.23 Example Views of a Live Healthcare Console

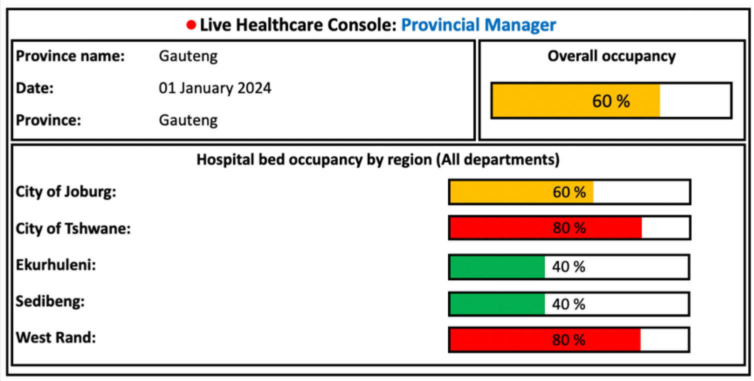
Example view	Description



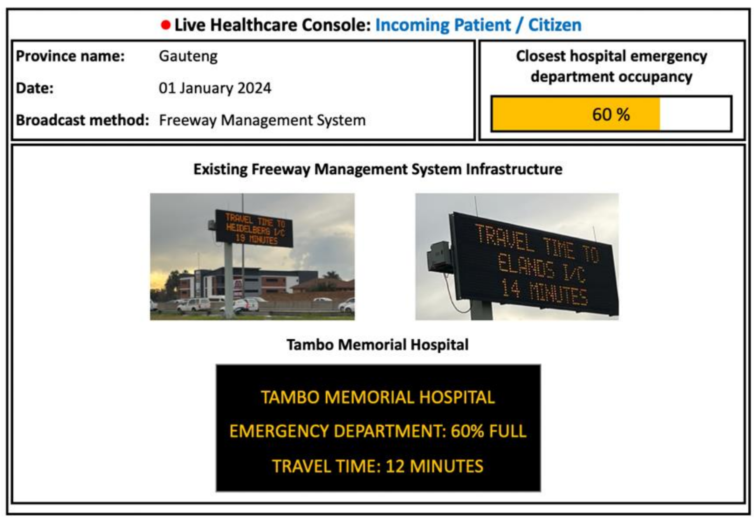
The Hospital Manager view shows the overall bed occupancy of each department. The emergency department could include incoming and discharging patients.



The Regional Manager view shows the higher-level of bed occupancy information for hospitals grouped by the current region. A regional manager should have the ability to delve further into a more detailed hospital view.



The Provincial Manager view shows a higher-level of bed occupancy information for the regions grouped by the province. A provincial manager should have the ability to navigate to a more detailed regional and hospital view.



Incoming patients or citizens could have information broadcasted to them via existing or new platforms. The major highways in Gauteng utilise a Freeway Management System (FMS), a network of digital signboards displaying real-time information (Bester, 2009). This could be extended to include the bed occupancy of nearby hospitals.

8.24 Informed Consent Letter

PARTICIPANT INFORMATION SHEET

UNISA REF:	2023/CAES_HREC/585
NHREC REGISTRATION:	REC-170616-051
STATUS:	Fully Approved by UNISA – College of Agriculture and Environmental Sciences (CAES)

Title: Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals

Dear Prospective Participant

My name is Mr Wesley Moonsamy and I am doing research with Professor Shawren Singh a Professor in the Department of Information Systems towards a PhD in Information Systems at the University of South Africa. We are inviting you to participate in a study entitled "Live Healthcare Console (LHC): A design model conceptualised in Gauteng, South Africa for public hospitals".

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information related to digital health systems that could contribute towards a design model used to make hospital capacity information available in real time to key stakeholders such as yourself. The aim of a real time system is to provide managers with accurate information so that they can make more informed decisions regarding the incoming and transferring of patients. This promotes the streamlining of processes ensuring the optimal use of critical resources. Patients and paramedics will also have the ability to make more informed decisions.

WHY AM I BEING INVITED TO PARTICIPATE?

