An Implementation Process of Interoperability: A Case-Study of Health Information Systems (HIS)

Grace Kobusinge *grace.kobusinge@ait.gu.se*
University of Gothenburg
Gothenburg, Sweden

Kalevi Pessi *kalevi.pessi@ait.gu.se*
University of Gothenburg
Gothenburg, Sweden

Dina Koutskouri *dina.koutskouri@ait.gu.se*
University of Gothenburg
Gothenburg, Sweden

Raymond Mugwanya *ray.mugwanya@gmail.com*
Makerere University
Kampala, Uganda

Abstract

Several advances have been made towards health information systems (HIS) use and implementations. However, these advances have not been matched by equal advances in HIS interoperability implementations. Current challenges in this domain are partly due to lack of implementation knowledge hence resulting into a number of failed HIS interoperability implementations. To gain substantive implementation knowledge on HIS interoperability projects, we have carried out interviews through an interpretive case-study approach to investigate a successful HIS interoperability project. Through this approach we propose an initial set of HIS interoperability implementation best practices comprising of these key processes: discovering interoperability need, projecting outcome, managing change and adopting an appropriate interoperability strategy which together depict a contingence management relationship. We conclude that this initial set of best practices contributes substantive knowledge that can guide future HIS interoperability implementations.

Keywords: Health Information Systems, Interoperability Implementation Process, Interoperability Strategies.

1. Introduction

Health Information Systems (HIS) have greatly enhanced health information processing and decision making within healthcare [1], [2]. Consequently, most federal governments and states have adopted health information technology to meet their information processing and decision making needs [3, 4]. This growing use of health information systems consequently calls for major advances in effective strategies to implement successful HIS that can met healthcare information needs. According to Berg [5] the use of HIS can help health facilities met their primary and secondary care needs. But these systems should be interconnected in order to offer comprehensive and holistic healthcare services, since according to Abbott and colleagues [6] the success of a system highly depends on the way it was implemented. However, current advances in HIS use and implementations have not been matched by equal advances in HIS interoperability implementations. By the standard IEEE interoperability definition, systems are

interoperable if they are able to share, exchange, and use the exchanged information [7]. Yet, HIS operate in silos and are non-interoperable [1], [8], [9], [10] and therefore cannot share and exchange health information [1], [11], [12] across contexts.

This is because they are built in isolation due to lack of clear implementation guidelines and concerted efforts to implement interoperable HIS [6], [13], [14], [9]. Until now, renowned holistic implementation approaches that foster HIS interoperability [15, 16], [17], [10] and collaboration among healthcare centers are limited. Very often during the HIS interoperability implementation process organizations face interoperability challenges due to limited solution sets [18], [19] [20]. Consequently, a number of HIS implementations have ended up unsuccessful, and this has resulted into a pool of failed HIS implementations [5, 21], [22], [23] failed HIS interoperability implementations [11], and wasted resources [15], [24]. Extant literature shows related works on HIS implementations and adoptions [6], [5], [17], [25], but lacks research focusing on HIS interoperability implementation processes [26] and on different interoperability strategies [24]. Interoperability strategies are mechanisms that can establish a communication link between interested parties [27]. Therefore, during HIS implementations discussions on the kind of interoperability strategies to adopt should be given utmost consideration. In order to understand the HIS implementation process, several authors including [6], [28] have called for empirical studies to provide a set of best practices. This is because empirical studies help researchers to create well-founded and informed decisions [29].

Against this background, our empirical study followed a successful HIS interoperability implementation project that covered radiology imaging centres within Västra Götaland Region (VGR) in Sweden. The aim was to gain an understanding of the kind of processes involved in HIS interoperability implementations and propose an initial set of HIS interoperability implementation best practices. Subsequently, this was realized by identifying critical incidents that influenced the BFR implementation process and their relationship, since according to Rowlands [30] critical incidents are key events that impact a particular phenomenon either positively or negatively.

The rest of this paper is structured as follows. Section 2 presents related literature and section 3 presents the methodology used. The findings are detailed in section 4 followed by a discussion of the research findings in section 5. Conclusion and future works are then presented in section 6.

