HEALTH INFORMATION SYSTEMS INTEROPERABILITY

Towards a Managing as Designing Approach

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I dedicate this book to my gracious and beloved mum Mary Salome, my beloved husband John Ronald, my cherished late sister Gloria, my treasured children Celeste, Louis, Tezra and Franklyn.

"The knowledge of "Where am I going?" comes during the process of implementation and dedication to the task"
- Sunday Adelaja

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ABSTRACT

Integrated digital healthcare systems promise improved quality public healthcare and patient continued care among others. However, these have been hampered by various challenges including limited data exchanges between health information systems (HIS) and inadequate collaboration among healthcare centers and healthcare professionals. The devastating healthcare interoperability state has been made evident by the COVID-19 global pandemic data sharing challenges. Nonetheless, such challenges can be overcome through collaborative digital healthcare initiatives that aim at integrating digital healthcare systems. Hitherto, a number of HIS are designed with no collective vision of sharing and exchanging information, and again, there is limited knowledge about the HIS interoperability implementation process.

To enhance HIS interoperability implementation, previous scholars have reiterated the salience of context and managerial capabilities in the design process. Against this backdrop, the overall purpose of the thesis is to elucidate how health information systems (HIS) interoperability implementation can be enhanced through contextual understanding and managing as designing (MaD) perspectives. Using an interpretive case study approach, two cases of HIS implementation have been studied, one in Sweden and the other in Uganda. The empirical investigation shows that the combined perspectives contribute to our understanding of HIS interoperability implementation, through the proposed MaD approach to IS interoperability implementation. In addition, the contextual understanding perspective led to the discovery of four critical factors and two guiding principles. The critical factors include having a collective interoperability design goal, managing the interoperability implementation process, analysing the context of interaction and determining an appropriate interoperability principle. The discovered two principles; include the minimum requirements principle and the informatics focus vs technology focus principle, these can guide implementers to delineate a context-appropriate interoperability solution.

The theoretical contribution consists of a new stance on how HIS interoperability implementation can be enhanced through embracing a MaD perspective. Thus, the proposed approach emphasizes a design atti-

tude that supports implementers to take into consideration the context of interaction; which includes information systems as well as actors working together. The approach seeks to motivate healthcare managers to collaborate with HIS designers to improve healthcare interoperability. Again, through the design attitude implementers can analyse the context of interaction and appropriate an interoperability solution during moments of sense-making and decision-making. The proposal of a design attitude is intended to inspire implementers into a more reflective problem-solving attitude as opposed to relying on a rational decision-making model. Taken together, the thesis contributes knowledge on how IS interoperability implementation can be enhanced through contextual understanding and managing as designing perspectives not only in healthcare but also in similar complex contexts.

Keywords: Health Information Systems (HIS), Managing as Designing (MaD), Interoperability Implementation, Contextual Understanding, Context of Interaction

LIST OF PAPERS

This thesis is based on the following papers, which are referred to in the text by the corresponding Roman numerals.

I. Kobusinge, G., Mugwanya, R., Pessi, K., & Koutsikouri, D. (2018, November). The (Missing?) Role of Health Information Systems (HIS) in Patient Care Coordination and Continuity (PCCC): The Case of Uganda. *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 275. Springer, Cham.*

II. Kobusinge, G., Pessi, K., Koutskouri, D., & Mugwanya, R. (2018). An Implementation Process of Interoperability: A Case-Study of Health Information Systems (HIS). (*ISD2018 Proceedings*). Lund, Sweden: Lund University.

III. Kobusinge, G. (2020). Contextual Factors influencing the Design and Management of Health Information Systems Interoperability. *In Proceedings of the 9th International Conference on Information Technology Convergence and Services (ITCSE 2020).*

IV. Kobusinge, G. (2020, January). Putting Interoperability on Health-information-systems' Implementation Agenda. *In Proceedings of the 53rd Hawaii International Conference on System Sciences.*

V. Kobusinge, G. (2020). Managing as Designing: Transforming Digital Healthcare Interoperability. *AMCIS 2020 Proceedings. 2.*

CONTENTS

PART 2 - THE PAPERS

Part 1

HEALTH INFORMATION SYSTEMS INTEROPERABILITY

Towards a Managing as Designing Approach

CHAPTER 1
INTRODUCTION

1.1 Research Motivation

This thesis tackles the enduring topic of information systems interoperability. Interoperability remains a major challenge to organisations in need of exchanging information within and across boundaries (Agostinho & Jardim-Goncalves, 2009; Hjort-Madsen, 2006; Mead, 2006). This challenge is attributed to data incompatibilities between different information systems (Abukwaik, Taibi, & Rombach, 2014; Agostinho & Jardim-Goncalves, 2009). To this end, many organisations are concerned with integration of their applications (Chakravorty, Jha, Barthwal, & Chakraborty, 2020; Hjort-Madsen, 2006; Lam, 2005). However, these efforts are not collaborative enough to achieve overall interoperability objectives; this is especially true for the emerging digital healthcare sector (Dixon, Rahurkar, & Apathy, 2020).

Within the healthcare sector, the interoperability challenge has been portrayed by the absence of a coherent patient medical record at the point

of care (Rexhepi, Åhlfeldt, & Persson, 2015) as illustrated by this quote (Zakaria and Meyerson 2009 cited in (Kohli & Tan, 2016, p.553).

> Last week, a 62 year old woman, whom we will call Mrs. B, came into our office complaining of shortness of breath. She also mentioned a history of severe hypertension, coronary artery disease and dialysis-dependent kidney failure. We discovered that she had been admitted several times in the past year to five different area hospitals. Beyond these bare facts, we had no other information. We had no reliable details of her recent testing, treatment or medications. Also, she could not recall the names or dosages of her sixteen pills, and she knew that she was severely allergic to a certain heart medicine, but she couldn't remember its name, either. We were understandably reluctant to prescribe new medications or therapies without obtaining her recent records.

The above story inspired this PhD study and the ensuing investigation into health information systems (HIS) interoperability implementation. Since inception, the information systems discipline, is concerned with how information systems can be well aligned to the organizations' strategy in order to boost performance and achieve business goals (Arvidsson, Holmström, & Lyytinen, 2014; Bush, Lederer, Li, Palmisano, & Rao, 2009; Luftman, Kempaiah, & Nash, 2008). Again, to enhance health information systems (HIS) interoperability, Kohli and Tan (2016) call on researchers in the information systems discipline to offer integration solutions to medical practitioners, "by guiding the design, implementation and evaluation of interoperable health information systems." Coming from the information systems discipline I was motivated to pursue research on the implementation of interoperable HIS and how they can be aligned to overall healthcare interoperability objectives in order to promote quality, coordinated and continued care.

More than ever before the interoperability challenge has been made evident by the COVID-19 global health crisis. This surging pandemic has highlighted the urgent need of implementing interoperable digital health technologies to facilitate health information sharing throughout the continuum of care (O'Reilly-Shah et al., 2020). Greene, McClintock, and Durant (2021) provide a good narrative of how COVID-19 has exposed

the current silos status of health institutions, and laboratories, and they conclude by calling on proponents to bring interoperability at the fore front in order to promote seamless data exchanges. Moreover, Greene et al. (2021) allude to interoperability as having an enormous role to the overall public good.

1.2 Background and Problem Area

A number of patients seek care and treatment at multiple healthcare sites (Dixon et al., 2020). Availability and accessibility of a coherent patient record can effectively facilitate ongoing treatment within the continuum of care and can promote patient care coordination and continuity (PCCC) across healthcare facilities (Kohli & Tan, 2016). Lack of PCCC on the other hand, can delay current treatments in search of patient medical histories (Jeong, Han, & You, 2016; Kohli & Tan, 2016), or lead to uninformed treatment that can have diverse critical effects on the patient's health (Christodoulakis, Asgarian, & Easterbrook, 2016). However, until now a number of healthcare practitioners still face challenges of accessing a patient's full medical record at the point of care due to existence of several HIS that cannot share data within and across facility boundaries (Adebesin, Kotzé, Van Greunen, & Foster, 2013; Dixon, 2016). Jeong et al. (2016) contend that for HIS to effectively gather and disseminate relevant health information across providers, they ought to be interconnected and interoperable. Health information systems are interoperable if they are capable of working together within and across organizational boundaries to advance the effective delivery of patient healthcare (HIMSS, 2013).

Though several interoperability approaches including frameworks, models, strategies, technologies and standards have been proposed, it still presents implementation challenges (Benson & Grieve, 2021). It is worrisome to note that; until now, a number of HIS are designed with no collective vision of sharing and exchanging information (Kouroubali & Katehakis, 2019). Several systems are developed in isolation based on local proprietary models (Kouroubali & Katehakis, 2019) and local assumptions (Cardoso et al., 2014), and thus end up as vertical silos and non-interoperable (Bygstad, Hanseth, & Le, 2015; Lehne, Sass, Essenwanger, Schepers, & Thun, 2019). Sometimes systems are designed in an ad-hoc

manner to simply address single program interventions (Kim, Farmer, & Porter, 2013). Yet again, several attempts to design for interoperability within healthcare have ended up in failure (Benson, 2010; Kierkegaard, 2015), and many of them even go unnoticed (Heeks, 2006). Specifically, there is a considerable lack of empirical interoperability implementation knowledge across the healthcare context (Hellman, 2009; Weber & Kuziemsky, 2019). Extant literature addresses vertical HIS implementation (Abbott, Foster, de Fatima Marin, & Dykes, 2014; Adenuga, Kekwaletswe, & Coleman, 2015; Bygstad et al., 2015; Heeks, 2006) but is limited on HIS interoperability-focused implementation (Heavin, 2017; Naudet & Chen, 2012).

The tenacious challenge of interoperability has been made evident by the current COVID-19 pandemic, whereby the global healthcare system has been faced with an emergency and urgent need of providing real time health information. Yet, the available health information systems could not provide seamless real-time health information required for immediate global action due to lack of interoperability (Guinez-Molinos, Andrade, Negrete, Vidal, & Rios, 2021). In their own words, Guinez-Molinos et al. (2021, p.13) note that:

> The involved systems lacked an interoperability strategy to address the pandemic.

Thus, to achieve meaningful advances in people's health through the provision of new technologies, Heavin (2017) calls for a more integrated and holistic approach to HIS implementation. In consequence, current healthcare efforts are towards implementing interoperable health information systems (Chakravorty et al., 2020), though this is quite challenging within the complex healthcare context (Kouroubali & Katehakis, 2019; Oyeyemi & Scott, 2018). However, with the current demands on sharing and exchanging health data, healthcare interoperability is no longer an option but rather an ever increasing requirement (Cardoso et al., 2014).

To tackle the healthcare complexity and interoperability implementation challenges, scholars call for explorative case study empirical investigations of interoperability implementation solutions, challenges and opportunities (Abukwaik et al., 2014; Kenny, O'Connor, Eze, & Heavin,

2017). They believe that such empirical studies could aid understanding of the healthcare context (Cho, Mathiassen, & Nilsson, 2008), and converging of all contextual factors that are critical to HIS interoperability implementation (Bouamrane, Tao, & Sarkar, 2015; Kouroubali & Katehakis, 2019). The discovered contextual factors or best practices could be convened into interoperability development methodologies (Hammami, Bellaaj, & Kacem, 2014), or step-by-step procedures that can guide enterprises to determine appropriate interoperability solutions that are unique to their needs (Daclin, Chen, & Vallespir, 2016), and to their local contexts (Kouroubali & Katehakis, 2019). Notably, understanding the context of interaction and critical factors enables implementers to determine an appropriate interoperability principle (Hugoson, Magoulas, & Pessi, 2008; Solotruk & Krištofič, 1980), and, this is more beneficial when done at the various levels of interoperability.

To thoroughly examine the healthcare context in regards to the various levels of interoperability requires concerted efforts from a number of stakeholders (Kouroubali & Katehakis, 2019). According to Benson and Grieve (2021), efforts are required at various levels including but not limited to clinical, technical, managerial, economic and political. Scholars mention the need to advance beyond technical considerations and incorporate more managerial capabilities (Benson & Grieve, 2021; Yaraghi, 2015) and political aspects (Wainwright & Waring, 2015). Moreover, the need to incorporate managerial capabilities is further emphasized by Mondorf and Wimmer (2017) who mention that interoperability projects should have effective managers who are able to manage several converging factors for a successful implementation. This is echoed by Urbach et al. (2019), who encourage joint collaborations between the information technology and business departments for successful joint innovations. Specifically in the healthcare sector, Hjort-Madsen (2006) encourages HIS designers to collaborate with healthcare managers in order to achieve overall healthcare interoperability objectives. According to Boland and Collopy (2004), agents who combine managing and designing are said to embrace a managing as designing - MaD approach. This is an approach that emphasizes management and designing in solving human problems through a design attitude (Boland & Collopy, 2004).

In line with this, Rauffet, Da Cunha, and Bernard (2009) in their study about organizational interoperability, note the potential of 'context analysis' and 'designing and managing' approaches in turning heterogeneous organizational systems into interoperable systems. Again, Pettigrew (2012) and Pettigrew (1985) recommend the application of both contextualist and management approaches for successful transformational interventions. Therefore, this thesis argues for contextual understanding (Hugoson et al., 2008; Kouroubali & Katehakis, 2019) and for managing as designing perspectives (Boland & Collopy, 2004) to enhance future health information systems interoperability implementation.

1.3 Research Aim and Question

The aim of the thesis is to develop knowledge on how HIS interoperability implementation can be enhanced through contextual understanding and managing as designing perspectives; in line with this I address the following research question:

How can health information systems interoperability implementation be enhanced?

The above question is addressed through a qualitative empirical investigation of interoperability implementation practices in two different healthcare settings: one located in Sweden and the other in Uganda. Through the discoveries in the five appended papers, the thesis contributes to extant research on information systems interoperability implementation with a particular focus on healthcare.

The contribution of this thesis is the development of a MaD approach to IS interoperability implementation that seeks to enhance organizations' capability to implement interoperable information systems through *contextual understanding* and *managing as designing* perspectives. As such, the approach seeks to encourage collaboration between managers and system designers to adopt a design attitude that employs sense-making and decision-making perspectives. To the healthcare practitioners, the proposed approach seeks to support healthcare managers and HIS designers in adopting a holistic approach to healthcare interoperability implementa-

tion; by 1) setting a shared interoperability design goal, 2) analyzing the context of interaction to appropriate an interoperability principle and, 3) to jointly manage and design for overall healthcare interoperability.

1.4 Thesis Structure

This thesis comprises a comprehensive summary of the thesis and the five research papers involved and discussed. It is structured as follows. Chapter 2 details prior research on information systems interoperability. In Chapter 3, I present the theoretical concepts and perspectives supporting the thesis. Chapter 4 provides an overview of the research process and methods applied in the investigation. In Chapter 5, I briefly describe the included papers underpinning the thesis, while Chapter 6 synthesizes the main empirical findings and resulting approach that answers the overarching research question. Finally, I discuss the implications of this research, outline the main theoretical and practical contributions, alongside limitations and future research opportunities in Chapter 7.

CHAPTER 2

INFORMATION SYSTEMS INTEROPERABILITY

This chapter describes established research areas in interoperability based on a review of contemporary research. The chapter briefly discusses interoperability definitions, barriers and levels, frameworks and models, strategies and principles, technologies and standards, and interoperability implementation within healthcare. In conclusion, research issues that call for more research are discussed and how this thesis is positioned towards these issues.

2.1 Defining Interoperability

The term interoperability is a multidimensional concept that can be viewed from various perspectives (Benson & Grieve, 2021; Kuziemsky & Weber-Jahnke, 2009; Lamine et al., 2017). While there are several definitions of the term 'interoperability' (Diallo, Herencia-Zapana, Padilla, & Tolk, 2011; Soares & Amaral, 2011), some of them offer a limited focus (Tu, Zacharewicz, & Chen, 2016). According to Öhlund (2017), the

description of the concept varies depending on the sector and the application area. However, the diversity in definitions presents a challenge when it comes to designing for interoperability, as the definition guiding the implementation highly influences the outcome (achieved interoperability) (Gibbons et al., 2007; Öhlund, 2017). For this reason, this thesis relates to the IEEE, EIF, and the HIMSS definitions.

The IEEE definition.

> The ability of two or more systems or components to exchange information and to use the information that has been exchanged (IEEE, 1990).

This is the earliest and widely cited definition, it mainly focuses on information and communication systems. A broader definition of interoperability should involve more than just information and communication systems. In a broader perspective, interoperability among information and communication systems is a means to the end of enabling organizations, governments, regions, or even national states to interact with each other more efficiently and effectively. The IEEE definition offers a relatively narrow view of interoperability, the thesis seeks to consider broader definitions such as the EIF definition, and the HIMSS that is more specific to the healthcare context.

The European Interoperability Framework (EIF) definition.

> The ability of organizations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organizations, through the business processes they support, by means of the exchange of data between their ICT systems. (European Union, 2017, p.5).

The European Interoperability Framework (EIF) offers a broader definition of interoperability and it emphasizes the organizations' ability to interact. Taking on such a definition would promote interoperability implementation at its various levels.