Your contact details (including name, surname, contact number and email address) were obtained in one of the following ways:

1. Information that is available on the public domain such as Department of Health and related websites and reports.
2. From the Department of Health
3. Via "snowball sampling" such as via a colleague or other relevant stakeholders

The position you hold provides key and unique perspectives on how digital health systems and processes benefit patients and citizens. During this study, I aim to interview a minimum of 40 participants with roles that are similar or related to yours in terms of hospital capacity. The study is limited to the Gauteng province and only includes public hospitals. At your specific facility, it is intended to interview approximately 3 participants. They can be from different stakeholder groups.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

This study involves a one on one semi-structured interview. The questions are related to your perspectives on digital health systems and data currently being used in your line of work. Your viewpoints on hospital capacity, scheduling of incoming and outgoing patients, patient transfers and the temporary closure of departments will also be discussed. It is expected that the interview will last 45 to 60 minutes. This time could be longer if you have further insights to share on the topic. The interview could take less time if you do not have further information to share or you are uncertain about certain processes. Following the first interview, you have the option to participate in an optional, shorter follow-up interview to discuss the information systems model that has been created as part of this research.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Your participation in this study is voluntary and there is no penalty or loss of benefit for non-participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form before the interview or after (in exceptional circumstances). Once the interview has concluded, it will not be possible to withdraw from the study due to the anonymity of the participants and the meeting recordings which have been made. Your role will not be asked during the interview, but your role might be revealed during the discussion based on your responses or further questions that arise. If at any point you want to withdraw during the interview, you may do so. Due to technical issues during online interviews, it might be possible that our connection is interrupted. An attempt will be made to reconnect but if this is not possible and sufficient information has been gathered during the interview, the interview will be deemed as concluded. In that case, the interview will be saved and you will no longer be able to withdraw from the study.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The aims of this study relate to utilising real time hospital capacity information. Individuals like yourself and those who perform a similar job function within your organisation could benefit from the implementation of a system that utilizes real time hospital information. Your role could be directly enriched by the results of this study and its future implications. In general terms, patients, citizens and the broader healthcare system can also benefit. It is intended to create a model that is generic enough to be used in other African countries due to their similarities with South Africa. Your participation in this study can have a positive impact on patients in need of help in Gauteng, the rest of South Africa and possibly globally. There will also be a contribution to the scientific community who can use the insights from this research to make other advances in Science and Technology.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

Your participation in this study is intended to have little to no negative impact to you. If the interview is conducted during your working hours and at your workplace, it might limit the amount of time you have for your work. If the interview is conducted during your lunchbreak, this would reduce your resting time. If you are unable to participate in the interview in this manner, an online interview can be conducted. This would be during your work or personal time. You will also require the necessary data or airtime to access the meeting. You will not receive any compensation for your airtime or data.

Depending on the information you share during the interview, it might be possible that you reveal information that is of a sensitive nature. Though it is not intended to ask questions that could lead to such information or cases being discussed, there is a possibility that this occurs. Based on your answers and position, it might also be possible for your position and consequently your identity to be linked to the response.

If during the interview, you feel that you have revealed information that is of a sensitive nature, you may withdraw from the interview and the recording will be not be used in the study. Efforts will be made by me to ensure that this type of scenario does not occur.

Due to the nature of cloud computing, the interview will be stored on the cloud and my devices (including but not limited to laptop and mobile phone).

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorder anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Your answers will be given a code number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee where applicable. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

The data collected in this interview will be used in a PhD thesis but will also be used in related journal articles, conferences or other material. In these publications, it will be mentioned that participants are anonymous. Efforts will be made to ensure your anonymity, but it is impossible to guarantee this.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of the notes taken during the interview will be stored at the researcher's residence in a locked cupboard for a period of five years for future research or academic purposes; electronic information will be stored on a password protected computer or cloud account. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Once the five-year period has elapsed, the hard copies will be shredded and discarded and electronic data will be deleted from the computer and cloud.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not receive any payments, incentives or compensation for your participation in this study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Mr Wesley Moonsamy on 41179609@mylife.unisa.ac.za. The findings are accessible in this manner for 12 months.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mr Wesley Moonsamy on the contact details above.