2. Related Literature

2.1. Interoperability Overview

Current interoperability body of knowledge is commonly represented in terms of frameworks, models and theories [31]. Renowned interoperability frameworks, models, interoperability maturity and reference levels are well summarized by [32], [31]. Interoperability frameworks often conceptualize possible courses of action, interoperability models represent abstractions of objects and interoperability theories explain interoperability design model solutions and interoperability reality [31]. However, frameworks, models and theories are at a high level definition rather than practical. Instead, [27] do recommend consideration of interoperability strategies in order to practically establish a communication link between participating entities. Indeed, several researchers have rigorously formulated various frameworks, models and strategies to overcome interoperability challenges. However, until now interoperability remains a critical challenge for participating entities intending to interoperate their systems [33]. Consequently many authors call for more research focusing on the generic nature of interoperability in order to overcome its' challenges [34], [32] and enrich the interoperability science body of knowledge [31].

2.2. Information System Interoperability Strategies

Interoperability is the ability for two (or more) systems or components to exchange information and to use the information that has been exchanged [7]. An information system (IS) interoperability strategy is a communication link that enables entities to interoperate [27]. Considerable care should be taken in choosing an interoperability strategy that aligns with the participating entities, as a mismatch may lead to failed IS interoperability implementations [35]. This paper discusses three interoperability strategies according to Hugson and Solotruk [36], [27] as follows: i. Unification: a strategy that produces unified information space for the participating information systems. This is made possible through 'one common systems' principle (participating systems are merged into physically one system) or 'replication' principle (inner structures, content and functions of the participating systems are standardized into many replicated systems). ii. Intersection: a strategy where the goal is to create a common shared information space by eliminating redundancies and duplications in participating systems. Intersection promotes sharing of identical system properties [27]. iii. Interlinking: a strategy where the goal is to promote interaction between participating systems by exchange of messages. Here interoperability is achieved with no interference on the involved systems.

2.3. HIS Interoperability Implementations

According to Sagiroglu and Ozturan [37] HIS practical implementations are more difficult than other information systems implementations in other sectors. Particularly because health information system implementations are complex socio-technical networks [6], [5, 21], [8]. To control socio-technical networks and HIS implementation failures, a number of authors have highlighted the need for holistic implementation approaches [6], [16], [8], [10]. Currently there is a high rate of failed HIS interoperability implementation projects [11] and failed HIS implementations [5], [38], [26] due to the limited literature addressing HIS planning –execution gap [17], [25] and HIS holistic implementation processes [6], [15]. Extant literature further reveals the lack and need of research addressing HIS interoperability implementation [14]. According to Abbott and colleagues [6]more empirical HIS implementation studies are needed to inform and improve HIS implementation processes by offering adoptable best practices. Similarly HIS interoperability implementation studies are needed to enlighten and improve HIS interoperability implementation processes by offering adoptable best practices since HIS interoperability research is limited within the related literature.

3. Research Methodology

3.1. Research Perspective

The study followed an interpretive case study perspective [39] by conceptualizing participants' responses [40] in order to clearly understand key events [30] that impacted the HIS interoperability implementation process. The case study and interpretive approaches were relevant for this study to capture participant's descriptions of the major project critical incidents. This process constructed understanding of the HIS interoperability implementation process by interpreting participants' descriptions.

3.2. Study Setting

Our study followed the case of Västra Götaland Region (VGR) in West Sweden that was implementing a single virtual central repository for critical imaging information referred to as the 'VGR radiology information infrastructure' termed as BFR (Bild- och funktionsregistret) in Swedish, henceforth the case will be referred to as BFR. The Västra Götaland Region is the second largest region in Sweden with an average of 1.5 million residents operating 17 hospitals, 121 healthcare centers and 170 public dental care centers. The major participating imaging healthcare centers are the 17 hospitals from VGR. Within VGR, Sahlgrenska University Teaching Hospital in Göteborg, the largest hospital in Northern Europe is at the centre of the

health network and provides specialized radiology services in the region. Sahlgrenska University Teaching Hospital in its' quest to meet both the present and future patient needs, advocated for the implementation of a single VGR radiology information infrastructure -BFR that would improve information transparency, harmonize patient medical history and increase efficiency [41]. We therefore chose BFR as our case study as it was deemed a successful HIS interoperability project by the implementers and it had been in operation for over 12 years. BFR was considered successful because it fulfilled its' intended goals of seamless information sharing by interoperating various heterogeneous information systems of the different radiology departments within the region.

3.3. Study Participants

The study involved four participants who were BFR project implementers from Sahlgrenska University Teaching Hospital. They included the Chief Information Officer-CIO-BFR project, Chief Medical Information Officer of VGR and two Radiologists. Our first participant was the Chief Information Officer-CIO-BFR project who proposed and introduced us to other members of the BFR implementation team. We were reliably informed by one of our respondents that the core BFR implementation team consisted of only four people, so our respondents were inclusive of all members of the implementation team and they were key informants as in Table 1.