One of the most important areas for interoperability is healthcare. A more specific definition of interoperability in healthcare is provided by

HIMSS (The Healthcare Information and Management Systems Society). HIMSS is a global advisor, thought leader and member association committed to transforming the health ecosystem. Their definition is concerned more with effective delivery of healthcare services across organizational boundaries.

> Interoperability means the ability of health information systems to work together within and across organizational boundaries in order to advance the health status of, and the effective delivery of healthcare for, individuals and communities (HIMSS, 2013, p.75).

As the interoperability field expanded over the years, broader definitions were introduced. Upon a thorough examination of several definitions, Soares and Amaral (2011) note that the use of the term is associated with situations where two or more separately developed heterogeneous entities that operate in an independent way, become able to operate together to achieve common overall objectives, while maintaining their independence. This implies that the systems or entities intending to interoperate must possess the interoperability potential or capabilities. According to Chen, Doumeingts, and Vernadat (2008) and Kanewske (2002) clear prescription of common prerequisite capabilities that must be inherent to all participating entities can lead to interoperability assurance. Therefore, through mutual collaborations at the organizational and legal levels, participating entities can ably meet technical and semantic interoperability requirements. In this case, participating (healthcare) entities can mutually propose interoperability prerequisites that can bring about desired and predictable overall healthcare interoperability benefits, just as emphasized in the HMISS interoperability definition.

Consideration of a broader interoperability definition can encourage organizations to have a thorough analysis of the context of interaction at the various levels of interoperability in order to prescribe interoperability prerequisites required to design for information systems interoperability.

2.2 Interoperability Barriers and Levels

A special area of research in interoperability focuses on obstacles and barriers at various levels that make it difficult for organizations to achieve good interoperability (Leal, Guédria, & Panetto, 2019). According to Chen and Daclin (2006) such barriers are experienced at the conceptual, technical and organizational levels. *Conceptual barriers* entail syntactic and semantic incompatibilities of information to be exchanged. *Technological barriers* are due to incompatibilities of heterogeneous communication devices and technologies. *Organizational barriers* relate to human problems like incompatible organizational structure, processes and management techniques (Chen & Daclin, 2006). Over the years, research on interoperability barriers and obstacles has influenced the definition of different interoperability levels as; semantic, technical and organizational (Lamine et al., 2017; Rezaei, Chiew, Lee, & Aliee, 2014). However, the European Union added the legal dimension that is concerned with legislation matters of the data to be exchanged (European Commission, 2011). Such a dimension is particularly important for sectors where the exchange of information is a sensitive issue, such as the healthcare sector.

Consequently, to overcome major interoperability barriers, interoperability is sought at technical, semantic, organizational (Chen & Daclin, 2006) and legal levels (European Commission, 2011; European Union, 2017). *Technical interoperability* ensures that information exchange is possible (Diallo et al., 2011), it covers applications and infrastructures that must link systems and services (European Union, 2017). *Semantic interoperability* ensures precise format and meaning of exchanged data, i.e. 'what is sent is what is understood' (European Commission, 2011; European Union, 2017). It can be achieved by agreeing on the meaning and structure of information, by either enumerating all possible statements or through a harmonization process (Diallo et al., 2011). *Organizational interoperability* concerns the capability of organizations to effectively communicate and transfer meaningful data (Rezaei et al., 2014). It also concerns alignment and coordination of processes, and expectations between organizations in order to achieve commonly agreed and mutually beneficial goals (European Commission, 2011; European Union, 2017). *Legal interoperability* refers to aligned legislation so that exchanged data is accorded proper legal

weight (European Commission, 2011). Taken together, the four levels of interoperability could ensure that the information is correctly exchanged, interpreted, and used between different systems among the participating entities. According to Hammami et al. (2014) and Leal et al. (2019) interoperability is not a one time achievement, it can be improved continuously with time at different levels. Addressing interoperability at its various levels can lead to an enhanced state of interoperability.

Apart from the mentioned four levels, extant literature presents a number of various aspects about interoperability, which include interoperability issues (Koussouris, Lampathaki, Mouzakitis, Charalabidis, & Psarras, 2011; Rezaei et al., 2014), interoperability forms such as syntactic, pragmatic, conceptual and dynamic (Yu, Mockus, & DeLaurentis, 2010), and operational, informational and static interoperability (Nilsson, 2019) and many other aspects. The existence of such several terms attributed to interoperability depicts its complexity (Delgado, Calegari, González, Montarnal, & Bénaben, 2020; Zeinali, Asosheh, & Setareh, 2016). However, this thesis is based on the EIF's four levels of interoperability; the organizational, the semantic, the technical and the legal. These four levels are based on barriers and obstacles that make it difficult to implement information systems interoperability. Investigating them is essential in understanding how health information systems interoperability implementation can be enhanced.

2.3 Interoperability Frameworks and Models

Another area of interoperability research focuses on frameworks and models. Extant literature presents a number of interoperability frameworks (Chen et al., 2008; Jardim-Goncalves, Grilo, Agostinho, Lampathaki, & Charalabidis, 2013) and interoperability models (Guédria, Naudet, & Chen, 2011; Van Staden & Mbale, 2012).

According to eHealth Network (2015, p. 6) an interoperability framework is:

> An agreed approach to interoperability for organizations that wish to work together towards the joint delivery of public services. Within its scope of applicability, it specifies a set of common elements such as vocabulary, concepts, principles, policies, guidelines, recommendations, standards, specifications and practices.

Examples of interoperability frameworks include the European Interoperability Framework (European Union, 2017), refined eHealth European interoperability framework for healthcare (eHealth Network, 2015), enterprise interoperability framework (Chen & Daclin, 2006), IDEAS interoperability framework (IDEAS, 2003), and ATHENA interoperability framework -AIF (ATHENA, 2003) (Chen & Daclin, 2006) and many more. The European interoperability framework and the refined eHealth European interoperability framework focus on the technical, semantic, organizational and legal interoperability levels. These European Union frameworks specify a common set of elements for implementing interoperability within European commission and its member states (eHealth Network, 2015).

The enterprise interoperability framework greatly summarizes the previous works as it was inspired by IDEAS and ATHENA frameworks. It focuses on interoperability barriers, interoperability concerns, interoperability approaches and interoperability dimensions (Chen & Daclin, 2006). Interoperability barriers were inspired by the European Interoperability Framework (EIF), they cover the technical, conceptual and organizational interoperability levels. The interoperability concerns include data, service, process and business, these were inspired by the ATHENA framework, and then interoperability approaches are the three interoperability strategies; integrated, unified, and federated as adopted by ISO (ISO 14258, 1999) (Chen & Daclin, 2006). For an extended overview on interoperability frameworks see (Jardim-Goncalves et al., 2013; Kalogirou & Charalabidis, 2019).

On the other hand, interoperability models are mainly for evaluation purposes, they allow analysis of the degree of interoperability and how it can be improved (Rezaei et al., 2014). According to Clark and Jones (1999), maturity models describe the stages through which systems, processes or organizations progress as they are defined, implemented and

improved. Examples of interoperability models include Levels of Information Systems Interoperability (LISI) developed by C4ISR, Organizational Interoperability Maturity Model – C2 developed by Clark and Jones, and Levels of Conceptual Interoperability Model (LCIM) (Tolk & Muguira, 2003), and the Government Interoperability Model Matrix (GIMM) (Van Staden & Mbale, 2012). Though there are several models, many are inspired by the LISI model, whereby they define five very similar levels of increasing interoperability from isolated/independent, to unified/harmonized. For a detailed systematic review of interoperability models see (Rezaei et al., 2014; Van Staden & Mbale, 2012).

In sum, interoperability models provide precise assumptions about a limited set of parameters (Rezaei et al., 2014; Van Staden & Mbale, 2012) and frameworks specify a set of general common elements for participating entities (eHealth Network, 2015). According to Mondorf and Wimmer (2017), the contents of interoperability frameworks and models are usually too generic to fully support interoperability development and deployment, as they do not reflect the how and why. In consequence, more practical interoperability implementation approaches, strategies and solutions are needed (Jardim-Goncalves et al., 2013).

2.4 Interoperability Strategies and Principles

There is some research on interoperability strategies and principles, although the previously mentioned areas have dominated historically. Research on interoperability strategies and principles aims to improve our knowledge of how interoperability can be designed and enhanced. An interoperability strategy is any form of a communication link between entities intending to interoperate (Solotruk & Krištofič, 1980). The three main interoperability strategies; *interlinking*, *intersection* and *unification* were originally introduced by Solotruk and Krištofič (1980) and were adopted by (ISO 14258, 1999) as federated, integrated, and unified interoperability approaches (Chen & Daclin, 2006). These were later on discussed by Hugoson et al. (2008) as interoperability principles, and are henceforth referred to as *interoperability principles* in this thesis.

The integrated/intersection principle imposes a standard format on all systems involved, the goal is to create a common shared information space

(Hugoson et al., 2008). Under the unified/unification principle, systems lose their original independence (Solotruk & Krištofič, 1980) because a common meta-level structure is imposed across participating models, this is made possible through 'one common systems' principle or 'replication' principle (Hugoson et al., 2008). In a federated/interlinking principle meta-models are not predetermined, they are dynamically accommodated on demand (Chen & Daclin, 2006; Panetto & Cecil, 2013). This occurs without substantial interference of the independence of the participating systems (Solotruk & Krištofič, 1980) and interaction is mainly through messaging (Hugoson et al., 2008).

An interoperability principle is not an end in itself, it is a strategy that employs other modern interoperability technologies such as standards, architectures and information infrastructures. In their proposed enterprise interoperability framework Chen and Daclin (2006) refer to an 'interoperability-principle' as a way through which interoperability barriers can be removed, and that; it is a 'user-defined' dimension depending on 'context' and the 'need' for interoperability. Recent researchers like Guo, Liu, and Nault (2019) mention that the interoperability approach can consist of collective interoperability decisions by concerned entities. Further, Chen and Daclin (2006) posit that the interoperability solutions (principle) ought to be identified in regards to interoperability concerns, barriers, objectives, and the context of interaction. This signifies that designing for information systems interoperability is contextual as emphasized by Solotruk and Krištofič (1980) and Hugoson et al. (2008) who recommend thorough examination of the context of interaction as a way to determine an appropriate interoperability principle. Consequently, a thorough examination of the context of interaction at the various levels of interoperability could guide implementers to compose, select and align an appropriate interoperability principle, to aid in designing for information systems interoperability (Daclin, Chen, et al., 2016). Therefore, depending on the interoperability needs and the context of interaction a unified, intersection, interlinked or a user-defined principle can be adopted for interoperability implementation (Chen & Daclin, 2006).

Further, in efforts to promote seamless services and data flow for European public administrations, the European Union in their European Interoperability Framework, suggest 12 principles that are intended to establish

general behaviours to interoperability actions. These; include subsidiarity and proportionality, openness, transparency, reusability, technological neutrality and portability, user-centricity, inclusion and accessibility, security and privacy, multilingualism, administrative simplification, preservation of information and assessment of effectiveness and efficiency (European Union, 2017).

2.5 Interoperability Technologies and Standards

A large area of research, but also for the field of practice, is about interoperability technologies and standards. Among the first data exchange technologies that enabled organizations to share and exchange data was the Electronic Data Interchange – EDI (Iacovou, Benbasat, & Dexter, 1995). Other technologies include standards (Lewis, Morris, Simanta, & Wrage, 2008; Sansone & Rocca-Serra, 2017; Weichhart & Egyed, 2018), architectural solutions (Kosanke, 2006; Ray & Jones, 2006) such as service oriented or enterprise architectures (Chen et al., 2008; de Corbiere & Rowe, 2013; Weichhart & Egyed, 2018), information infrastructures (Hanseth, Lyytinen, & organizations, 2004; Monteiro, Pollock, Hanseth, & Williams, 2013; Racherla & Mandviwalla, 2013), cloud computing solutions (Battleson, West, Kim, Ramesh, & Robinson, 2016), APIs (Weichhart & Egyed, 2018), internet of things (Kumari, Tanwar, Tyagi, Kumar, & Engineering, 2018), block chain technologies (Hardjono, Lipton, & Pentland, 2019; Pilkington, 2016; Yaga, Mell, Roby, & Scarfone, 2019) and many others. These, can for example be enabled through ontologies, mediators, wrappers, middleware (Abukwaik et al., 2014) and web-services (Nilsson, 2019; Perumal, Sannasi, Selvi, & Arputharaj, 2021) among others. However, to enable an integration several interoperability technologies embed standards (Lewis, 2013; Pahl, Zhang, & Fowley, 2013).

Standards are agreed-upon conventions for doing something, which are established by a community or an authority. They permit the underlying exchange and sharing of information between different systems (Sansone & Rocca-Serra, 2017). They define common elements, such as representations of data, user/system interfaces, protocols for the exchange of data, and interfaces accessing data or system functions (Kasunic, 2001). Standards ensure semantic interoperability of the information exchanged

between different systems (Zhao et al., 2018). Standardization ensures that information is understood and interpreted consistently across various contexts (Silsand & Ellingsen, 2016), though the challenge is usually in the implementation of consistent standards across board (Bates & Samal, 2018), given a wide variety of standards (Batra, Sachdeva, Mukherjee, & technology, 2015; Oemig & Snelick, 2016). This led into alternative standardization strategies such as information infrastructures and architectural solutions that are supported by well-working multi-level organizations (Silsand & Ellingsen, 2016).

Architectures are important in system engineering to show the system components, their relationships to one another and to the environment, and the principles guiding their design and evolution (Hilliard, 2000). According to Pessi, Hugoson, Magoulas, and Hadzic (2014) architectural principles express how the 'enterprise needs to design and deploy information systems across the enterprise to connect, share and structure information.' Architectural solutions provide an underlying architecture for interoperability between participating systems (Hugoson, Magoulas, & Pessi, 2010; Kasunic, 2001). They enable information to be shared across multiple systems (Mzeru, Officer, & Mwendo, 2017; Ross, Weill, & Robertson, 2006) through the use of standards (Desai, Sheth, & Anantharam, 2015). Ray and Jones (2006) mention that early efforts to develop interoperability focused on system architectures, and one such effort resulted into the Open Systems Architecture for CIM (CIMOSA). On the other hand (information) infrastructures are shared, evolving, heterogeneous installed base of IT capabilities based on open and standardized interfaces or protocols (Hanseth et al., 2004; Monteiro et al., 2013), which constitute a shared community of interoperation between systems or organizations (Constantinides, Henfridsson, & Parker, 2018; Öhlund, 2017).

There are a number of modern techologies including cloud computing and blockchain technologies that are supported by the underlying architectural and infrastructure capabilities. Cloud computing technologies enable integration of fragmented systems (Manya, Nielsen, & Pundo, 2016), by providing on-demand or real-time access to shared information or resources (Battleson et al., 2016; Mell & Grance, 2011). Cloud computing technologies can easily move data from one cloud provider to another (Lewis, 2013). To promote interoperability cloud computing

must implement universal standards (Pahl et al., 2013). On the other hand, blockchain technologies offer distributed online ledgers (Pilkington, 2016; Yaga et al., 2019). Scholars believe that using blockchain could increase interoperability while maintaining privacy and security of data (Dagher, Mohler, Milojkovic, & Marella, 2018; Vazirani, O'Donoghue, Brindley, & Meinert, 2019). For instance, within healthcare blockchain could be used to manage electronic health records efficiently (Narayana, Gopi, & Chaitanya, 2019; Vazirani et al., 2019). Hence, the ever-evolving modern technologies could potentially enhance information systems interoperability if they are well governed and managed within a community of common interests, as pointed out by Ajer, Hustad, Vassilakopoulou, and Olsen (2021) that enterprise-wide architectures need strong leadership.

2.6 Implementing Interoperability within Healthcare

Healthcare is a large area of application with a focus on interoperability, which is also reflected in research. This section presents some of the research about interoperability within Healthcare. The benefits of healthcare interoperability cannot be underestimated as they range from overall quality healthcare, continued and integrated patient care, collaboration between different healthcare environments (eHealth Network, 2015; Oyeyemi & Scott, 2018), cost-effectiveness (Soares & Amaral, 2011), information sharing, mutually beneficial and agreed upon common goals (Diallo et al., 2011; Soares & Amaral, 2011), patient self-management (Roehrs, Da Costa, da Rosa Righi, & De Oliveira, 2017), and the reduction of the likelihood of critical adverse clinical outcomes (Oyeyemi & Scott, 2018).

However, lack of interoperability has been noted as a major barrier to digital healthcare transformations, since a number of health information systems cannot effectively share and exchange data (Lehne et al., 2019). This is due to the incompatible standards and various communication protocols or architectures that result into systems' heterogeneity on data representation and meaning among other challenges (Abukwaik et al., 2014; Zeinali et al., 2016). In addition, the challenge of uncoordinated efforts in HIS development has further led to fragmented interoperability solutions within the healthcare sector (Dixon et al., 2020).