Should you have concerns about the way in which the research has been conducted, you may contact Professor Shawren Singh on 011 471 2721 or singhs@unisa.ac.za. Contact the research ethics chairperson of the CAES Health Research Ethics Committee, Prof MA Antwi on 011-670-9391 or antwima@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Mr Wesley Moonsamy

CONSENT TO PARTICIPATE IN THIS STUDY

I, ____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time (during the interview) without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interview and optional follow-up interview (where applicable).

I have received a signed copy of the informed consent agreement.

Participant Name & Surname………………………………………………………… (please print)

Participant Signature……………………………………………Date…………………………

Researcher's Name & Surname……………………………………………………… (please print)

Researcher's signature…………………………………………Date…………………………

8.25 Interview Transcript

Interviewer:

The recording has started, so before we get in straight into the interview, this is just a few notes that I want to make. Hello and thank you for your time and willingness to participate in my research. Please note that this interview is being recorded and will later be transcribed by software into text for analysis. My name is Wesley Moonsamy, a PHD student from the University of South Africa. My research is entitled Live Healthcare Console, a design model conceptualised in Gauteng, South Africa for public hospitals. Before we start with the interview, I want to make note of a few points. There is a participant information sheet that you may sign and send back to me. Alternatively, you may confirm your willingness to participate in this research verbally. Would you like to give me verbal or written consent? Would you like to sign the document and send it back to me or would you like to confirm verbally?

Interviewee:

I'll confirm now verbal please.

Interviewer:

OK, so do you consent to participating in this research?

Interviewee:

Oh, OK.

Interviewer:

This is an anonymous interview, so try not to mention your name, surname, place of work or position. For example, try not to say as the CEO of the hospital or as the head of Information Technology Department statements such as these might compromise your identity. With this in mind, I will try not to refer to you by your name or your title. This research involves healthcare information relating to the operation of the hospital. It specifically targets emergency care and hospital bed occupancy. If a question falls outside the scope of your role at the healthcare facility. Please advise me so that I can adjust the question and we can continue all right. So given this background we can now start.

Interviewee:

Oh, OK.

Interviewer:

Alright, so in your day-to-day function at the healthcare facility, what systems do you use? Do you capture information on any systems?

Interviewee:

Yes, we capture information on HIS system.

Interviewer:

Is that SAP HIS?

Interviewee:

Sorry, it's abbreviation, it's health information system.

Interviewer:

OK, So what information do you capture on the system?

Interviewee:

OK. We capture our patient information that we get from the patient. So what we need from the patient, we need the ID book, we need the payslip. If the patient is working, we need the municipality bill that state the address where the patient stays. We also need if let's say the patient is not working, we need the UIF letter that state, maybe the patient is no longer working if he or she was working. And yeah, if the patient, it's the baby from zero to six years, we need the birth certificate. And yeah, that's the information that we get from the patient. Or if the patient, or if the patient is not a South African, we request the passport or the Asylum.

Interviewer:

OK, so when you capture this information. Where about in the hospital? Are you capturing this information? Where do you sit?

Interviewee:

Where I'm based like right now I'm in the ward. I'm in medical B ward. So I use the computer there to capture the information.

Interviewer:

OK. And that computer that you use, is it dedicated to you or do others also use it?

Interviewee:

It's all of us.

Interviewer:

OK, but when you use.

Interviewee:

It's for doctors and nurses, yes.

Interviewer:

OK. And when you log in, when you work on HIS, you've got your own username and password.

Interviewee:

Yes.

Interviewer:

OK, so you captured this information and then the patient is admitted. What happens when the patient is discharged?

Interviewee:

Patient is discharged, will request we actually check in the file the TPH3 if it's signed by the doctors and we also look for the discharge summary that is written by the doctor also that confirms that the patient is being discharged then that's when we discharge the patient.

Interviewer:

So what's the process that you follow when you discharge the patient?

Interviewee:

The process is that I start logging in and then I go to discharge because already the patient is admitted and on my discharge they only need if the patient is discharged. With discharged summary or the patient was refused the treatment of the hospital or the patient maybe passed away. If it is death or if the patient absconded, then yeah, that's when we discharge the patient.