Table 1. Details of interview respondents.

Respondent	Tittle held by key informant respondent	Interview duration in minutes
R1	Chief Information Officer (CIO- BFR)	63:30 m
R2	Chief Medical Information Officer of VGR	55:00 m
R3	Radiologist at Sahlgrenska University Teaching Hospital	38:11m
R4	Radiologist at Sahlgrenska University Teaching Hospital	40:00m
R5	Chief Information Officer (CIO- BFR)	40:00 m

3.4. Data Collection

Data was primarily collected through in-depth interviews, workshops and regular formal and informal meetings with key informants. Two workshops that brought together the researchers and some members of the implementation team were held to gain an understanding of what happened during BFR implementation. There was an initial workshop before the interviews and another workshop to confirm and supplement interview findings. In-depth interviews were carried out to gain an understanding of critical incidents that happened during BFR implementation process. In each interview recording permission was granted after building rapport, and each session lasted approximately 60 minutes. During the workshop and interview discussions respondents described critical incidents that were significant during the BFR implementation process. Furthermore, Regular meetings were carried out between the researchers and the Chief Information Officer (CIO- BFR) to gain a deeper understanding and confirmation of critical activities carried out during the implementation process. These were validity checks for credibility, transferability, dependability and confirm-ability as recommended checks for qualitative data [30]. Secondary data included 'General Electric' BFR company documents and BFR implementation planning, progress, annual, and status reports that were reviewed to have an overview of the entire BFR project and to cross check validity of the collected text data. General Electric Company is the company that partnered with VGR to develop the regional radiology information infrastructure [41].

3.5. Data Analysis

Data analysis was based on the general inductive approach [42] to generate an understanding of the critical incidents in the studied implementation project. The first stage of analysis

consisted of reading the interview transcripts several times to make sense of the situations and the themes discussed during the interviews. In this phase, we were able to infer an initial set of categories which illustrated critical incidents linked to the BRF implementation process. Second, we then went back to the data and once again examined the identified critical incidents and further refined them. We initially identified nine categories that were later refined into four final categories namely: 1) Discovering interoperability need, 2) Projecting outcome. 3) Managing change 4) Adopting an appropriate interoperability strategy.

4. Findings: Critical Incidents

From the interviews we identified key processes that formed four critical incidents as described in the sub-sections that follow.

4.1. Discovering Interoperability Need

Respondents perceived that the challenges faced before BFR implementation were key drivers to its implementation. These major challenges including but not limited to: missing information for referred patients, vendor specific use of standards and silos heterogeneous systems by the different imaging centers within VGR, problems getting data from the small hospitals, problems of sharing imaging information between imaging centers, problems of travelling long distances to deliver imaging information whenever needed, and problems of time wastage as one waits for the delivery. This is evident from the verbatim quotes by our respondents regarding data sharing challenges.

Respondent R4: *"We could not share them, we had many departments using film, it was impossible to share, when we wanted to see something we had to phone, ask for an examination someone had to go to the archive and send it by some ordinary transport maybe taxi took about 3-4 days, to receive the images."*

Respondent R3: "Even if we were having data images as digital data it was tough to ***communicate data***. *Even vendors out in the region were reluctant to store data in the appropriate format"*.

Faced with accessibility and data sharing challenges the main referral and teaching university hospital that provides specialized radiology services across Europe needed to find a smart interoperability solution. Hence the top management at the university teaching hospital took a major decision to implement a virtual VGR radiology information infrastructure (BFR) for all vital imaging related information by interoperating the different heterogeneous systems. This is evident from the verbatim quotes based on opinions by our respondents.

Respondents R3 *"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* ***we decided to install****, to buy and install a common central archive that was vendor neutral". "So at Sahlgrenska* ***we decided to buy storage and archive*** *that was the same for this town Gothenburg"*.

Respondent R1:"*Upper management decided that,* ***all x-rays*** *produced in the region should be* ***digital"****.*

4.2. Projecting Outcome

In order to succeed in BFR implementation, top project managers had to sell BFR's interoperability vision to all stakeholders involved. This involved using soft skills to effectively talk about the benefits from its implementation. Consequently, the decision to implement BFR was highly embraced by imaging departments since they anticipated seamless collaborations. For example, upon successful BFR implementation there would be a total revolution in the imaging world in terms of data management and sharing. Below are some of the excerpts from respondents' verbatim quotes.