However, current healthcare efforts are concerned with integrating health information systems (Chakravorty et al., 2020), in order to meet overall healthcare interoperability needs. In fact, a number of solutions address technical and semantic interoperability as opposed to organizational interoperability (Kuziemsky & Peyton, 2016) or clinical interoperability (Benson & Grieve, 2021). Just like in other sectors, semantic and technical interoperability within healthcare have been tackled through use of standards (Benson & Grieve, 2021; Oyeyemi & Scott, 2018), ontologies (Abukwaik et al., 2014; de Farias, Roxin, & Nicolle, 2016), architectural solutions (Abukwaik et al., 2014; Jonnagaddala, Guo, Batongbacal, Marcelo, & Liaw, 2020), information infrastructures (Aanestad & Jensen, 2011; Öhlund, 2017), service oriented architectures and cloud computing technologies, (Li, 2017) and blockchain solutions (Gordon & Catalini, 2018; Narayana et al., 2019; Vazirani et al., 2019) to mention but a few.

Given the complex nature of the healthcare domain (Kouroubali & Katehakis, 2019; Wolverton & Thomas, 2018), interoperability implementation is a challenging endeavour (Benson & Grieve, 2021; Narayana et al., 2019). Moving forward we need to tackle this complexity by understanding the healthcare context (Cho et al., 2008) and addressing interoperability at its various levels. Analyzing the healthcare context during HIS implementation is paramount (Axelsson & Melin, 2014; Cho et al., 2008), as it enables understanding contextual factors that in one way or another impact the HIS interoperability implementation process (Kouroubali & Katehakis, 2019). In addition, contextual understanding can enable implementers to determine an appropriate interoperability principle (Hugoson et al. (2008), since interoperability is contextual (Novakouski & Lewis, 2012).

2.7 Positioning the Current Research

Extant literature presents a wealth of knowledge about interoperability frameworks, models, strategies, technologies and standards, but there are limited studies focused on the implementation process of interoperable information systems. Healthcare interoperability still presents implementation challenges (Benson & Grieve, 2021). Moreover, Panetto and Cecil (2013) and Daclin, Chen, et al. (2016) note the lack of approaches to aid

implementers appropriate interoperability solutions to context. To address this need, scholars call for more empirical investigations on health interoperability implementation (Abukwaik et al., 2014; Kenny et al., 2017). They believe that such empirical discoveries could as well be formulated into interoperability methodologies or step-by-step procedures (Daclin, Chen, et al., 2016; Hammami et al., 2014) that could guide implementers to appropriate interoperability solutions to the context of interaction (Kouroubali & Katehakis, 2019).

Against this backdrop, this thesis addresses the need for improved understanding of the HIS interoperability implementation process to the benefit of healthcare organizations. Emphasis is on developing a complementary focus on the combined potential of contextual understanding and management capabilities within the interoperability design process. Hugoson et al. (2008) suggest that once implementers thoroughly understand the context of interaction, they can make better decisions about how to enhance the implementation of interoperable systems. Understanding the context of interaction at the various levels of interoperability is quite a challenging task that calls for effective management during the design process (Benson & Grieve 2021; Mondorf & Wimmer, 2017). According to Boland and Collopy (2004) agents who combine design and management are said to adopt a managing as designing perspective. Thus, the central argument developed throughout this thesis is based on the tenets of enhancing information systems interoperability implementation centering on contextual understanding and managing as designing perspectives as discussed in the following chapter.

CHAPTER 3

THEORETICAL PERSPECTIVE

This chapter presents the main theoretical perspectives guiding the research and analysis, namely; *information systems interoperability implementation*, *contextual understanding* and *managing as designing*.

3.1 Information Systems Interoperability Implementation

In this thesis information systems interoperability implementation refers to the implementation of interoperable information systems across participating entities. This means more than one information system or even organization is involved. Lee (2001, p.iii) mentions that:

> Research in the IS field examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerge when the two interact.

Since inception, the information systems discipline is concerned with designing and aligning information systems to the organizations' strategy in order to boost performance and achieve business goals (Arvidsson et al., 2014; Bush et al., 2009; Luftman et al., 2008). According to Rahimi, Vimarlund, and Timpka (2009) information technology is not a panacea; just installing the latest technology will not by itself, make a company more successful, instead the real value comes from the process innovations delivered on those technologies.

Similarly, organizations cannot enjoy interoperability benefits unless such capabilities are designed within the participating information systems/entities. This implies that interoperability cannot happen on its own (Agostinho & Jardim-Goncalves, 2009; eHealth Network, 2015), it is a system capability possessed either inherently (Chapurlat & Daclin, 2017; Rothenberg, 2008), or retrofitted whenever need arises (Rothenberg, 2008; Tu et al., 2016). Thus, concerned parties (entities) must agree to work together towards the common good as emphasized among EU member states, who together pursue the European digital single market (Du, Raposo, & Wang, 2021). According to Rahimi, et al. (2009) fostering the right process innovations on the installed IT base and propagating them effectively are both executive responsibilities not mere technical tasks. This is echoed by Urbach et al. (2019) who encourage early proactive collaboration between IT and management departments in order to implement aligned joint innovations. This would help the involved parties to avoid what Arvidsson et al. (2014) label as outcome-strategy-blindness; whereby the implemented system does not meet the strategic organizational needs. In healthcare, this would align the health information system to the overall healthcare interoperability objectives.

Useful insights on alignment and on how to manage HIS implementation within the healthcare context are offered by (Berg, 2001). For instance, he calls on managers to avoid the myth of leaving the HIS implementation process to the IT department alone. He further points out that, the information systems implementation process is very unpredictable and not fit to a planning and control model, rather the process should be managed as it unfolds. Such collaborations would solve system implementation management challenges and system alignment challenges (Jonnagaddala et al., 2020). Specifically, Hjort-Madsen (2006) encourages healthcare man-

agers to collaborate with HIS designers to jointly manage and design for interoperability. According to Boland and Collopy (2004) implementers who combine design with management are said to adopt a managing as designing approach.

Weber and Kuziemsky (2019) note that the interoperability implementation process needs to be dynamically managed as an evolving socio-technical process; requiring concerted efforts ranging from political, clinical, economic, technical to managerial (Benson & Grieve, 2021). Yet again, according to Mondorf and Wimmer (2017) interoperability projects must employ skilled managers to practically manage various converging factors including resources, information security, legal controls, incentives, and market forces. This highlights the importance of understanding context during information systems implementation (Axelsson & Melin, 2014; Doherty, Ashurst, & Peppard, 2012; Holeman & Barrett, 2017) as well as interoperability implementation (Hugoson et al., 2008; Solotruk & Krištofič, 1980). Hugoson et al. (2008) speak of having higher chances of successful interoperability implementation once the interoperability principle is matched to the context of interaction.

With this backdrop, the thesis emphasis is on developing a complementary focus on the combined potential of contextual understanding and managing as designing perspectives to enhance future information systems interoperability implementation. These two specific perspectives guiding the research are discussed next.

3.2 Contextual Understanding

For this thesis, contextual understanding and context analysis refer to the exercise of analyzing the context of interaction in order to understand the contextual factors affecting the implementation process. The term 'context of interaction' is used to define the boundary of the context in question, just like Bazire and Brézillon (2005) mention of the 'context of the interaction'.

According to Griffin (2007), context is defined as "A set of circumstances in which the phenomena (e. g. events, processes or entities) are situated" and the phenomena can be enabled or constrained by the very context. The issue of context has been addressed by various authors (e.g. Bazire

& Brézillon, 2005; De Regt & Dieks, 2005; Hinds, Chaves, & Cypess, 1992) and several definitions given (e.g. Bazire & Brézillon, 2005), but this thesis takes on the definition offered by Griffin (2007). The interest is in understanding a set of circumstances (contextual factors) within the context of interaction that impact the design of HIS interoperability.

Contextual factors are key features within the context which have an impact on the outcome of the intervention (Ogrinc et al., 2015), and are therefore of crucial importance when it comes to explaining successes and failures of interventions (Doherty et al., 2012; Gichoya, 2005; Ogrinc et al., 2015). Context analysis helps agents understand the factors impacting the implementation process in a given context (Davenport, 2006; Doherty et al., 2012; Stange & Glasgow, 2013) since a system that works well for one specialty cannot simply work in a different context (Benson, 2010). It is thus, important to understand the context in which the information system is embedded (Avgerou, 2001; Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Lau et al., 2015), given that 'context matters for information system implementation' (Holeman & Barrett, 2017).

Several authors argue for contextual understanding during information systems implementation (Axelsson & Melin, 2014; Bern, Pasi, Nikula, & Smolander, 2007; Brown & Brown, 2011; Dopson, Fitzgerald, & Ferlie, 2008), and during interoperability-focused system implementation (Hugoson et al., 2008; Panetto & Cecil, 2013; Tu et al., 2016; Ullberg, Lagerström, & Johnson, 2008). According to Kouroubali and Katehakis (2019), investigation of converging factors that influence the process is critical for the success of HIS interoperability implementation. Contextual understanding leads to clear identification of any interoperability issues (Rauffet et al., 2009), interoperability barriers, and concerns within a given context (Leal, Guédria, & Panetto, 2020). Additionally, it leads to clear prescriptions of interoperability requirements that must be inherent to all participating entities for interoperability assurance (Chen et al., 2008). Further, Hugoson et al. (2008) and Solotruk and Krištofič (1980) believe that a thorough analysis of the context of interaction of all participating entities can lead to identification of an appropriate interoperability principle.

Despite their impact on the success of information system implementation (Axelsson & Melin, 2014; Lau et al., 2015), contextual factors are

often not given much attention as they deserve (Doherty et al., 2012; Dopson et al., 2008). Nevertheless, literature points out some factors that could affect interoperation, including diversity, heterogeneity, autonomy of systems, application solutions, work process, and the business context of an enterprise (Berre et al., 2007). Lam (2005) points to top management support, overall integration strategy and project planning and execution as important critical factors for successful implementation. Particularly in healthcare, Kouroubali, Koumakis, Kondylakis, and Katehakis (2019) mention availability of adequate resources, redesign of services and processes, and a thorough understanding of the environment, incentives, interrelationships, supporting policies and stakeholder needs as converging factors that must be present for HIS interoperability implementation. According to Doherty et al. (2012) and Malinauskienė (2013) integrating the identified factors could lead to interesting results; which could as well be formulated into interoperability development methodologies (Hammami et al., 2014) or step-by-step procedures to guide the implementers (Daclin, Chen, et al., 2016).

Though the famous saying 'context matters' is appreciated by many scholars and practitioners alike, it has not been fully explored to assess its potential in information systems design and implementation (Holeman & Barrett, 2017). There is need to unpack the term 'context matters' (Holeman & Barrett, 2017), and explore how implementers can analyze the context of interaction during information systems interoperability implementation. In regards to that Pettigrew (2012) and Ullberg et al. (2008) call on agents to employ effective management strategies in context analysis. In the same vein, Rauffet et al. (2009) refer to 'context analysis' and 'designing and managing' as approaches that can impact interoperability implementation.

3.3 Managing as Designing Perspective

In addition to the perspective on context, this thesis explores the combined potential of management and designing capabilities in interoperability implementation. This is done through the use of a "managing as

designing" perspective. Managing as Designing (MaD) is an approach that combines both managerial and design skills in order to solve human problems at hand (Boland & Collopy, 2004). It is an emergent field in organizational research that is rooted in the discussion about the 'design attitude'. The design attitude as discussed under MaD brings together the traditions of sense-making and decision-making in order to study human actions (see Figure 1) (Boland, 2008). The proposal to bring sense-making and decision-making together is not through an integration, but through the meta-level constructs of design thinking. Remarkably, it is the management scholar Herbert Simon, who points to 'design' as an activity that brings the seemingly diverse subjective form-giving aspects of sense-making together with the objective aspects of the decision-making discipline (Boland, 2008). Boland (2008) notes that these two fields are always in constant play in our everyday human actions for change as we try to 'make-sense' of the situation and at the same time 'decide' activities that improve that situation. Boland (2008) posits that 'sense-making' tends to always go further in surfacing new possibilities, but notes that this unending search can always be closed off by decision-making. Incidentally, both sense-making and decision-making are kept alive in organizations through the underlying design belief that things can always get better than they are now.

To illustrate the 'verb' managing as designing, the agents should be able to "*seize, mould and make particular competences through certain combinations of technology, vision and narratives*" (Boland & Collopy, 2004). New technology implementation often refer to a vision (how things ought to work) and a narrative (how things have worked in the past). Through such continuous networking of nodes, practical outcomes that can inform future designs are thus created (Boland & Collopy, 2004). This study therefore, explores a MaD approach that applies both sense-making and decision-making perspectives to make-sense of past competencies, and build them into new decision-possibilities that can be adopted to improve future design implementation (Boland, 2008) as illustrated in Figure 1. Figure 1, inspired by Boland (2008) shows that managing as designing relies on *moments of sense-making* and *moments of decision-making*, whereby the former draws on past histories and experiences and the latter envisions the desired future.

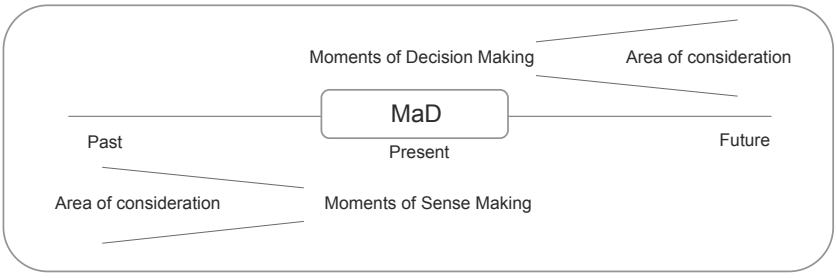

Figure 1. Moments of sense-making and decision-making in managing as designing (inspired by Boland (2008)).

3.3.1 Moments of Sense Making

Literature presents various philosophies of sense-making (Dervin, 1983, 1998; Weick, 1969, 1979), but central to them is that humans make sense of their worlds as they move from the current situation by constructing meaning to make the situation better. According to Weick (1969) this is through a process of organizing where people make sense of equivocal inputs and enact this sense back into the real situation to improve status quo. Patterns of organizing are located in human actions and conversations which usually begin in acts of noticing and bracketing (Weick, Sutcliffe, & Obstfeld, 2005) into 'verbings' (Dervin, 1999; Dervin & Foreman-Wernet, 2012; Dervin & Frenette, 2003). Sense-making is characterized by human actions of traversing through a context of time and space from a situation with history, facing gaps, building bridges across them, evaluating outcomes and moving on to arrive at new situations (see Figure 2). Figure 2 shows the different phases implementers go through during moments of sense-making from analysing the current situations, gaps, bridging the gaps into prospective outcomes for future action (Dervin, 1998, 1999; Savolainen, 2006). Thus, sense-making involves making, defining, constructing ideas, cognitions, conclusions, procedures, values, intuitions, stories and narratives (Dervin, 1999; Weick, 1993) into plausible meanings that are later retained through the Donald Campbell's framework of enactment, selection and retention (Weick et al., 2005). Consequently, the retained meanings materialize into a springboard of identity

and further action (Weick et al., 2005) in order to improve the current state (Weick, 1969).

Fundamentally, sense-making relies on context (Weber & Glynn, 2006; Weick, 1995) as antecedents for making sense through action formulation into future transformations (Weber & Glynn, 2006). Practically, implementers analyze their context by examining the situation (past and present challenges), identifying gaps, questions and muddles, and brainstorming on how to bridge the identified gaps through agreed upon strategies (outcomes) that transform the situation (Dervin, & Frenette, 2003). In practice, moments of sense-making begin with gap identification within the current situations (Dervin, 1998) and the desire to improve that situation (Weick, 1979) through questions like what do we do next? To arrive at potential analogic explorations during such times, there are constant agreements and disagreements, and Dervin (1999) and Weick (1993) argue that in such moments interpretation not choice should be the central focus.

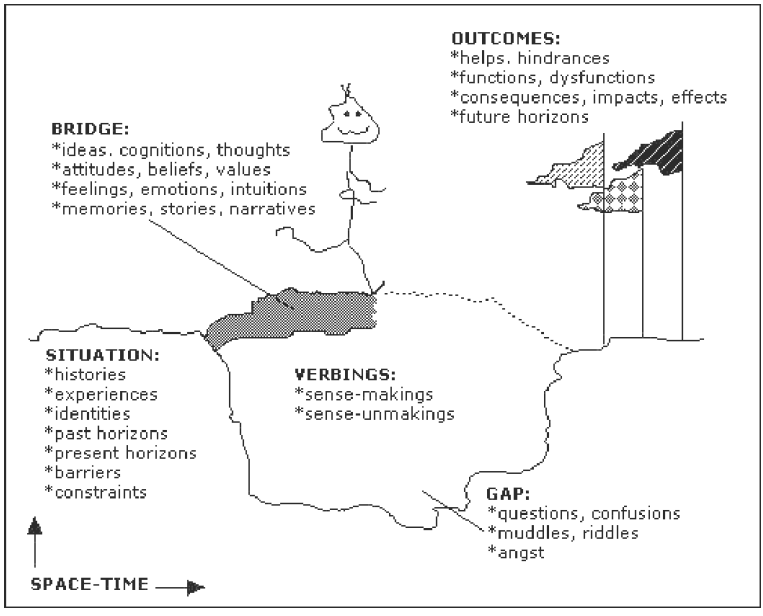

Figure 2. Sense-making Analytical Framework adopted from Dervin, & Frenette, (2003).