Interviewer:

OK, before we get into that, then I also wanna ask you, what is the process when you transfer a patient out or transfer a patient in?

Interviewee:

I click on the transfer out so using the transfer we have the internal transfer and the external transfer. If let's say the patient is in medical B and then I'm transferring the patient to the psych ward I go to transfer and then I choose the ward the patient is going to and then he is in the Doctor who's actually transferring the patient.

Interviewer:

So my research focuses on digital health systems and what we're trying to do is we're trying to figure out how to make certain pieces of information available to the right stakeholders. So for example, if you take the hospital bed capacity, you know you've got a certain number of patients that can be admitted into a ward. And we're trying to determine who needs to have access to that information and how we can get how people can get access to it so. When you are admitting a patient, how do you know whether there's an available bed for that patient?

Interviewee:

OK, because we also do the ward rounds. If they there's a bed in the ward because we also have the board on the notice board we write the patient there and then in my system whenever I discharge the patient then I have the space for the patient then I click on the bed utilisation. If the patient is sleeping in room I'll see it there it appears. As green lights. And if there's no beds, it's just red. But if there's an empty bed, that's when I can see there. There's a green dot there.

Interviewer:

So tell me about the TPH21. You use that document?

Interviewee:

Yes, we do, but it's for the nurses, actually. When they admit the patient, they write the patient's name and surname and the sign name they write the file number of the patient, the age of the patient and whenever their patient is being discharged, the nurses they write the time and the date when the patient is being discharged is not us. The only thing that we do as ward clerks, we just check if they did the right thing they noted down that the patient left. Or the patient still in the ward. Basically they update information every morning.

Interviewer:

OK. And I want to understand a little bit more about, let's just say the data that is captured. So how often do you log into HIS and do something, how often does that happen?

Interviewee:

Basically, every day, every now and then, like whenever the patient maybe comes in, we do log in and then we admit the patient every morning. Actually, most of the time it's every morning when we come in, we check if we had the activations because we're not working night, we check if we have the admissions, the new admissions in the ward, that's when we log in and then we admit those patients that were admitted over the night and. We also check the discharges. If we had the discharges over the night or maybe in the afternoon when we left because we knock off at 4.

Interviewer:

Can it ever happen that the ward is full? You mentioned all the lights are red on the system. What do you do then?

Interviewee:

Is there that the ward is full? They don't bring the patient at all. They wait for us to tell them if the there's a bed in the ward because remember the patients that in casualties, so casualties they call us to check if there's a bed in the ward and then if there's a bed that's when they can transfer the patient. If there's no bed the patient wait, or they can transfer the patient to other wards.

Interviewer:

OK. And what happens in a case where the hospital, as you've said, now maybe it's full or certain departments are full and they create a divert, do you know about the divert process?

Interviewee:

Maybe you mean to say if they transfer the patient to other hospital for in case if we don't have beds at all here. Hmm.

Interviewer:

So not really transfer more case of before the EMS can even get to you. They receive a message to say don't go to that hospital because they're currently full and they are on divert. Does that ever happen?

Interviewee:

I'm not quite sure, I'm not quite sure about it.

Interviewer:

That's fine, because that's that seems to be more on the emergency side of things, OK.

Interviewee:

Yes, yes, it happen, yes.

Interviewer:

OK, so in your line of work now, apart from you doing the admissions and the discharges and the transfers, do you also have to do any kind of reporting?

Interviewee:

Any kind of reporting, yes.

Interviewer:

So what kind of reports do you have to create?

Interviewee:

OK. We also do stock. Oh, we also do the stock we actually order stock in the ward and we check around what we need every day. So we also make sure that we collect the supervisor in the ward that this is what we need today or the supervisor also remind us as the ward clerk what we have to do for the day. We also report the maintenance remember in the ward there's sometimes the lights are not on. Is dark in the toilets. I think that something happened on the ceiling. Everything that it's, it's a maintenance in their ward, we report that every morning we are. We are also assisted by the cleaners like people are cleaners, nurses. They check around the ward and they tell us as what's next to what, to report each and every morning.

Interviewer:

So then from, let's just say a patient perspective, if someone had to ask you how many patients are there in a particular ward without you physically checking, where would you go to see this information?

Interviewee:

Come again?

Interviewer:

So if I had to say to you how many patients are there in maternity ward, right, let's, let's just assume you work at maternity ward, but without you going to see the ward. If I said to you go on to the system and look, where would you go for that?

Interviewee:

OK, I'll go to the head count. Remember each and every day without the patient, we check on the head count. We have a list of head count whereby we write the patient on that list, and we also check on the hand over or how many patient they have on that time. Yes.

Interviewer:

But is that if? Is that like a form, a physical document? And is it like a whiteboard as well?

Interviewee:

Yes, it's like the whiteboard we write on the whiteboard and also in the book.

Interviewer:

But it's not a digital system. OK so.

Interviewee:

I'm not sure if on digital we don't really check. We are used to maybe manual. I'm not sure, so maybe we are, maybe we ignore that on the system, but I think I saw something like that on HIS.

Interviewer:

OK. But then let me ask you, when you're saying that you're used to the manual system, so how accurate is the manual system? Does it work well for you?

Interviewee:

It does, but not all the time, because remember, there's also human error whereby maybe they the nurses, they don't add the patient, but you can pick it up, that there's a patient who's missing here, and then who's that. And then we correct it so.

Interviewer:

How many ward clerks are there in a particular ward?

Interviewee:

Each and every ward we have one ward clerk.

Interviewer:

And is it a shift or do you work only in the day?

Interviewee:

It's day shift only.

Interviewer:

OK, so at night, is it possible for a patient to be admitted?

Interviewee:

Yes, it's possible for the patient to be admitted, remember they'll admit the patient manually on the admission book and also on the TPH21. Then when we come in the morning we checked in the admission book, if we have the new admissions and we also check on the TPH21, if there's a that patient is been added on that approval.

Interviewer:

In that case, would you say that? Between the night and the day, can they be a delay in the information so a patient comes in, you know, you put the stuff down physically, but on the system. So you're saying that they can be a delayed.

Interviewee:

There can be a delay. Yes, because sometimes, like, maybe they had pressure. Maybe they admitted more patients. So sometimes we find out that they didn't admit the last night patient and of which they will. That the day shift will admit that patient who came over the night. And they'll also tell us that this patient we have the new patient and then that's when we capture digitally

Interviewer:

Does the ward clerk work Monday to Friday or is it weekends as well?

Interviewee:

It's Monday to Friday only.

Interviewer:

OK, Monday to Friday. OK. So in the weekend, then, let's just say Friday night, a patient gets admitted. So then a ward clerk would only be able to capture that on the system on Monday morning?

Interviewee:

Yes, that's how we work. Unless sometimes, sometime maybe if the casualty collects that the ones who are supposed to admit those patients. But our casualty, the way they work like the ward clerks, I mean the clerks who are working in casualties they are at the back. So sometimes nurses they don't refer those patients to the to the casualty. So we find out that they are patient who haven't been admitted over the weekend. But sometime if they refer the patient before they come to the ward, then we find out that they are admitted. But most of the time the patient are not admitted on time over the weekend.

Interviewer:

OK, that makes sense. Now in terms of this TPH21 document right now once you said the nurses normally fill that in, you do your part by filling information in on the system and do you know what happens to that information after you are done with it, who uses that information? You know, why you fill the information on those forms?

Interviewee:

Yes.

Interviewer:

And why do you have to capture it on the system?

Interviewee:

Yes, after each and every morning we tear that yellow page, TPH21, of which it goes to the HIS. They captured that information. That's when we submitted that Yellow Pages. Now every morning. And yeah, I think.

Interviewer:

OK, want to ask you a question more related to the management of the hospital as well as the district, right. Do you know what an MMO is?

Interviewee:

MMO have no idea. Not sure.

Interviewer:

There's a person that is responsible for certain pieces of information is called a managing medical officer, and this person is responsible for diverts and for things like that. So let's just say at district level, a person needs to make some kind of decisions, right about information. Now you capture important information because you basically discharging a patient and making a bed available.

Interviewee:

Yes, yes.