3.3.2 Moments of Decision Making

During moments of decision-making the manager seeks out alternatives, calculates consequences, resolves uncertainties, and eventually finds ways of action that are sufficient (Simon, 1979). The classical management decision-making model assumes that it is easy to generate alternatives from which a choice must be made (Boland & Collopy, 2004). However, Boland and Collopy (2004) having been inspired by the design attitude believe that it is not easy to generate good alternatives through the classical decision-making model. They believe that effective decision-making should be preceded by moments of sense-making, just as the cynefin decision-making framework that enables context analysis of the problem space by relying on sense-making aspects. The cynefin framework presents four contexts; the simple context where the manager must *sense, categorize, and respond*, the chaotic context - where the manager must *act, sense and respond*, the complex context - where the manager must *sense, analyse and respond,* and the complicated context where the manager must *sense, analyse, and respond* (Snowden & Boone, 2007). Important to note is that the cynefin framework introduces the acts of sense-making and analysis as antecedents for decision-making in order to exhaustively search the problem space and arrive at sufficient actions.

Hence, Boland and Collopy (2004) emphasize thorough analysis of the problem space through rigorous design exercises as opposed to the classical decision-making model. Therefore, in a MaD approach an appropriate choice of action is usually identified within the design process and therefore moments of decision-making are entwined in moments of sense-making. Simon states that the activity of design is primarily focused on sense-making than decision-making since design is the science of decision-making (Boland & Collopy, 2004).

3.4 Summary of the Conceptual Framework Guiding the Research

The thesis seeks to develop knowledge on how HIS interoperability implementation can be enhanced through contextual understanding and managing as designing perspectives. This is upon an understanding that interoperability is contextual, and that context analysis plays a vital role in

enabling implementers to appropriate an interoperability principle. Again, to effectively analyze the context of interaction during the interoperability design process, management capabilities are considered fundamental. The thesis suggest a combination of contextual understanding, and management capabilities into the information systems interoperability design process. Thus, it explores the combined potential of contextual understanding, management, and designing capabilities. Boland and Collopy (2004) note that agents who combine management and designing are said to adopt a managing as designing perspective. Hence, to enhance health information system interoperability implementation the thesis builds on the concepts of contextual understanding and managing as designing as shown in Figure 3.

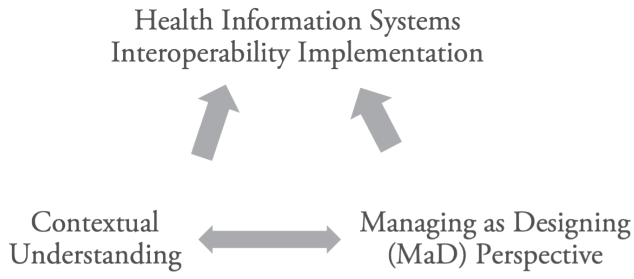

Figure 3. Conceptual framework guiding the research

Figure 3 shows that the thesis seeks to develop knowledge on how HIS interoperability implementation can be enhanced through contextual understanding and managing as designing perspectives. The MaD approach as proposed by Boland and Collopy (2004) encourages managers to adopt a design attitude (to manage and at the same time design), thus the term managing as designing. However, this thesis applies the managing as designing perspective as an approach that seeks to encourage healthcare managers to collaborate with HIS designers. Thus, the MaD approach seeks to stimulate implementers (e.g healthcare managers and HIS designers) to adopt a design attitude in solving healthcare interoperability challenges through moments of sense-making and decision-making during the implementation process. The MaD approach was chosen for its emphasis on context analysis during moments of sense-making, and for its overall management model which are relevant to interoperability implementation.

CHAPTER 4

RESEARCH METHOD

This chapter describes the research process and approach, and provides a description of the case studies carried out in Sweden and Uganda. This is followed by the presentation of the main data collection and analysis methods and methodological reflections that sprung out of the research journey.

4.1 Research Process

Setting the Scene

I began my PhD journey upon securing a SIDA scholarship (Swedish International Development Cooperation Agency) through a collaboration research project with Makerere University, under the *BRIGHT-Project No. 317: Building Research Capacity in Innovative Information and Communication Technologies for Development (ICT4D) for Sustainable Socio-economic Growth in Uganda*. The scholarship requirement was to apply information communication technologies to solve practical problems. I was motivated by a healthcare practical problem faced by medical professionals at

the point of care, whereby they cannot access the patient medical history (record) to inform on-going treatment. This is a well-known problem within the interoperability research community. Despite its extensive history, the persistent data sharing and exchange challenge within healthcare is quite alarming. I was therefore determined to explore how healthcare interoperability can be enhanced.

The scholarship was tenable at University of Gothenburg in Sweden and Makerere University in Uganda. As part of the first study phase, I took part in an advanced research methodology course that gave me a good start and direction on the imminent field studies. A number of authors believe that the research question or objectives very often pave way for the research direction and research methods to be applied. For instance, Thomas (2021) posits that when one is particularly interested in the uniqueness of the phenomena (thing) to understand why or how something might have happened a case study option could be chosen. Way back Elliott (1999) inspired by Patton wrote an article entitled '*And the question shall determine the method*' in which she discusses the importance of making sensible method choices given the purpose of the inquiry.

In reference to my research objective, I needed to get first-hand information from the implementers involved in the HIS interoperability implementation process, thus the most applicable methods turned out to be interpretive and qualitative in nature (Rowlands, 2003). According to Hennink, Hutter, and Bailey (2020) when the experience of the implementers is required (like in my case), interviewing and case study approaches would be appropriate. I read more practical insights to PhD students who are discerning the methods to use in their early research carriers (Ponelis, 2015; Rowlands, 2003). Ponelis (2015) and Rowlands (2003) talk about interpretive research, qualitative research, case study research and the related data collection and analysis methods and when and how to use them. For instance, Miles and Huberman (1994) encourage a combination of data collection methods among which are interviewing and reviewing of relevant documents for qualitative research.

Moving forward I purposively sampled two case studies, one in Sweden and the other in Uganda. Patton (2002) recommends choosing the case study that is informative in regards to the study objectives. The study aimed at gaining knowledge on the HIS interoperability implementation

process, thus investigating current HIS interoperability implementation practices would be beneficial. Case study I in Sweden had successful integrated various heterogonous HIS into a seamless sharing environment – called VGR radiology information infrastructure termed as BFR (Bild- och funktionsregistret) in Swedish, henceforth referred to as BFR. Case study II investigated HIS implementation practices of the mainly used HIS in Uganda, henceforth referred to as the Uganda case. The difference between the cases is that BFR was a successful HIS interoperability project, while the Uganda case represented ordinary HIS implementation practices in order to investigate how interoperability was being catered for.

Entering the Field

I began my first study phase in Sweden within Västra Götaland Region (VGR) in 2016. With the help of my supervisors and a colleague at Faculty of AIT at University of Gothenburg, two cases that had successfully implemented interoperability namely, e-prescription and BFR were suggested. I ended up choosing BFR because it was focused on integrating patient records, and I had direct access to BFR implementers through the colleague at the AIT department.

Thereafter, in July 2017 I started my second field study phase in Uganda, which was carried out over a 12-months period. I decided to find out from the Ministry of Health about the HIS in use at a country level. At the Ministry of Health I was informed that there were many HIS initiatives throughout the country and was given the names of some major HIS in use, namely DHIS2, UgandaEMR and clinic master. Through further investigations and literature review I discovered two other systems: Nganisha health information system and Helecare2x (care 2x) that were worth studying since they seemed mindful of interoperability at health facility level. I discovered Helecare2x through literature review and later met its developers who were academic colleagues, and for the case of Nganisha it was recommended by one of the Ministry of Health officials who was overseeing its development. Hence, the Uganda case consisted of five individual HIS namely; DHIS2, clinic master, UgandaEMR, Helecare2x (care 2x), and Nganisha health information system. These two cases produced useful insights regarding HIS interoperability implementation.

I would like to mention that my data collection and initial analysis phase were purely inductive; that is, they were data-driven. Interestingly, I was advised by the opponent at my PhD-planning seminar to go to the field with open eyes. This piece of advice helped me get out of the confusion of 'forcing' theories and focus on the investigation in terms of capturing 'what was going on'. At that moment I remembered one particular maxim during my research methodology course that I treasured *'never take theory concepts to the field',* literally meaning that as a researcher do not impose your theoretical concepts onto the respondents, just listen to them and conceptualize later during data analysis. In an inductive approach the researcher is interested in describing the actual program effects not just pre-planned effects (Thomas, 2006). I had discovered quite a number of theories through the research methods course that I thought would apply to my study. These, included Technology-Organization-Environment framework (TOE), institutional theory, process theory, contingency theory and the genre repertoire. I actually had all these as proposed theories in my planning seminar report (PhD proposal), however, by the time I finished the planning seminar I had remained with none, interesting!

Starting the Data Analysis and Paper Writing Phase

Phase I: Papers 1-3

After the first phase of interviews I started analysing the data in order to proceed with writing papers for my thesis. Paper 1 relied on data from the Uganda case. In this paper I set out to discover the systems (HIS) that were in use within the country and their challenges towards Patient Care Coordination and Continuity –PCCC, in order to discover research implications for improvement. The rationale was to discover the root cause for the lack of involvement of the existing HIS in PCCC within the country, as this would point to clues on how the challenges would be overcome. I quote *"a problem well stated is a problem half-solved." Charles Kettering*. The paper highlighted a number of challenges that were being experienced and at the same time pointed out implications for future improvements.

In the meantime, I was working on Paper 2 using the data set from the BFR case to further explore the phenomena under investigation. Paper 2 objective was to gain substantive knowledge on the implementation process, decisions and activities that influence HIS interoperability implemen-

tation. This paper led to the discovery of critical incidents and a contingent consequence relationship between them. According to Glaser (1978) the success of the implementation in such relationships highly depends on the contingent conditions. The desire to situate the discovered critical incidents sparked my interest to further explore context and management aspects that were depicted as contingent. I pursued this line of thinking to streamline my research question to focus on contextual understanding and on management aspects during interoperability implementation. This was expounded in Paper 3 that explored contextual factors with an influence on the design and management of HIS interoperability using the dataset from the Uganda case.

Phase II: Papers 4-5

Moving forward, I wanted to explore all the emerging factors and further discover how they relate to each other in order to come up with consolidated findings. Heigham and Croker (2009) mention of how the research is redefined as the researcher moves back and forth between data collection and analysis. As I continued with data collection (follow-up interviews) and analysis, I began to notice data saturation as the respondents were giving related information. At this time, further readings and rigorous data analysis gave the research process a twist. I advanced to interpretive analysis by incorporating theory in order to substantively ground my emerging findings (Braun & Clarke, 2006). Gregor (2006) mentions different ways of how theory can be used as a researchers' lens to understand the phenomena under investigation, and Walsham (1995) points out its practical use in three ways, as an initial lens, within the study design, and as an end product. In this research, theory was applied within the study design to aid the last phase of data analysis. To find a theoretical framework to which I could relate my emerging findings. I began to familiarize myself with the managing as designing (MaD) approach proposed by (Boland, 2008; Boland & Collopy, 2004). I noticed that their MaD perspective brings management and design perspectives together to solve the problem at hand while making sense of the current situation (context). As a result, I realised that I could relate my emerging findings (factors) to this managing as designing approach. They both shared similar characteristics of aiming to improve the situation through rigorous problem solving and management techniques that synthesize the context. I adopted Bolland and Collopy's MaD perspective for further analysis (Papers 4 - 5).

4.2 Research Approach

This research followed an interpretative case study approach (Walsham, 1995). The thesis intended to examine HIS implementation with an aim of understanding how interoperability can be enhanced in healthcare settings. This rendered the case study method ideal to illustrating the phenomenon in action (Creswell, 2009; Denzin & Lincoln, 2005). To construct meaning out of the respondents expressions to inform my study objectives, it was important for me to listen to what they (implementers) made of their actions and experiences (Orlikowski & Baroudi, 1991). Thus, the research was both descriptive and exploratory in nature, it entirely depended upon human constructs, interpretations and meanings (Rowlands, 2003; Walsham, 1995). This is why an interpretive, qualitative and case study approach (Walsham, 1995) was chosen as the research design. The qualitative data collection methods included semi-structured interviews, document reviews and formal and informal (individual and group) meetings (Cibangu, 2012). Data was mainly collected through interviews, as this is a credible method in qualitative case studies to be able to get first-hand information from key informants (Hennink et al., 2020). The collected data was analysed through the general inductive analysis method to qualitative studies (Thomas, 2006). Then in the BFR case, the generated categories were further fitted to an existing analytical framework (see Figure 2), in order to make theoretically grounded propositions. According to Thomas (2006) after the inductive analysis the researcher may proceed to fit the generated categories to an existing model, theory or framework. This allows the researcher to connect to the existing body of knowledge (Hennink, Hutter, & Bailey, 2011), through interpretive analysis (Braun & Clarke, 2006).

4.3 Case Presentations

Both the Uganda case and BFR investigated a number of HIS initiatives. The Uganda case consisted of five independent health information systems, and BFR was an infrastructure built on top of a number of heterogeneous radiology systems within VGR - Västra Götaland Region. Based on this, the unit of analysis for the studies has been the HIS implementation process.

4.3.1 BFR Case

This is a case study of Västra Götaland Region in West Sweden that had implemented a virtual central imaging repository referred to as 'Västra Götaland Region radiology information infrastructure' termed as BFR (Bild- och funktionsregistret) in Swedish. Västra Götaland Region is the second largest region in Sweden with an average of 1.5 million residents, and at the time of BFR implementation, the region was operating 121 healthcare centers and 17 radiology departments. At the time of BFR implementation, Sahlgrenska University Teaching Hospital in Göteborg that provides highly specialized radiology services in the region had realised patient data exchange challenges in the region. Thus the decision to implement BFR - a virtual central imaging repository to increase efficiency, harmonize patient medical information and improve information transparency throughout VGR (GE, 2012). At the time of this study, BFR project had been in operation for an average of twelve years and was considered by its implementers as a successful 'HIS interoperability project'.

The study involved seven participants who were part of key BFR project implementers. They included the Chief Information Officer-CIO-BFR project, Chief Medical Information Officer of VGR, one BFR project manager and four staff at the technical level. The first participant was the Chief Information Officer-CIO-BFR project who proposed and introduced me to other members on the BFR implementation team. The CIO-BFR was interviewed several times in order to gain a clear understanding of what transpired during the BFR implementation process. One respondent reliably informed me that the core BFR implementation team consisted of only a few skilled people, since it was the first project of its kind they had engaged in. Therefore, the study respondents were inclusive of most members of the implementation team and they were key informants as shown in Table 1. These respondents mainly reported on the different system implementation phases, core activities carried out, critical interoperability decisions taken and the interoperability principle adopted, the different stakeholders involved and their roles, critical success factors and other salient factors that influenced the management and implementation process.

Table 1. Details of study participants of the BFR case.

Study participants (Respondents)	Tittle held by key informant respondent	Interview duration in minutes
R1	Chief Information Officer (CIO- BFR) /Innovator	63:30 m
R2	Chief Medical Information Officer of VGR/Innovator	55:00 m
R3	Radiologist at Sahlgrenska University Teaching Hospital-Technical staff	38:11m
R4	Radiologist at Sahlgrenska University Teaching Hospital-Technical staff	40:00m
R5	Chief Information Officer (CIO- BFR) /Innovator	40:00 m
R6	Chief Information Officer (CIO- BFR) /Innovator	80:16 m
R7	BFR Program Manager – Phase II	59:29
R8	Solution Architect-BFR Technical staff	67:39
R9	Technical staff -BFR	67:39

4.3.2 The Uganda Case

This case consisted of five health information systems that were mainly used in Uganda across health facilities at the time of the study. These included District Health Information System -DHIS2, Uganda-EMR, Clinic master, Nganisha health information system and HeleCare2x. The description of these systems is as shown in Table 2.

Table 2. Description of HIS forming the Uganda case

HIS	Description
DHIS2	The District Health Information System -DHIS2, this is a health management system "which provides a coherent platform for data entry and processing, and presentation of data to planners" (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007). This system is highly recommended by the Ministry of Health (MoH) for reporting about health indicators to the MoH.
HeleCare2x	HeleCare2x was customized for Uganda, from Care2x which is an Integrated Hospital Information System including Surgery, Nursing, Outpatient, Wards, Labs, Pharmacy, Security, Admission, Schedulers, Repair and Communication among others (Kanagwa, Ntacyo, & Orach, 2016). At the time of the study the client base were health facilities under the Uganda catholic medical bureau private non-for profit. (http://care2x.org/).
Nganisha	Nganisha health information system: a comprehensive health facility management information system developed locally in Uganda to provide real time and complete data of a health facility. At the time of the study, pilot testing was ongoing in government health facilities (Mbarara district) by health net chattered Uganda. https://twitter.com/ugandahealthnet
UgandaEMR	UgandaEMR is an OpenMRS based electronic medical record system customized for Uganda. This is a system recommended by the Ministry of Health as the nation's patient records' system. At the time of the study, pilot testing was ongoing in selected districts in the country. http://emrportal.mets.or.ug/
Clinic Master	This is an integrated health information management and medical billing software that automates patients' transactions at the clinic on a visit basis and daily procedures. At the time of the study the client base were private health facilities. https://clinicmaster.net/about-us/

The study involved 46 participants in the capacity of MoH officials, project managers, system developers and system users of the five HIS under investigation. Project managers and system developers provided information concerning system goals and functionality, implementation phases, critical activities and critical interoperability decisions taken. System users were included among participants to verify existence of the studied systems and provide their user experiences. Ministry of Health key officials provided information about the existing HIS in the country, the interoperability and HIS implementation guidelines in place, and how the ministry oversees HIS and interoperability implementation in the country. Upon ascertaining the major health information systems in use from the Ministry of Health officials, I visited the headquarters for the identified systems in order to organize meetings with other study participants. The study participants were inclusive enough, since information system implementation teams are often made up of few but skilled persons, thus all respondents were key informants as shown in Table 3.