Interviewer:

So do you think it's necessary for people at district level or CEO level to have a view of how many available beds, how many open and how many closed beds there are? Do you think it's important for someone on that level to know about this?

Interviewee:

Yes, it is important. It is important because they will know the bed utilisation in their wards and they'll know the steps that the states, how many patients we are actually having each and every day. Because most of the time like my what we utilise 32 beds. So they will be able to see if the ward is full or is not they will know so that they can also know how when to stop. Maybe if there's a need to stop the patient to come to our hospital if it's full. I think it's very important for them to know that that information.

Interviewer:

OK. So you're saying that they can make decisions based on this information?

Interviewee:

Yes.

Interviewer:

What about patients? Do you think patients should have access to certain pieces of information? Maybe they don't need to know exactly how many patients can be admitted into a ward. But you know, if the patient has an idea that, you know, we are 90% full, do you think that information is important to a patient?

Interviewee:

Yes, I think it is so that maybe the patient can also make the decision if they can go to the other hospitals, maybe they know that those are true for themselves, not for us to decide for them. So and also to know that they will have to wait if they have to wait in casualties. Because remember in the hospital we don't return anyone home, we will just make sure that we accommodate you in that room. But it's not a ward. You'll just wait until we have a space. We need to give that information to the patient.

Interviewer:

OK, so the even the patient can make decisions.

Interviewee:

Yes, they can make decisions by themselves if they will wait or they can go to their nearest hospitals.

Interviewer:

OK. Do you think that something like that can give the patient some kind of empowerment, do you think the patient feels like they are in charge of their health?

Interviewee:

Yes, I think they'll feel more important as individual to say, oh, at least now I know, I know why I'm waiting. Wherever I'm waiting or I'll know what to do or what can I do. Maybe they'll get advice from maybe their partners if they're if those if the patient is married or if the patient is under 18. If the patient's got the parents assistance. I think so.

Interviewer:

Do you think anyone else should have access to this type of information?

Interviewee:

Yes, anyone else, as long as they would like to know that information, we can give to the patient to anyone else is.

Interviewer:

So often you know it's difficult for people to find information within the hospital, are there any TV screens or charts or anything that shares information with patients and with family?

Interviewee:

Yes, we do. We do have we do have charts, but not all the departments now whereby they can see on the screen what is happening. But some of the like Psych ward, they have touch screens.

So in my what we don't like we had before but I don't know what's happening now with that screens. Yeah.

Interviewer:

OK, that's fine. Well, OK, I think I've asked you all the questions I wanted to ask you. Do you maybe have any questions or comments for me?

Interviewee:

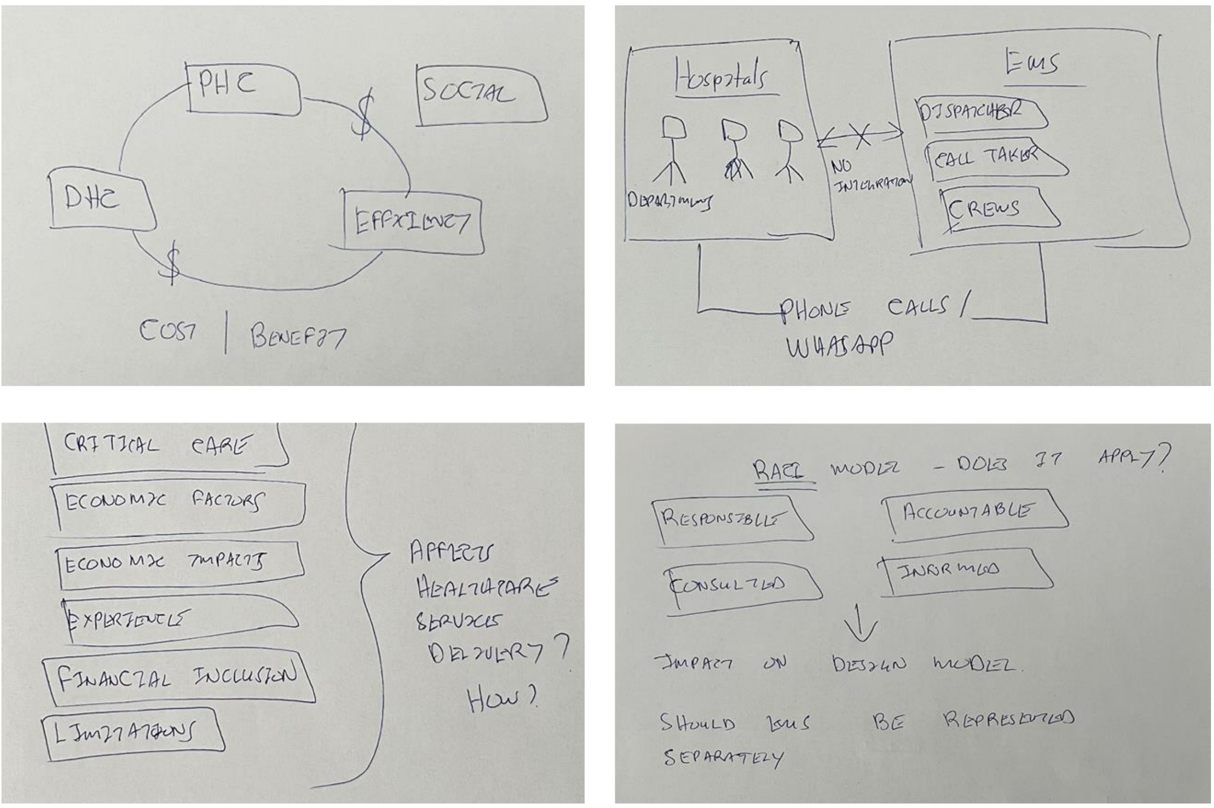
I'd like to thank you for the opportunity. This was a great time that I had with you and I think I've learnt a lot and I'll do a research about some of the questions that maybe I wasn't aware that I'm behind with. Yeah. So I think some of the things maybe I wasn't aware, I'll just make a research about them so that maybe I have more knowledge about the everything that is happening in the hospital especially that are capturing.

Interviewer:

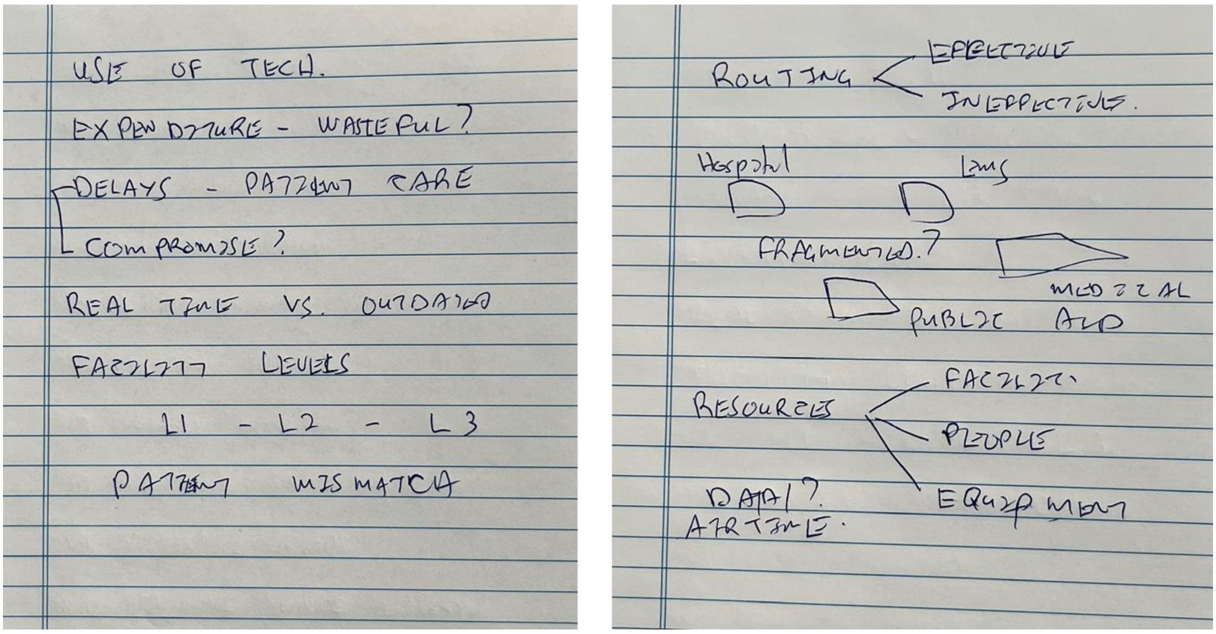
OK. Well, thank you very much for your time. I really appreciate your time as well. Can you just stay on the line for a moment? I'm going to stop the recording now.