Table 3. Details of study participants of the Uganda case

Respondent details/ role	Number of respondents interviewed per system					
	DHIS2	Nganisha	Hele-Care2x	Clinic master	Ugan-daEMR	Total
Project managers	1	2	2	1	1	7
System developers	4	3	3	4	1	15
Users	3	6	-	7	3	19
Ministry of Health officials	5					5
						46

4.4 Data Collection

The data collection exercise began in the year 2016 and was completed in December 2018. It involved face to face interviews; individual as well as group formal and informal meetings, and document reviews (Cibangu, 2012). Inspired by Rowlands (2003), I collected the data mainly through

face to face interviews with key informants, in my first phase of the study. Interviews were semi-structured in order to stimulate engaging interactions between the interviewer and interviewees and generate deep knowledge. Interviews focused on extracting participants' responses regarding interoperability measures taken during the system implementation process. These included thoughts, decisions and activities concerning interoperability that were taken during the system implementation process. The interviews also focused on the factors and the challenges that influenced the implementation process. All interviews were recorded with permission and each session approximately lasted 60 minutes. However, in some cases I would engage with the respondents in informal discussions to get to know each other better, and anything that came-up concerning the research would be noted (field notes). As I proceeded with the research I read key documents in each case study to supplement my interviews, and later on I had follow up meetings/interviews (face to face and in some cases short phone interviews). These extra activities were key qualitative validity checks for credibility (Rowlands, 2003). Key documents for the Uganda case included the e-health policy, e-health assessment report, company websites and the national sector development plan. Key documents for BFR case included 'General Electric' BFR company documents, BFR implementation planning and progress reports.

4.5 Data Analysis

A general inductive approach to qualitative analysis Thomas (2006) was applied during data analysis in order to generate an understanding of interoperability implementation issues in the studied contexts. The emphasis was to conceptualize the participants' responses in accordance to the study objectives in order to generate study categories (Rowlands, 2003; Thomas, 2006). The general inductive method supports a thorough analysis of the data through several activities, right from data transcription to generation of final study categories (Thomas, 2006). Thus, the first stage of analysis in both case studies consisted of verbatim transcription (Hennink, Hutter, & Bailey, 2010). The second stage involved reading of the interview transcripts over and over in order to make sense of the study objectives and generate initial data categories through coding (Thomas, 2006). The

coding process involved segmenting the raw data into units, and then rearranging them into categories to facilitate insight, comparison, and proposition development (Miles & Huberman, 1994).

In the Uganda case, the generated initial set of categories illustrated the system implementation goals and functionality, critical implementation activities and interoperability decisions taken, and implementation challenges of the five HIS under study. In the BFR case, the initial set of categories illustrated critical implementation activities, interoperability decisions taken, the interoperability principle identified, implementation challenges and factors that influenced the management process during the BFR implementation project as reflected in Paper 2. In the Uganda case, the third analysis phase involved revisiting of the data, refining of categories and discovering interrelations between them in order to construct final working categories as presented in **Appendix A**.

In the third analysis phase for the BFR case, the emerging critical factors were related to each other to reveal additional insights (Doherty et al., 2012; Malinauskienė, 2013). The interrelated critical factors showed similar characteristics to MaD aspects, which led to the adoption of the MaD analytical framework in the next phase. Hence, the fourth phase involved analyzing the reported BFR activities through the MaD analytical framework. This was to explore its potential in enhancing the HIS interoperability implementation process as presented in **Appendix B** and as reflected in Papers 4 - 5. Within the MaD analytical lens, moments of decision-making happen within moments of sense-making, thus, analysis happens in the confines of the sense-making framework. Through the sense-making framework (see Figure 2) both moments of sense-making and decision-making within the BFR case were identified. Different thoughts, decisions and activities taken by BFR implementers during problem solving moments were analyzed through the sense-making framework by noticing the situation, gaps, bridges and outcomes as shown in **Appendix B**. The generated data categories for the BFR case were the basis for the identified critical factors and for research Papers 2, 4 & 5. The MaD analytical lens was applied to reflect the various activities during the HIS interoperability implementation process in a more nuanced approach as shown in the formulated MaD approach to IS interoperability implementation.

4.6 Methodological Reflections.

The research was conducted in two settings (Sweden and Uganda) with different dynamics. I had to meet the different research and ethics requirements in each case. In the BFR case, I was introduced to all my respondents before our meetings, as they were recommended through snowballing (Myers & Newman, 2007). In the Uganda case, I had an introductory letter from Makerere University that I presented to my potential respondents. Though for main referral hospitals I obtained further authorization from the hospital research office before meeting potential respondents. In both settings people were friendly and willing to help which enabled me to smoothly carry out my field activities. However, when it came to writing papers I experienced some challenges. A number of information system conferences require papers rooted strongly in theory, this gave me a challenge since I was data-driven. This is how I ended up using institutional theory in Paper 3 to emphasize that contextual factors are either internal or external. Nonetheless, I believe it can further be explored to reveal its potential in understanding institutional logics in collaborative ventures for inter-organizational interoperability.

CHAPTER 5

PAPER CONTRIBUTIONS

In this chapter I present a summary of the included papers (1-5) and their respective results and contributions to the thesis.

5.1 Paper 1

Kobusinge, G., Mugwanya, R., Pessi, K., & Koutsikouri, D. (2018, November). The (Missing?) Role of Health Information Systems (HIS) in Patient Care Coordination and Continuity (PCCC): The Case of Uganda. *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 275. Springer, Cham.*

With a theoretical background of non-interoperable systems and lack of PCCC, I set out to understand the current systems in use in Uganda and their challenges towards PCCC across the continuum of care. Through semi structured interviews and documents reviews, the following challenges were discovered; 1). HIS were non-interoperable due to the lack of country uniform HIS implementation guidelines. 2). Several systems were

designed to manage and store patient records at the facility level not across facilities, i.e. interoperability is usually not considered as a design requirement. 3). Lack of a national standard for the patient record, each system keeps a localized patient record; there is no standard patient record for exchange across the continuum of care. This is exacerbated by the lack of a national patient identification system. 4). Data ownership by health facilities, each health facility records its own data in its own format. 5). Non-technical challenges, these included presence of the policies that do not support patient data exchange across facilities, resistance to change, and those particular to developing countries like; infrastructure, cost of purchasing and maintaining computing equipment among others. The implication of these findings is that adopting an interoperability goal as a design requirement would enhance implementation of interoperable systems that can promote PCCC. This paper therefore, contributes to the thesis through its recommendation of HIS initiatives that focus on designing for IS interoperability through having a collective interoperability design goal.

5.2 Paper 2

Kobusinge, G., Pessi, K., Koutskouri, D., & Mugwanya, R. (2018). An Implementation Process of Interoperability: A Case-Study of Health Information Systems (HIS). *(ISD2018 Proceedings).* Lund, Sweden: Lund University.

Being in Sweden a country with success stories of PCCC (Healthcare, 2018), gave me a chance to investigate HIS interoperability implementation practices. Through use of interviews, I followed a one HIS project that had successfully integrated various heterogonous information systems into a central virtual information infrastructure (BFR) for vital radiology information within Västra Götaland Region VGR. The objective was to gain substantive knowledge on the HIS interoperability implementation process and identify best practices. The study revealed four critical incidents that were fundamental in the implementation process, and the concept of contingence management that was depicted from the relationship between the identified critical incidents. The identified critical incidents and the concept of contingence management together formed the initial set of HIS

interoperability implementation best practices that can enlighten future HIS interoperability implementation. The identified critical incidents were major activities that were carried out during the implementation process, they included discovering interoperability need, projecting outcome, managing change and adopting an appropriate interoperability strategy. The study implications were as follows; 1). That implementing interoperability is driven by the need to change the status quo, overcome current data exchange challenges, and improve the situation. In other words, the interoperability need is turned into an interoperability objective to be pursued. 2). That once the proposed interoperability project outcomes are made known to the participating stakeholders, they envision a seamless sharing environment and are willing to collaborate towards the success of the project. 3). That the interoperability strategy must be aligned to the context of interaction for successful interoperability project implementation. 4). That interoperability projects are organizational change processes that require effective management. Further, contingence management depicts the impact of 'context' and the importance of the 'management aspect' since project management skills vary and affect the project outcome differently. Therefore, this paper contributes to the thesis by highlighting; 1) critical interoperability implementation activities and 2) the importance of 'context' and 'management' during HIS interoperability implementation. These identified critical incidents point to contextual factors that are critical to information systems interoperability implementation.

5.3 Paper 3

Kobusinge, G. (2020). Contextual Factors Influencing the Design and Management of Health Information Systems Interoperability. *In Proceedings of the 9th International Conference on Information Technology Convergence and Services (ITCSE 2020).*

Several authors recommend understanding of contextual factors during information systems implementation. It is important to understand contextual factors that are very often neglected yet have a great impact on the projects' outcome; as they can hinder or enable it. In the same vein, context analysis during HIS interoperability implementation is important

to enable implementers to understand system requirements and determine an appropriate interoperability principle. Thus, this paper explored contextual factors with an impact on the design and management of HIS interoperability. The paper discovered seven contextual factors including intended system goals, policy, institutional autonomism, interoperability standards, existing health-information-systems, national HIS implementation guidelines and resources in terms of labour and money. The paper contributes to the thesis by highlighting some contextual factors that can influence HIS interoperability implementation.

5.4 Paper 4

Kobusinge, G. (2020, January). Putting Interoperability on Health-information-systems' Implementation Agenda. *In Proceedings of the 53rd Hawaii International Conference on System Sciences.*

The previous papers emphasize a focus on designing for information systems interoperability by having a collective interoperability design goal. This paper followed a successful HIS interoperability project (BFR) with an aim of understanding how the implementers arrived at their interoperability prerequisites. Interoperability prerequisites in this paper are considered as the system design interoperability-requirements elicited in the early stages of system implementation. Through interviews with key members on the implementation team, I discovered interoperability requirements that were arrived at to guide the system implementation. These included knowing who, knowing what, knowing how and knowing which. Knowing what to focus on; realising current challenges and deciding to design for interoperability within context. Knowing who is on the implementation team, funders, managers as well as technical staff. Knowing which specifics to focus on, minimum requirements - an informatics focus vs a technology focus alongside legislation adherence. Knowing how to go about with the system design and implementation; determining an interoperability principle in regards to the context of interaction. The identified prerequisites actually point to contextual factors that are critical to designing for information systems interoperability. Overall, this paper contributes to the thesis by elucidating that designing for healthcare interoperability does not

just happen, rather it rests upon conscious design and management decisions taken by HIS interoperability proponents. The paper further highlights what HIS implementers need to focus on (prerequisites) in order to bring interoperability on HIS implementation agendas and design for it. A fundamental study implication is the use of the sense-making framework in analyzing the context of interaction. Analyzing implementer's activities through the sense-making lens led to the discovery of interoperability prerequisites, and in this the potential of sense-making in context analysis.

5.5 Paper 5

Kobusinge, G. (2020). Managing as Designing: Transforming Digital Healthcare Interoperability. *AMCIS 2020 Proceedings. 2.*

This last paper summarizes findings of the previous papers by exploring the MaD approach. Previous papers have emphasized the importance of having a collective interoperability goal (Papers 1 - 4), the importance of managing the HIS interoperability implementation process (Papers 2 - 3), the importance of considering context and identifying contextual factors that might influence the design and management of HIS interoperability (Papers 1 – 4). This paper brings all the previous paper findings (critical factors) under one umbrella coined as managing as designing MaD and explores its potential in enhancing HIS interoperability implementation. It relies on the premise that designing for interoperability is contextual, and explores a MaD approach that is mindful of the particulars of the context during sense-making moments. In this paper, a MaD HIS interoperability conceptual framework was developed. It highlights that through the design attitude implementers can design for information systems interoperability through moments of sense and decision-making, in order to improve the interoperability status quo. Therefore, this paper contributes to the thesis by investigating the potential of a MaD approach and lays ground for the proposed MaD approach to IS interoperability implementation.

CHAPTER 6

EMPIRICAL FINDINGS

This chapter synthesizes the empirical findings from the two case studies. The findings are presented using the theoretical categories as presented in Chapter 3; *contextual understanding* through attuning to critical factors and, *managing as designing perspective* by presenting the proposed MaD approach to IS interoperability implementation.

6.1 Contextual Understanding

Findings show that during the HIS interoperability implementation process implementers try to solve the problem at hand by trying to make sense of the context of interaction. This is through the discovery of both enabling and constraining factors to HIS interoperability implementation. Context is understood by analyzing the contextual factors that make it up. As I listened to the implementers' stories and experiences, the emerging contextual factors were pointing to decisions, observations, and actions that they considered critical when designing for HIS interoperability. Several contextual factors were discovered as discussed in Papers 1- 4 and showed in **Appendix A** and **Appendix B**. The discovered contextual factors have been categorized into four critical factors as shown in Table 4.

Table 4. Conceptualized critical factors to enhance HIS interoperability implementation across the two case studies.

BFR Case	Uganda Case	Cross Case Analysis	Critical Factors to Enhance HIS Interoperability implementation
Fully focused on interoperability Implementers had a goal to address PCCC at all radiology centers. They had a collective decision to pursue interoperability.	No collective focus on interoperability during HIS implementation. Systems were developed with a narrow focus. However, respondents noted the need to focus on interoperability during HIS implementation.	Both cases advocate for a focus on interoperability during HIS implementation.	Having a collective interoperability design goal
Implementers fully examined the context of interaction. They assessed past and current interoperability status, challenges and future interoperability vision. For example they noticed several non-interoperable HIS at the different radiology centers.	Implementers talked of the need to examine context before implementation of new systems. For example assessing the existing systems, interoperability policies, standards, implementation guidelines and legal requirements.	Both cases advocate for contextual understanding. Understanding the context of interaction in order to understand contextual factors that are critical to designing for HIS interoperability.	Analyzing the context of interaction
Management was a major component for the success of the implementation process. Information technologists worked closely with regional politicians and healthcare managers. A competent team was put in place to manage all the project activities, stakeholders and all available resources. The entire project was well managed and specifically change was well managed.	There were no collective HIS interoperability initiatives. HIS designers worked independent of healthcare managers. Both system implementers and the Ministry of health officials noted the need of their mutual collaboration to enhance HIS interoperability within the country.	Both cases advocate for managing the HIS implementation process. Both cases advocate for close partnerships between healthcare managers & HIS designers. Realisation that managing is as important as designing for HIS interoperability implementation.	Manage the interoperability implementation process
They opted for a data harmonization strategy (intersection interoperability principle) since there were many systems that could not be discarded. They emphasised unique patient identification to enable traceability at any health center using any HIS. They emphasised an informatics focus vs a technical focus; they focused on the information to be shared not on the systems themselves. They also focused on minimum requirements for an integration.	Often times HIS are designed with no interoperability obligations, but respondents noted that whenever an integration is needed they would apply interoperability standards such as APIs, and or install central servers at data centers in cases of similar systems. Respondents further emphasised a need for a standard format for patient ID - unique identification or patient record to enable traceability of a patient at any healthcare center (informatics focus)	Both cases advocate for application of appropriate strategies or interoperability standards to aid an integration. They emphasize pplication of an appropriate interoperability principle (unified, integrated/ intersection, interlinking) in regards to the context of interaction. For example, they mentioned the use of interoperability technologies such as standards, APIs, central servers.	Determine an appropriate interop principle in regards to the context of interaction (guided by the minimum requirements principle and informatics focus principle).

Alongside the four critical factors were the *minimum requirements* and *the informatics focus vs technology focus* principles that were fundamental decisions in guiding implementers appropriate an interoperability principle. The critical factors include *having a collective interoperability design goal, managing the interoperability implementation process, analyzing the context of interaction* and *determining an appropriate interoperability principle* as discussed below.

6.1.1 Having a Collective Interoperability Design Goal

Having a collective interoperability design goal means that HIS implementers can purposively focus on designing for information systems interoperability by having it as a system design goal.

Interoperability is a system capability that must be possessed by entities intending to interoperate (IEEE, 1990). It is an illusion to expect systems to interoperate when interoperability is not catered for. Paper 1 findings indicate that a number of systems are designed with no interoperability obligations, and that is why many of them are non-interoperable. These findings, highlight the need of implementing systems that focus on interoperability, whereby the implementers have interoperability as a system design requirement to be pursued. According to Chen and Daclin (2006), defining interoperability prerequisites can pave way for designing for interoperability. To this effect, respondents noted that, they usually design systems according to the users' demands. They mentioned that when the users demand that their system should be interoperable, then they design with that requirement in mind and develop a system with interoperability capabilities, as stated by a system developer:

> Implementation decisions are made based on client needs, yes so it is more of demand driven, and we build on demand, but if we have a requirement (need/goal) that it must talk to some other system, then we ensure we produce the right data either as input or output for any system.

During system development the first step is requirements elicitation, a phase where the system designers collect system requirements (intended system goals) from the intended system users. The intended system goals

pave way for the system development process (as discussed in Paper 3). Paper 3 discusses 'the intended system goal' as one of the contextual factors impacting interoperability implementation. It goes without say that when interoperability is considered as a system design goal, the developed system will have interoperability capabilities, as seen in BFR project. The BFR project can be described as an interoperability-focused project (see Paper 2), from the project onset BFR aimed towards designing for interoperability amongst all radiology departments within VGR region, as stated by one Radiologist at Sahlgrenska University:

> At Sahlgrenska University hospital because we have a lot of patients that start their journey in the health care system outside this hospital, they get ill at their home town, they are examined in their home hospitals and they are referred to Sahlgrenska. This is the main hospital in the region, so we needed to access their data and we had had lots of problems getting data from the small hospitals. So at Sahlgrenska we decided to buy and install a common central archive that was vendor neutral that was the same for this town Gothenburg. When I am looking at patients I just have to ask one archive for the complete history. I want to be able to communicate with any hospital within Sweden with my radiology images and my radiology requests and reports and I don't want to care about which system they use.

BFR implementers had a collective interoperability design goal. They had an informatics focus of keeping a centralized view of the patient throughout VGR. The desire and decision to design for interoperability was upon a realization and acknowledgement of the data sharing and exchange challenges they were encountering. This means that interoperability can be designed for or continually be improved if it is given utmost consideration; it will not simply happen own its own. To this effect, Paper 4 argues for the importance of having a collective interoperability design goal onto the information systems implementation agenda and having it among the system design requirements. Hence, the findings posit that having a collective interoperability design goal is key to designing for information systems interoperability. However, findings further indicate that the interoperability design goal alone cannot guarantee success, there are other factors that altogether lead to successful interoperability implementation as discussed in Papers 2 - 4.

6.1.2 Managing the Interoperability Implementation Process

Managing the interoperability implementation process entails several management activities involving managing people, change, resources and the implementation process itself. It further refers to having healthcare managers get involved in accomplishing overall healthcare interoperability objectives by collaborating with HIS designers.

Findings show management as a contingent factor onto which the success of the implementation greatly depends. Findings show that project management is key and that the competence, experience and composition of the team members matters as stated by the Chief Medical Information Officer of VGR/Innovator:

> Actually we also had a management perspective, we had the regional perspective. In this case I would say, the stakeholder was, if we put it as a regional aspect, saying we from an organizational point of view said it was interesting to keep a centralized view of the patient. We had experience from the x-ray domain prior to this, so we know all the challenges with in.

As stated by Phase II - BFR Program Manager:

> Build competent project management from the beginning. Work hard with control mechanisms to get a good quality. Without a 100% dedicated management team it's hard to run the project.

BFR project had strong support from the top regional managers through their commitment, involvement and funding. There was a regional political decision to digitize all radiology information way back before the actual BFR implementation started. This shows that regional political and healthcare managers where committed to the vision of integrating radiology information within the region. Further, the BFR project had competent staff that were highly experienced with both management and technical skills. They even had prior experience in building infrastructure projects. Having prior experience, the BFR team was primed to handle among other things, the implementation process, change, people, and related resources.

Respondents emphasized the importance of managing change, as in any transformational intervention where change is inevitable. They also mentioned 'vendor handling' as one of the most significant management tasks, as the vendors were required to re-engineer some of their products/services and they were not willing to change. The implementation team had to devise a number of change management strategies for a successful implementation. Some of the change management strategies included stakeholder management through negotiations and vendor motivational strategies. Another change management strategy was path dependency through step-by-step innovations. This was a technique of 'change without change' that was promoting change in a step-by-step procedure without much disruption to existing processes. Changes were in support of existing structures and technologies that could slightly be modified to fit the new mode of operation. Below are some verbatim opinions concerning the different management strategies that were employed in BFR.
The Chief Medical Information Officer of VGR/Innovator stated:

> If you do not do change management, you will not see any difference at all but it's not mainly technical standards it's more out of change management perspective because you as people, you have your comfort zone is the way you know how things should be carried out because they have always been carried out that way. The other big problem that we had to work with several years was that the vendors out in the region were reluctant to store data in the appropriate format. So we needed to spend a lot of time to have meetings with the various vendors to have them realize that they needed to change their interpretation of the standards in some way.

The Chief Information Officer (CIO- BFR)/Innovator stated:

> So in my earlier days I used to talk about changing without change. In the strategy, this is also important to understand when we talked about that it is really not a change for the local. We are following exactly the legal rules as it was before, and as I said we had well established in Sweden the use of the Digital Imaging and Communication in Medicine (DICOM) standard. We said to the local department, but guys you do the same way you have always done. They didn't need

> to change anything internally, for the local people it did not change anything. So what we needed to support in the infrastructure was actually the existing vendors of the existing systems as a legacy of the things already there, we helped them to develop HL7 interfaces. We found out who was the vendor did they support HL7 and after discussions we realized that the best thing to do was actually to go back to the Local vendors and say, we will actually support and pay you to develop HL7 interface.

For the local radiology departments, the changes were incremental, so the locals did not feel the impact of the required changes. The step-by-step procedure helped to limit resistance from the local departments as the changes did not disrupt their daily routines. These findings from the BFR case show that employing effective management strategies to manage the entire project in terms of people, change, resources, and the process is crucial to the interoperability project success. Some of the effective strategies mentioned by the respondents included having competent and experienced staff, securing top management support and commitment, managing change and the entire process. Change management necessitated wining stakeholders to buy the vision and decision to pursue interoperability, which was achieved through a number of strategies including publicizing the benefits for seamless data exchanges.

Whereas the management component was so evident in the BFR case, it was not the case with the Uganda case. In the Uganda case, there were no recognized interoperability projects to investigate, each of the studied systems were discrete developer initiatives which were not jointly managed. System developers worked independent of the Ministry of Health, there was no overall support and coordination of HIS implementation within the country. Findings indicate that healthcare authorities had interoperability policies under development, while at the local implementation level health information system designers were developing systems with no interoperability obligations. Several systems within the country were non-interoperable and they could not avail a patient record at the point of care (Paper 1). The national and top health officials were aware of the various uncoordinated ongoing health information system implementation initia-

tives within the country, as mentioned by the Ministry of Health (MoH) officials and as indicated in the initial e-health assessment report.

Respondents also noted the lack of national implementation guidelines, policies and standards in support of HIS interoperability. They also lacked guidance on the kind of data or patient details that can be shared or exchanged. They further indicated that the policies in place did not support sharing of patient information due to privacy and security issues. Thus, due to lack of implementation guidelines and management support from national health officials, the country ended up with numerous stand-alone HIS. One Project Manager noted the lack of top management involvement and support as stated below:

> We had no regulatory framework, no policy, no standards, no interoperability framework, people just implement haphazardly without following any guidelines from the ministry.

Respondents noted the importance of having support from top officials in terms of setting interoperability implementation guidelines, offering financial support and monitoring ongoing HIS implementation initiatives within the country.

However, at the national level, the Ministry of Health considers the management component in high esteem, the Ministry of Health respondent mentioned that they have a management plan with a phased implementation approach that is research-led for sustainability. The official further mentioned that they plan for healthcare interoperability through the e-health policy, health pillars and the implementation guidelines. At the time of this study the Ministry of Health official mentioned that they were carrying out an internal assessment of all e-health applications within the country, working on the policy and on the interoperability architecture as a way forward towards improving health information systems interoperability within the country. Through such exercises they anticipate their increased involvement, coordination and management of HIS initiatives within the country as stated in their initial e-health assessment report.

Overall, findings from the two cases emphasize the importance of the management component, and having healthcare managers collaborate with HIS designers to effectively manage interoperability implementation in order to achieve desired overall healthcare interoperability benefits.

6.1.3 Analyzing the Context of Interaction

Analyzing the context of interaction refers to examination of the context to discover contextual factors enabling or constraining the HIS interoperability implementation process. To this effect, findings emphasize the importance of contextual understanding as it paves way for new system developments. Respondents noted that before they develop any system, they first examine the context. For instance, they examine existing systems of their capabilities, to gauge if the proposed system will be of value so that they do not reinvent the wheel, as stated by one of the system developers:

> Before you design, probably the solution might be within the country so why would you go ahead and reinvent the will.

Findings show that examining the context before any new information system development helps to identify what is missing and what is needed for the new system to meet overall interoperability objectives. For example in the BFR case, the implementers noticed the presence of many heterogeneous systems and devices that were in use, many vendors and stakeholders, varied standards, inconsistent DICOM (Digital Imaging and Communication in Medicine) standards, varied patient IDs (identification number), lack of a patient record, and many others.

Upon discovery of various contextual factors, the implementers devised strategies on how to manage them. Some of the strategies including applying the *principle of minimum requirements*, *focusing on the informatics instead of the technology*, and employing *effective change management strategies*. Findings show that BFR implementers focused on how to get things done without much disruption, they focused only on minimum requirements for an integration. For example, one of the minimum requirements was to have an informatics focus by streamlining the patient data that was needed for the exchange, as stated by the Chief Information Officer (CIO-BFR)/Innovator:

> …but it is important to agree on minimum requirements to build up a shared infrastructure in radiology. What is the minimum we need to agree on to get things to work and to have departments to say the same things to call the things the same. So we found out that not to put too much pressure on the departments we said to them the only thing we need to agree on is that the personal ID needs to follow this rule.

Findings show that analyzing the context can lead to the discovery of several contextual factors, for example in this thesis they are presented as critical incidents in Paper 2, as contextual factors in Paper 3 and as interoperability prerequisites in Paper 4. The identified critical incidents included having a collective interoperability design goal, projecting interoperability benefits to all stakeholders to win them over, effectively managing change, context, vendors and the entire implementation process, and determining an appropriate interoperability principle (Paper 2). The identified contextual factors that influence the HIS interoperability implementation process as discussed in Paper 3 included existing systems, devices, and technologies, intended system goal, policies, standards and guidelines, institutional autonomy, and required resources in terms of money and labour. The identified interoperability prerequisites included knowing who, knowing what, knowing how and knowing which (Paper 4). All these identified contextual factors have been categorized as critical factors to enhance HIS interoperability implementation alongside the two identified guiding principles of minimum requirements and the informatics focus vs technology focus.

6.1.4 Determining an Appropriate Interoperability Principle

Determining an appropriate interoperability principle refers to coming up with an appropriate strategy to designing for information systems interoperability that takes into consideration the prevailing conditions within the context of interaction.

For two or more systems to interoperate there has to be a communication link, which according to Solotruk and Krištofič (1980) is created through an interoperability principle. An interoperability principle is a

strategy identified by the implementers through which they plan to design for interoperability between the participating entities. The interoperability principle has to be identified in accordance with the context of interaction. Thus, to be able to determine an appropriate interoperability principle that matches the context, the implementers have to thoroughly examine the context of interaction. When the context is not fully examined, the implementers are likely to adopt an interoperability principle that does not match the context of interaction and there will be higher chances of failed interoperability.

Findings show that upon thorough examination of the context BFR implementers were able to determine an appropriate interoperability principle to guide the implementation process. Guided by the 'minimum requirements principle' the implementers chose not to discard systems and standards such as HL7 and DICOM that were already in existence. They decided to harmonize the data through an information infrastructure, which was achieved through the 'intersection interoperability principle' by use of interoperability standards as stated by the Chief Medical Information Officer of VGR/Innovator:

> So now, I am totally safe in my thoughts that we need standards. You have to follow the specification of what data has to be inside the DICOM object. Use of standards is mandatory, we had to tighten the use of the DICOM standard, and to use it in a strict way was a success factor. Yea, to make the information available, system independent and harmonized. We focused mainly on the information and on information sharing, data sharing.

Furthermore, findings show that guided by the minimum requirements principle the BFR implementers chose an *informatics focus vs technology focus,* where they focused on the data required at the point of care rather than the individual information systems in use. It did not matter the kind of systems at the different radiology departments, but the focus was on the kind of data to be shared as stated by one Radiologist at Sahlgrenska University:

> We did what was quite unique, we allowed hospitals to have different systems, but we said you have to store in a standardized way. We just made it in a format that it's always available no matter what system you are working in, the data format is standardized.

The informatics focus principle was emphasized also in the Uganda case, respondents noted the importance of defining patient details and unique identifiers to be able to share and exchange patient data across systems. They indicated that the systems in use do not necessarily have to be the same but the needed patient details could be defined, or standardized to enable exchange, as stated by a system developer:

> Systems need to have the same understanding of every entry. We have tried to look for any document that defines that but in vain, all of them stop on the point of integration and interoperability but they don't narrow down on what should be shared, they stop on that high level only. We cannot have the same system but all these systems must have the same language that they don't confuse the end system. So we must have a standard we follow, because once we all follow these standards then at the end of the day, we will have the same. If we can all follow the same rules, no matter what system you go to, we can still get you as the same patient.

Just like in the BFR case, respondents from the Uganda case noted the need of a harmonization strategy through use of standards and APIs as means for creating a communication link (interoperability principle) between different systems, and use of central servers in case of similar systems. This was the vision for Nganisha and Clinic master systems that were installed at various health facilities. Respondents talked of having data centers and using central servers through which the patient record could be tracked at every health facility. Further, the thesis presents an informatics focus as a good minimum requirements principle that can guide the choice of an interoperability principle during context analysis.

Overall, findings show that through the sense-making framework, implementers tried to understand their current situations, discovered the existing gaps, brainstormed on different strategies/bridges into future design horizons/outcomes. Through sense-making implementers were

able to analyze the context of interaction and identify critical factors that enabled them to design for interoperability (referred to as interoperability prerequisites in Paper 4). It is through sense making activities that the implementers discovered an appropriate interoperability principle.

6.2 Managing as Designing Perspective

The potential of the managing as designing perspective was demonstrated through the formulated MaD approach to IS interoperability implementation. Findings show that the managing as designing approach can enhance HIS interoperability implementation as explored in Papers 4 - 5. Analyzing implementer's activities through the sense-making lens led to the discovery of interoperability prerequisites, and in this the potential of sense-making in analyzing the context of interaction (Paper 4). Again, analyzing implementer's activities through MaD concepts led to the development of the MaD HIS interoperability conceptual framework, and in this the potential of MaD in enhancing interoperability implementation (Paper 5). Overall, findings show that analysis of the implementers' step-by-step procedures through the sense-making concepts of situation, gaps, bridges and outcomes led to the discovery of HIS interoperability implementation activities as shown in **Appendix B**. These HIS interoperability implementation activities were then related to MaD concepts to formulate the proposed MaD approach to IS interoperability implementation as shown in Table 5. Table 5 summarizes the proposed MaD approach to IS interoperability implementation.

Table 5: Formulation of the MaD approach to IS interoperability implementation

MaD Concepts	Design attitude: aims at improving status quo	Managing as designing (emphasises collaboration between management and designing)	Moments of sense-making	Moments of decision-making
HIS interoperability implementation activities (during contextual understanding)	Acknowledgement of past and present data sharing and exchange challenges and Collective decision to pursue interoperability.	-Form competent implementation teams, -Secure funding, -Inspire healthcare managers and HIS designers into collaborative teams. -Manage change, people, resources, and entire process. -Involves all management activities (identified interoperability implementation activities).	-Analyse HIS in existence. Analyse the context of interaction for contextual factors most especially for critical factors to enhance HIS interoperability implementation.	-Determine an appropriate interoperability principle. -Enforce strict adherence to agreed-upon structures like the standards, policies, legal procedures, implementation guidelines like the minimum requirements principle and the informatics focus vs technology focus).
MaD approach to IS interoperability implementation	Adopt a design attitude by having a collective interoperability design goal: This involves acknowledgement of past and present data sharing and exchange challenges and decision to improve status quo by having a collective interoperability design goal.	Managing (as designing) the interoperability implementation process: It inspires collaboration between healthcare managers and HIS designers. It's about managing the interoperability implementation process and involves a number of management activities such as managing change, people, resources and entire implementation process.	Moments of sense-making for contextual understanding: Involves analysing the context of interaction to understand contextual factors (critical factors to enhance HIS interoperability implementation).	Moments of decision-making for making key decisions and determining an appropriate interoperability principle: Involves determining an appropriate interoperability principle. Enforcing strict adherence to agreed-upon design-decisions, and legal structures and policies.

The thesis proposes the MaD approach to IS interoperability implementation that consists of the following procedures as shown in Table 5: *Adoption of a design attitude by having a collective interoperability design goal, Managing (as designing) the interoperability implementation process, Moments of sense-making for contextual understanding, Moments of decision-making for making key decisions and determining an appropriate interoperability principle*.