8.26 Informal Notes

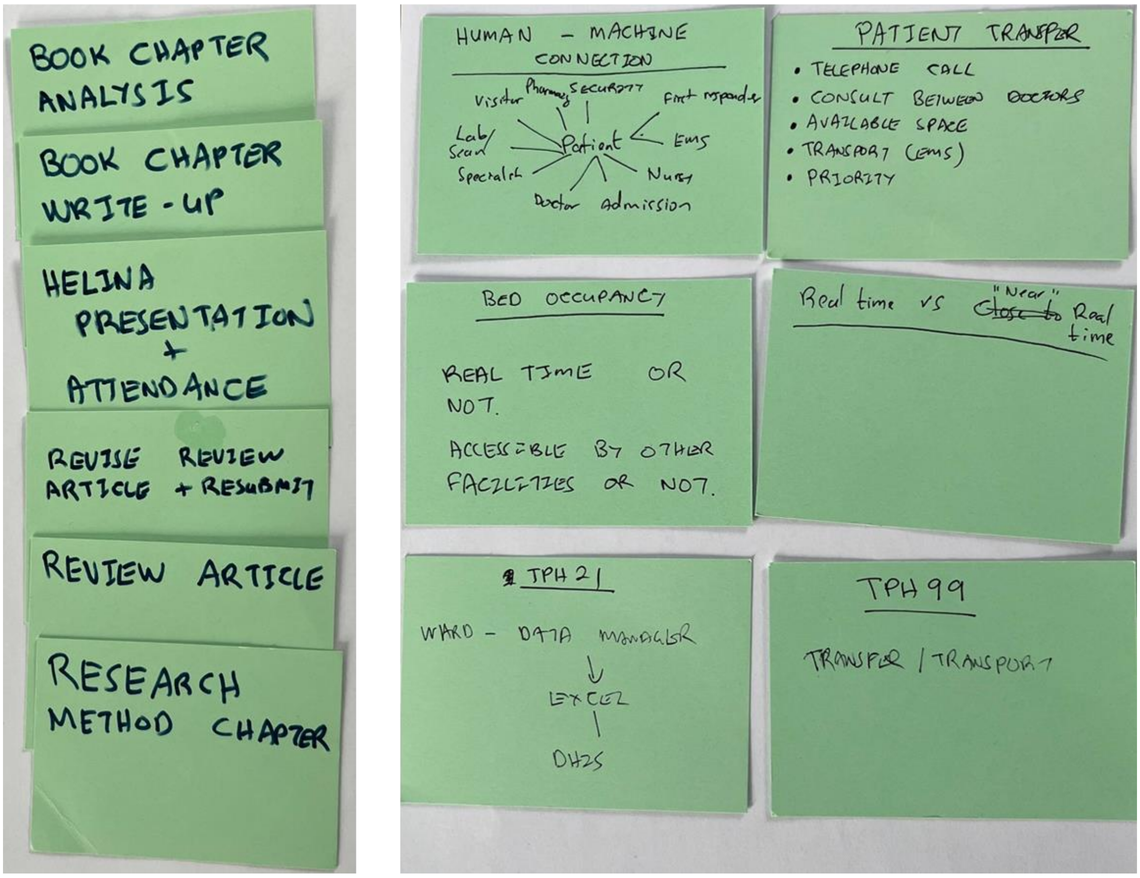
General notes on systems, themes and the development of the design model



Notes referring to the identification of networks and themes



Notes for keeping track of to-do items as well as associations between ideas discussed during interviews



Notes made during interviews