Findings indicate that under the proposed MaD approach to IS interoperability implementation, the interoperability implementation process begins with *adoption of a design attitude* which involves acknowledgement of past and present data sharing and exchange challenges and a collective decision to design for healthcare interoperability by *having a collective interoperability design goal*. To set the interoperability implementation process rolling a number of activities have to be performed, one of them being the institution of implementation team(s). Given that MaD emphasises a combination of management and designing, then the implementation team(s) can consist of concerned managers and system designers to jointly manage and design interoperable health information systems that will meet overall healthcare interoperability objectives. Once competent implementation team(s) have been installed they have a responsibility of managing a number of activities including securing stable funds, managing stakeholders, managing change, managing resources and the entire implementation process. All these activities are grouped under one umbrella '*managing (as designing) the interoperability implementation process*'. During the interoperability-problem-solving-cycle the implementers engage in *moments of sense-making* and *moments of decision-making* which consist of; *analysing the context of interaction* in order to *determine an appropriate interoperability principle*, enforcing *major interoperability design decisions*, *adherence to agreed-upon structures*, *policies, standards, guidelines and legal requirements*, and finally implementing interoperable health information systems.

CHAPTER 7
DISCUSSION

This thesis has concerned the development of an approach to support health information systems interoperability implementation. Through two case studies in two healthcare settings, one located in Sweden and one in Uganda, I have set out to address the following question:

How can health information systems interoperability implementation be enhanced?

In this chapter I will discuss the key findings and present the specific contributions to the research community and practice. Then finally I discuss the study limitations and future research opportunities.

7.1 Proposed MaD Approach to IS Interoperability Implementation

The thesis argues for the MaD approach to IS interoperability implementation based on the tenets that it: promotes a managing as designing perspective, promotes the design attitude, and promotes contextual understand-

ing. A managing as designing perspective during the HIS interoperability implementation, seeks to encourage healthcare managers and HIS designers to jointly manage and design interoperable HIS. The design attitude seeks to inspire implementers to continuously improve the interoperability status quo. At the same time, it motivates them to solve interoperability problems through moments of sense-making and moments of decision-making. During these moments implementers can examine the context of interaction, make fundamental decisions, and determine an appropriate interoperability principle to aid implementation of interoperable HIS. Overall, the proposed approach seeks to motivate implementers to analyze the context of interaction and to holistically manage the implementation process and design for overall healthcare interoperability through the design attitude (Papers 4 - 5).

7.1.1 Promotes a Managing as Designing Perspective

The proposal of a managing as designing perspective is aimed at encouraging healthcare managers to collaborate with HIS designers to promote both management and designing perspectives during HIS interoperability implementation.

Previous scholars have emphasized the importance of effective management during HIS interoperability implementation, for instance, Mondorf and Wimmer (2017) argue for effective managers who are capable of handling various converging factors. Management is about the proper handling of things and people in an organization setting (Kessler, 2013), usually aimed at helping people to be more innovative and productive in common efforts to create value for customers (Magretta, 2012). Due to the complexity and uncertainty of the management task, a number of companies have fallen victims of poor management (Kessler, 2013). Despite the challenges, strategic management is the road to a company's increased performance and productivity (Hill, Jones, & Schilling, 2014). Findings point to management as a contingent factor that affects the implementation process differently in different context, thus warranting special attention.

Findings show that management capabilities are as important as designing during HIS interoperability implementation, since according

to Boland and Collopy (2004) good solutions do not just emerge they are designed and managed. According to Simon (1969) managers are the overall organizational form givers, and are fully responsible for its performance. Through the proposed MaD approach to IS interoperability implementation, the thesis argues for healthcare managers' involvement in the implementation of interoperable HIS that meet overall healthcare interoperability objectives since they are the vision bearers. In Paper 2, it was discovered that several organisations aim at digitizing processes, and that very often HIS designers seldom collaborate with healthcare managers. This is attested by Kouroubali and Katehakis (2019) who note the ever increasing number of HIS that are designed in isolation moreover with no interoperability obligations. A case in point, is where healthcare authorities establish national interoperability implementation guidelines and policies that are hardly enforced at the actual implementation level as discussed in Paper 3.

Whereas there was no observed collaboration between healthcare authorities and system designers in the Uganda case, we see both management and designing perspectives profoundly embraced in the BFR case. There was strong management support from political and regional healthcare authorities who jointly collaborated with the information technology -IT team (system designers). Usually managers employ a number of strategies to accomplish their activities. According to Hill et al. (2014) a strategy is a set of related actions that managers take to increase their performance, however, each strategy impacts the company's performance differently. To stir the BFR project to success, the team employed several management strategies such as stakeholder management, path dependence and change management among others. They also enforced key implementation decisions such as; the minimum requirements principle and the informatics focus vs technology focus principle. Paper 5 shows that through the proposed MaD HIS interoperability conceptual framework, healthcare managers would come into collaboration with HIS designers to jointly manage and design interoperable HIS that meet overall healthcare interoperability objectives (Kobusinge, 2020). These findings are in agreement with Hjort-Madsen (2006) who calls on joint collaboration between healthcare managers and HIS designers to effectively design for interoperability, and

Urbach et al. (2019) who argue for collaboration between management and information technology departments for joint innovations.

Again, through the MaD approach Boland and Collopy (2004) call on managers to embrace the design attitude in order to improve the current interoperability status quo.

7.1.2 Promotes the Design Attitude: to Improve Current Interoperability Status Quo

The design attitude always aims at making things better than they are now (Boland & Collopy, 2004). Through the proposed design attitude healthcare organizations can continuously look forward to improving the state of interoperability by having a collective interoperability design goal, after all, interoperability is not a onetime achievement.

With the increased desire to promote public health, quality care, PCCC, and to have a patients' medical history at the point of care across the continuum of care (Heavin, 2017), a collective healthcare interoperability objective would be beneficial. This is because, if some HIS along the care process (continuum of care) are non-interoperable, data exchange would still be challenging and PCCC would not be achieved. Findings show that one way to purse interoperability is by having an informatics focus vs a technology focus. Findings show that great emphasis was put on defining what was required for the exchange (to be shared) as opposed to which individual service systems in place. This is what the informatics focus vs technology focus principle emphasizes; to not only focus on the technology but to pay attention to the required information for the exchange. Daclin, Daclin, Chapurlat, and Vallespir (2016) recommend implementers to pay specific attention to the data for the exchange during interoperability requirements verification.

Findings point out that a system is implemented in accordance to the 'intended system goal', that is to say, in accordance to the verified system design requirements. For instance, when the 'interoperability need' is mentioned among the system design requirements i.e. when the implementers have 'a collective interoperability design goal' then they implement interoperable systems otherwise the implemented systems will have no interoperability obligations. This critical factor of having a collective

interoperability design goal is supported by several authors though termed differently: 'overall integration strategy' (Lam, 2005) and 'objective of the integration' (Adebesin, Kotze, Ritz, Foster, & Van Greunen, 2014; Pagano, Candela, & Castelli, 2013; Panetto & Cecil, 2013). With reference to the stated interoperability definitions, the participating systems or entities must possess the capability to interoperate. Otherwise the designed systems will have no ability to interoperate since interoperability cannot just happen on its own (Agostinho & Jardim-Goncalves, 2009; eHealth Network, 2015).

The salience of having a collective interoperability design goal is to enhance the implementation of interoperable systems. As seen in the two case scenarios: 1) the BFR case were there was a collective healthcare interoperability objective of having a seamless radiology environment within VGR; 2) the Uganda case were there was no shared healthcare interoperability objective; several HIS were designed primarily to digitize processes. Findings indicate that the BFR project successfully attained seamless interactions throughout VGR region, whereas in the Uganda case the systems were standalone (non-interoperable). Thus, through the design attitude the thesis emphasizes the need of having a shared overall interoperability objective across the healthcare domain for mutual healthcare benefits across the continuum of care as exclusively discussed in Paper 4. Findings show that the collective objective to design for interoperability in the BFR case was arrived at upon acknowledgement of their data sharing challenges. Thus, through the proposed design attitude that aims at making things better, organizations can be inspired to improve the interoperability status (i.e. make things better).

Besides, the thesis emphasizes adoption of a design attitude due to its open mode of problem solving as opposed to the closed and deterministic classical management decision-making model (Boland & Collopy, 2004). In organizational studies, managing is an essential activity for the organization, where managers constantly plan, direct, organize and control operations to ensure accomplishment of organizational goals (Dale, 1965). However, the design attitude as presented by Boland and Collopy believes that true good alternatives can be arrived at through the rigorous problem solving design exercises of sense-making and decision-making

(Boland, 2008). Through the design attitude implementers can view and reflectively solve interoperability as a collective design activity that synthesizes the particulars of the context of interaction, through which they can compose context specific interoperability solutions. Through the proposed MaD approach to IS interoperability implementation, HIS implementers would embrace a design attitude in which they solve healthcare interoperability challenges through moments of sense-making and moments of decision-making, thus attaining a contextual view of interoperability.

7.1.3 Promotes Contextual Understanding

The bottom line of understanding the context of interaction is to enable determination of an appropriate interoperability principle (Hugoson et al., 2008; Solotruk & Krištofič, 1980). The thesis argues for a MaD perspective through which implementers can examine the context of interaction, make fundamental decisions, and determine an appropriate interoperability principle during moments of sense-making and moments of decision-making.

Every information system is implemented within a particular context that is different from any other context, which renders 'context' a constant critical factor for any information system implementation, as reiterated by this thesis and by (Doherty et al., 2012). The salience of context is highlighted by several scholars through the maxim 'context matters' for information system implementation (Axelsson & Melin, 2014; Holeman & Barrett, 2017). Not only does context matter in information system implementation but it matters even more when systems need to interoperate, thus the use of the term 'context of interaction'. Interoperability is said to be contextual (Novakouski & Lewis, 2012), and indeed Paper 2 findings point to context as a contingent factor that ought to be given utmost consideration during HIS interoperability implementation.

To facilitate contextual understanding, Papers 4- 5 proposes the application of sense-making. This is in agreement with (Weber & Glynn, 2006) and (Weick, 1995) who point to context as antecedents for sense-making. Thus, the MaD approach seeks to emphasize contextual understanding

through the sense-making framework (Paper 4). Through the sense-making framework, implementers move through their current *situations,* realizing interoperability challenges and deciding to improve the interoperability status quo by pursuing interoperability (having a collective interoperability design goal). In the pursuit of interoperability, implementers are faced with a number of questions, puzzles, muddles and confusions (which are referred to as *gaps*) in which they have to figure a way out by creating *bridges* over the identified gaps into agreed upon *outcomes* or horizons for interoperability improvement. Findings show that during moments of sense-making; implementers discover their current interoperability challenges, identify gaps and brainstorm on strategies, and during moments of decision-making; implementers take on important decisions such as deciding on an appropriate interoperability principle (Papers 4 - 5). Boland (2008) notes that these two fields are always in constant play in our everyday human actions for change as we try to 'make-sense' of the situation and 'decide' activities that improve that situation. Therefore, the MaD perspective promotes implementers' capabilities to analyze the context during moments of sense-making and to make critical decisions and determine an appropriate interoperability principle during moments of decision-making.

The study emphasizes the importance of determining an appropriate interoperability principle that takes into consideration the context of interaction, as seen in both case studies. In the Uganda case, since there were several standalone systems, respondents mentioned the use of APIs –application programming interface, and central servers for similar systems. According to Hugoson et al. (2008) when the systems are the same (replica) they can communicate through a unified interoperability principle. In the BFR case, an intersection principle (harmonization strategy through standards) was arrived at upon context analysis through the sense-making framework (Papers 4 - 5). It was deemed necessary to maintain existing systems and technologies and simply modify them by building an information infrastructure over them, thus the proposal of an intersection principle, where all systems subscribe to this central repository. Therefore, depending on the context of interaction a unified approach, intersection, or interlinking through use of modern interoperability technologies and

standards such as: cloud computing, block chain, information infrastructures or architectures could be adopted to create a communication link between participating entities.

The thesis is in agreement with previous scholars who note that examination of the context of interaction enables implementers to discover contextual factors (Leal et al., 2020; Rauffet et al., 2009), interoperability prerequisites (Chen et al., 2008) and most importantly determine an appropriate interoperability principle needed to design for information systems interoperability (Hugoson et al., 2008; Solotruk & Krištofič, 1980). For instance, once an appropriate interoperability principle was identified, BFR implementation proceeded successfully and various heterogonous HIS were integrated into a central virtual information infrastructure via the intersection principle. This is in agreement with Hugoson et al. (2008) who mention that there are higher chances of successful implementation once the interoperability principle is matched to the context of interaction.

To align the interoperability principle to the context, it is imperative to thoroughly understand the context of interaction at the various levels of interoperability. This is crucial to understanding several contextual factors that are critical to designing for HIS interoperability at the technical, organizational, semantic and legal interoperability levels. This is in line with the EIF definition and framework principles that call on organizations to agree to work together and interact by considering their information needs, ICT systems, and their business processes (European Union, 2017). Otherwise, once some interoperability levels are not thoroughly examined, there might be a likelihood of failed interoperability implementation due to an inappropriate interoperability principle.

Both existing literature and this thesis are in support of this notion, for example: at the technical level it is important to discover systems, devices, technologies and infrastructures that are critical when designing for HIS interoperability in a given context. Similarly, at the semantic level it is important to determine similar or same data formats and meanings across board, so that all participating entities get the same understanding of the shared or exchanged data. This is the essence of interoperability; that entities have the ability to exchange information and equally understand what has been exchanged (IEEE, 1990). Findings show that in both cases implementers examine existing structures such as HIS and technologies in use,

and the importance of defining the kind of information that needs to be shared – which was referred to as having an 'informatics focus vs a technology focus'.

The need for contextual understanding at the organizational and legal levels can be seen in both cases; whereby healthcare managers are encouraged to get involved in HIS interoperability implementation, adherence to policies is emphasized and collaboration among healthcare organizations. This is because managers hold the organizations' vision, and have the authority to enforce adherence to legal procedures. Having them on board, would lead to creation of solutions (HIS) that can meet overall healthcare interoperability objectives that are moreover aligned to the required legal procedures (policies, standards & guidelines). Overall, understanding interoperability at its various levels is supported by (European Commission, 2011; European Union, 2017; Leal et al., 2020).

To aid contextual understanding at the various levels of interoperability, this thesis proposes two guiding principles namely: minimum requirements principle and the informatics focus vs technology focus principle that could aid implementers in determining an appropriate interoperability principle aligned to the context of interaction. The minimum requirements principle helps the implementers to focus only on critical factors at the technical, semantic, organizational and legal levels that are needed for interoperability. As seen in the BFR case, the implementers focused only on the minimum requirements needed to have interoperability. This was one way of not overwhelming the involved parties. Alongside the minimum requirements principle, is the informatics focus vs technology focus principle that guides implementers to not only focus on the technology as is always the case, but to also pay attention to the required information for exchange. For instance in the BFR case, they primarily paid attention to the required information for exchange as opposed to the individual service systems. In other words, the service systems were seen as enablers not and end in themselves; they were secondary to the primary information required for exchange. With these two principles the involved parties were not overburdened, and the interoperability requirements were kept at the minimum to ensure smooth implementation. Jensen and Aanestad (2010) refer to a case where the interoperability implementation failed due to unrealistic targets and strategies and to being over ambitious. Overall, the two proposed principles are not the only principles, these are examples

of what was discovered during the investigation, they supplement other design principles discovered by previous scholars (e.g. European Union, 2017; Jensen, 2013).

7.2 Contributions

The contribution of this thesis is the development of a MaD approach to IS interoperability implementation that seeks to enhance organizations' capability to implement interoperable information systems through *contextual understanding* and *managing as designing* perspectives. Previous scholars note the need of interoperability implementation approaches (Hammami et al., 2014), thus this thesis responds to this need by developing both theoretical and practical knowledge in this regard. In addition, Holeman and Barrett (2017) call on scholars to unpack the term 'context matters'. This thesis attempts to address this call through the discovery of some critical factors to HIS interoperability implementation. Overall, the thesis contributes to understanding the dynamics of IS interoperability implementation not only in healthcare but also in similar complex contexts.

7.2.1 Contribution to IS Research

According to Gregor (2006) researchers can contribute knowledge in several ways. Inspired by Gregor this thesis contributes to the research community by re-contextualizing an existing perspective (managing as designing), and by drawing together two existing ideas (contextual understanding and managing as designing) and showing that the combination reveals something new and useful.

First, the theoretical contribution consists of a new stance on how HIS interoperability implementation can be enhanced through the MaD perspective. The salience of contextual understanding and managerial capabilities has been emphasized by previous scholars, but the proposal of a managing as designing perspective to enhance HIS interoperability implementation is a contribution by this thesis. In addition, the proposed MaD by Boland and Collopy (2004) seeks to inspire managers to manage as they design. However, this thesis seeks to inspire managers to collaborate

with system designers. As such, the thesis also reiterates context as a fundamental dimension of IS interoperability implementation.

According to Boland (2008), the MaD perspective has strong foundations in management and designing, design attitude, sense-making and decision-making lenses. Therefore, the proposed MaD perspective seeks to inspire implementers into a more reflective problem-solving attitude (design attitude), as opposed to relying on a rational decision-making model. The approach seeks to encourage managers to collaborate with system designers to manage and design for healthcare interoperability through the design attitude. Through the design attitude implementers (e.g. healthcare managers and system designers) can collaborate towards improving the interoperability status quo by solving interoperability challenges through reflective moments of sense-making and decision-making. The combined perspectives contribute knowledge on how to enhance HIS interoperability implementation while being reflective of the context particulars. In this way, a more contextual view of interoperability is obtained since this is a prerequisite for beginning to address interoperability challenges.

Second, the combined potential of contextual understanding and managing as designing perspectives led to the formulation of the MaD approach to IS interoperability implementation. As noted by Gregor (2006), the combination of these two exiting perspectives provided new insights on how to enhance IS interoperability implementation .

7.2.2 Implication for Practice

The proposed approach seeks to emphasize collaboration between healthcare managers and HIS designers to jointly improve the interoperability situation through the design attitude, by enabling context analysis during moments of sense-making and determination of an appropriate interoperability principle during moments of decision-making.

First, encouraging healthcare managers to collaborate with HIS designers and adopt a new attitude (i.e., design attitude) towards enhancing interoperability, contributes to the practicing community by creating an understanding that interoperability rests upon conscious design and management decisions. For systems to interoperate they must possess interop-

erability capabilities (IEEE, 1990), otherwise technology is not a panacea, just developing HIS does not guarantee their interoperation (Rahimi et al., 2009). Therefore, to meet overall healthcare interoperability needs, concerned parties need to pursue collective healthcare interoperability objectives during HIS implementation. The thesis emphasises this through the design attitude, the critical factor of having a collective interoperability design goal and through the informatics focus principle.

Second, the thesis highlights that managing is as important as designing through the managing as designing perspective that seeks to encourage healthcare managers to collaborate with HIS designers. Through this proposed approach they can together address healthcare interoperability challenges through the design attitude that is aimed at improving status quo. Having healthcare managers work closely with HIS designers would lead to the incorporation of overall healthcare interoperability objectives during local HIS implementation, and would eliminate the myth of leaving the HIS implementation process to the Information Technology department alone (Berg, 2001). This would also eliminate implementation of HIS in isolation, which usually end up as information silos. It was discovered that as healthcare/national authorities draft HIS interoperability implementation guidelines/policies they need to ensure that HIS designers at the local and actual implementation levels adhere to them. The thesis therefore argues for support of local HIS implementation by healthcare authorities in terms of financial support, overall coordination and monitoring since managers are organizational/institutional form givers.

Finally, the proposed approach promotes contextual understanding during moments of sense-making; through which implementers could analyse the current interoperability situation, identify existing gaps, and bridge them by proposing future interoperability design horizons. Practically during these moments of sense-making and decision-making implementers can analyse the context, make/enforce critical decisions and determine an appropriate interoperability principle to enhance HIS interoperability. For example, they can identify contextual factors at the technical, organizational, semantic and legal levels. Further, through the proposed *minimum requirements* and the *informatics focus vs technology focus* principles implementers could appropriate an interoperability principle to the context of interaction. Implementers could focus on minimum require-

ments for healthcare interoperability through an informatics focus principle. For instance, they can focus on the kind of information that needs to be shared across the healthcare sector (e.g. patient record) regardless of the individual service systems, because interoperability is only achieved when the shared data can be put to meaningful use.

In sum, the implications for practice entail that the proposed MaD approach to IS interoperability implementation seeks to support healthcare managers and HIS designers in adopting a holistic approach to healthcare interoperability implementation; by 1) setting a shared interoperability design goal, 2) analyzing the context of interaction to appropriate an interoperability principle and, 3) to jointly manage and design for overall healthcare interoperability.

7.2.3 A Summary of the Thesis Contribution

Table 6 shows how the research findings and the contribution relate to prior literature.

Table 6. Relationship of thesis contributions to study findings and prior literature

Findings	**Contribution**	**Literature**
The findings show that having a collective interoperability design goal can impel interoperability implementation.	Understanding that designing for systems interoperability is a conscious management and design goal that begins with the desire to improve interoperability status quo.	This finding is in agreement with previous research that emphasizes having an overall interoperability objective: (Agostinho & Jardim-Goncalves, 2009; eHealth Network, 2015; Pagano, Candela, & Castelli, 2013; Panetto & Cecil, 2013). Further, this finding agrees with Agostinho and Jardim-Goncalves (2009) and eHealth Network (2015) that interoperability cannot just happen on its own. However, no previous research has identified it as a conscious management and design goal.
There is need for management capabilities when designing for systems interoperability.	Understanding that when designing for systems interoperability managing is as important as designing. This activates the managing component that was rather missing during information systems interoperability implementation.	This finding responds to the call for management capabilities when designing for information systems interoperability (Benson & Grieve, 2021; Mondorf & Wimmer, 2017; Weber & Kuziemsky, 2019).
The findings highlight the minimum requirements principle and the informatics focus vs technology focus principle as essential decisions that guided the HIS interoperability implementation process. Emphasis on understanding the context of interaction in order to determine an appropriate interoperability principle aligned to the context.	The proposed minimum requirements principle and the informatics focus vs technology focus principle are among essential decisions that could guide implementers to examine the context of interaction at the various levels of interoperability and appropriate an interoperability principle to the context of interaction.	Thesis findings further emphasize the need for contextual understanding in order to align an appropriate interoperability principle just as (Chen & Daclin, 2006; Hugoson, Magoulas, & Pessi, 2008; Solotruk & Krištofič, 1980). These principles have been slightly mentioned by previous researchers including Blackstock and Lea (2013) and Quinn et al. (2011) who mention the importance of defining minimum information towards interoperability. However, the current research proposes these as guiding principles to contextual understanding in order to appropriate an interoperability principle to context. Furthermore, it is fundamental that the exchanged information is understandable and usable by participating entities (IEEE, 1990), thus through the informatics focus this need can be addressed. The proposed principles by this thesis supplement other principles in existence such as those established in these studies (e.g. European Union, 2017; Jensen, 2013).
The discovered critical factors to enhance HIS interoperability implementation: having a collective interoperability design goal, managing the interoperability implementation process, analysing the context of interaction and determining an appropriate interoperability principle.	Critical Factors to enhance IS interoperability implementation. Contributes to understanding context. Interrelated factors that led to the discovery of the potential in MaD	Findings are in agreement with scholars who emphasize the need for contextual understanding when designing for information systems interoperability (Chen & Daclin, 2006; Hugoson et al., 2008; Solotruk & Krištofič, 1980). The thesis addresses the call by Holeman and Barrett (2017) to unpack the maxim 'context matters'. The thesis integrates the discovered factors to arrive at more interesting results as recommended by (Doherty, Ashurst, & Peppard, 2012; Malinauskienė, 2013).

Findings	Contribution	Literature
Step-by-step interoperability implementation activities formulated into the proposed MaD approach to IS interoperability implementation.	New stance on how HIS interoperability implementation can be enhanced through a managing as designing perspective.	Fölster (2012), Henningsson (2008) and Panetto and Cecil (2013) note the lack of approaches to solve interoperability problems, and Hammami et al. (2014) mention the need of interoperability development methodologies and Daclin, Chen, and Vallespir (2016) mention the need for step-by-step procedures to guide the implementation of interoperable systems. This thesis meets these needs by proposing an approach to guide implementers in enhancing information systems interoperability.
	MaD approach to IS interoperability implementation. An approach that seeks to enhance systems interoperability implementation.	The proposed approach combines management and designing perspectives. This finding is in agreement with Urbach et al. (2019) who call for collaborations between management and designing departments for joint innovations.
		Findings are in agreement with Hjort-Madsen (2006) who advocates for collaboration between Healthcare managers & HIS designers to enhance HIS interoperability.
	An approach that advocates for change of attitude from rational decision-making to adoption of a more reflective design attitude during HIS interoperability implementation.	Thesis findings are in agreement with scholars like Plattner, Meinel, and Weinberg (2009), who advocate for design thinking approaches into systems development methodologies. However, the current research proposes the integration of the design attitude into IS interoperability.
	Extending the application of sense-making in aiding implementers to understand the context of interaction during information systems interoperability implementation.	According to Weber and Glynn (2006) and Weick, (1995) the antecedents for sense-making is context. Thus the current findings are in agreement that context can be understood through sense-making, and extends the application of sense-making to systems interoperability.
	Consequently, through the proposed MaD approach to IS interoperability implementation, implementers can enhance systems interoperability through contextual understanding and can holistically manage and design interoperable systems.	Rauffet, Da Cunha, and Bernard (2009) mention of context analysis, and designing and managing through organizational capabilities and roadmaps. Boland and Collopy (2004) propose the MaD approach, but no previous studies have extended its use to IS interoperability. Thus, the thesis extends the application of the MaD approach to IS interoperability and proposes its use for both managers and system designers.

7.3 Limitations and Future Research Opportunities

To promote further research, the thesis highlights three focal limitations that can motivate future studies.

First, though the research was conducted in different countries, it did not take into consideration the differences in these settings. These countries are at different levels of development and with quite different cultures, a consideration of which would revealed useful insights into how differences in culture and setting influence IS interoperability implementation. However, the two countries displayed differences in their levels of commitment to interoperability implementation in healthcare. The BFR case in Sweden was a project committed to pursuing interoperability within radiology departments, yet in Uganda there was no observed interoperability project within healthcare. In the BFR case the political and regional healthcare managers were committed to achieving regional interoperability within radiology departments, while in the Uganda case this was not the case. As mentioned above, the research did not investigate what attributed to these differences. Future research could investigate how cultural and other differences in contextual setting influence IS interoperability implementation. In regards to this, the institutional theory that was introduced in Paper 3 could be explored further to assess its potential in contextual understanding.

Second, the empirical investigation was limited in coverage, only one case (BFR) was considered from Sweden, and only five health information systems were considered from the Uganda case, though these case studies were quite representative. BFR was considered a successful interoperability project, but the Uganda case was not entirely an interoperability project, so the cases provided examples from different but varied contexts. A consideration of several other interoperability cases would have facilitated additional insights. There lies an opportunity for future research to generate IS interoperability implementation knowledge.

Third, the Managing as Designing (MaD) perspective was originally developed to inspire managers to incorporate design into their management activities; however, this research proposes its usage for both managers and designers. Moreover, the proposed approach has not been explicitly evaluated as it was used at an analytical level within this research. Future

research is needed to empirically evaluate its full potential to increase its relevance to practice (Baskerville & Myers, 2004). For instance, action research methods could help further modify the resulting MaD approach to IS interoperability implementation.

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APPENDICIES

Appendix A

Generating data categories for the Uganda case.

Uganda Case Empirical Observation	Implications (basis for contextual factors in paper 3)	Implied Critical Factors to Enhance HIS Interoperability Implementations
Respondents pointed out that they usually implement new HIS to meet certain needs. Sometimes according to client needs, developer needs, patient needs, ministry needs or to address specific donor needs, i.e. systems are designed according to user needs (according to the intended system goals). In terms of interoperability if the users need it we take care of that need during the system implementation process. However, several HIS are designed to improve records keeping, to move from paper based to computerized processes.	The intended system goal is a determinant factor. Several existing HIS do not necessarily address interoperability needs, and many of them are non-interoperable. Realization of focusing on interoperability as a design goal	Having a collective interoperability design goal
Implementers examine context before new system implementations. For example they assess existing systems, interoperability policies, standards, implementation guidelines and legal requirements. During system implementation, they follow standard procedures for systems development. They work in development teams, they follow both local and international development standards where necessary. They also take into consideration the status of the health center whether public or privately owned. This is because HIS usage in public healthcare units is highly regulated as opposed to private ones. Again private healthcare unit tend to own their data and are not very much interested in data sharing or exchange.	Analyse the context before system design. To asses system requirements. To specifically examine existing systems and other pressing contextual factors e.g interoperability policies, standards implementation guidelines. Enforce and follow required/legal procedures both guidelines and policies. Institutional autonomism affects interoperability implementations.	Analysis of the context of interaction to identify contextual factors critical to designing for HIS interoperability. Adherence to policies and agreements

System implementers noted the lack of interoperability supportive structures like policies, standards, and implementation guidelines. They also noted the lack of skilled labour and lack of support and monitoring by healthcare authorities when it comes to HIS interoperability implementations. Further, a number of the developed systems were donor funded or commercial systems. Thus the HIS initiatives within the country were not coordinated or even monitored and as a result there are several silos, fragmented HIS within the country. Ministry of health officials noticed their lack of involvement in the country's ongoing HIS initiatives as there were many silos HIS developed within the country without their notice and involvement. However, the ministry of health advocates for interoperability through the development of supportive structures and policies like the interoperability architecture and the eHealth policy, they also all HIS to interface with the national system DHIS II.	Planning for interoperability and managing the entire project. Having healthcare managers collaborate with HIS designers to jointly manage and design interoperability. Installing skilled labour and establishing stable funding.	Managing the implementation process
Several HIS are designed with no interoperability obligations, however, when an integration is needed respondents mentioned that they would apply interoperability standards such as APIs. They would also apply local or international interoperability system implementation standards and guidelines. For example three of the studied systems specifically (nganisha, clinic master, helecare2x) were implemented to deliver a single patient record at a facility level (i.e. no other systems in use only one system in use at all the departments within a health facility). However, if a hospital has a functional system at a given department they envisioned integration through application of interoperability technologies/standards. For example for clinic master and nganisha systems implementers envision installing central severs at data centers. Respondents also noted the lack and need of a national standard patient ID and patient record format to enable traceability of a patients at any healthcare center regardless of the individual HIS in use.	The implementers look out for interoperability implementation guidelines, policies and standards to design for interoperability whenever need arises.	Identifying an appropriate interoperability principle and proceed with system implementation

Appendix B

Generating data categories for the BFR case

BFR Case Empirical Observation – analysed through moments of sense making and moments of decision making. Through the sense making concepts of situation, gaps, bridges & outcomes	**Implied activities to designing for HIS interoperability inspired by the implementers' step by step procedures (basis for paper 5)**	**Implied Interoperability Prerequisites (basis for paper 4)**	**Implied Critical Factors to Enhance HIS Interoperability Implementations**
Moments of Sense-Making: (situation) Ongoing interoperability thoughts: acknowledgement of past and present actualities. Realization of data sharing and exchange challenges within radiology departments in Västra Götaland Region. Challenges of accessing up-to-date patient records at the main teaching hospital Sahlgrenska.	Acknowledgement of past and present data sharing and exchange challenges	Knowing what	Discovering interoperability need
Moments of Decision-Making: (bridge/outcome) Decision to improve status quo. A collective decision to design for interoperability among all radiology departments within Västra Götaland Region was central.	Taking a collective conscious decision to design for healthcare interoperability	Knowing what	Having a collective interoperability design goal
Moments of Sense-Making: (gaps/bridges) Thoughts about funding: Regional Top managers had secured funds for the entire BFR project & fully in support of the project. Thoughts about personnel: competent implementation team put in place, managers and HIS designers were brought into collaborative teams. Thoughts about change: BFR team had to convince all stakeholders that BFR would promote seamless data exchanges in order to minimize resistance to changes.	Secure funding. Form a highly experienced team with both management and technical competence and encourage managers to work with system designers. Manage process: Managing change, people and resources.	Knowing who Knowing how	Managing the interoperability implementation process
Moments of Sense-Making: (gaps) Thoughts about existing systems, analysis of all radiology HIS within Västra Götaland Region. Realisation of; existence of non-interoperable systems, inconsistent data formats & exchange standards, inconsistent 'digital imaging and communications in medicine' standard, different vendors and stakeholders, lack of a uniform patient record to be shared, inconsistence Patient ID format, etc. Thoughts and insights about pressing factors, analysis of security, privacy, policies, legal requirements, HIS implementation guidelines and standards in regards to interoperability.	Analysis of all HIS in existence alongside other contextual factors like policies in regards to designing for HIS interoperability.	Knowing what	Analysing the context of interaction

Moments of Sense-Making: Thoughts about the new system: **(bridges/outcomes)** Adherence to strict 'digital imaging and communications in medicine' - standard format and other agreed upon relevant standards e.g. HL7. Enforcement of strict patient ID format. Creation of minimum data record to be shared, Definition of mandatory and optional fields. Applying minimum requirements principle, and having an informatics focus vs technology focus	Enforce strict adherence to 'agreed' upon formats, standards, requirements and methods in regards to interoperability. (enforce adherence to design-decisions), such as the minimum requirements principle and the informatics focus vs the technology focus	Knowing which	Analysing the context of interaction
Moments of Decision-Making: (bridges/outcome) Depending on the context of interaction, a decision to harmonize the data was reached which is an intersection interoperability principle. A decision to design a 'central repository' system was reached. All other systems would post the required patient radiology data for archiving into the central repository. Upon determination of an intersection principle BFR designing commenced.	Determine an appropriate interoperability principle depending on the context of interaction Implement system, deploy it and maintain it	Knowing how	Determining an appropriate interoperability principle
Moments of Sense-Making: Thoughts about BFR: a functional BFR, patient data sharing and exchanges within the region are possible by anyone, anywhere and anytime. Updated patient imaging record within the region.	Enjoy interoperability benefits of the developed system. Post maintenance and improvement horizons		Continuous management - Post implementation

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