Respondent R1:*"Saying we from an organizational point of view said it was interesting to* ***keep a centralized view of the patient****." "Nobody said no when we could give them* ***all the exams that was done on the patient****, the radiologists felt more secure". "We guaranteed that every time you store something in the infrastructure, we guaranteed that you will get back".*

Respondent R3: *"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".*

Interestingly, the participating departments finally experienced the anticipated seamless collaboration as at the time of this study, BFR had been in existence for close to 12 years. This is evident from the verbatim quotes by our respondents.

Respondent R4: *"Well it was a revolution; with BFR we had everything in the same place. We had a possibility with a broad view to take part in the other hospitals examinations as well. I could search for the pictures there and compare what I see now with what happened with the patient for the last time they were at the local for example, so we have everything in the same place, of course it is not only that, you can look at the pictures at the same time, we can collaborate".*

Respondent R5: *"The interesting thing when we connected BFR we just did one connection and connected 32 departments, that was good".*

Respondent R2: *"We were the only one who had the report and image together we had that for the very first time since we started to have digital information we had everything online."*

4.3. Managing Change

Many respondents emphasized the presence of a well-planned change management strategy during the implementation process. Very often information technology projects face resistance, so for BFR project top managers were well prepared to handle any anticipated resistance. Below are some of the excerpts from respondents' verbatim quotes regarding managing change.

Respondent 2 *"We focused mainly on the information and on information sharing, data sharing, and also that we had experience from the x-ray domain prior to this, so we know all the challenges with in".*

Respondent R2: *"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". "So we can create a virtual x-ray department, a regional watch virtual one and* ***we do not need to change the organization at all****."*

This strategy of managing change was devised by the implementation team from the project onset in order to handle the imaging departments, and other stakeholders like the vendors. Originally, when BFR project was introduced to all stakeholders it was observed that the vendors did not welcome the idea, because they were required to re-engineer some of their products/services. This is one of the reasons why the implementation team had to devise a strategy to manage change and resistance right away. Below are a few respondents' verbatim opinions to express the resistance and how it was handled.

Respondent 2 *"You have a standard consisting of vendors participation from vendors and they do not want to do any re-engineering they want to use their product and then it is a negotiation". "There always standardization that you need to use to have their cooperation otherwise each vendor will be stuck with their solutions".*

Respondent 3 *"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".*

Strategies to manage vendor resistance included

Respondent 2"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".

Respondent 1 *"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"*.

Expediently, the team was experienced in project management and thus employed a number of change management tactics as seen from the respondents' perspectives. They included: path dependency -promoting and improving what was in existence, soft communication skills, convincing and motivation strategies, step-by-step innovations, and stakeholder management. In particular one major sub category of 'change management' was 'path dependency'. This was a technique of *'change without change'* as one of the respondents put it. This strategy was in other words promoting change in a step-by-step procedure. Therefore, new changes were in support of existing technologies and frameworks and could simply be modified to fit the new mode of operation. Below are some verbatim opinions on the path-dependency tactic.

Respondent R1: *"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 DICOM standard." ".we said to the local department, but guys you **do the same** way you have always done."*

Respondent R2: *"They didn't need to change anything internally, for the local people it did not change anything"*

4.4. Adopting an Appropriate Interoperability Strategy

An interoperability strategy is important to establish a communication link. In BFR the top managers decided to install one central imaging repository. This is a strategy in itself that called for execution. So the experienced team managers had to look for a way of harmonizing the data that should be exchanged and stored in the central repository. So the data harmonization strategy by use of standards was adopted. Most respondents expressed the importance of identifying appropriate interoperability strategies during HIS interoperability implementations that are mindful of the context. Like in the BFR context most standards like Digital Imaging and Communication in Medicine (DICOM) were already in use, so it was appropriate to follow the same path.

The adopted data harmonization strategy was aimed at ensuring that all the participating radiology departments use the same terms of reference to enable their different heterogeneous systems to easily communicate and understand each other. This strategy ensured that the participating systems share common data in a standardized format. From the respondents' perspectives, data harmonization characteristics included: identification of minimum vital data, standardization of vital data only, metadata development and strictness of the set standard rules. Below are a few opinions from respondent's verbatim quotes.

Respondent R4:*"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**". "As I said we set the rules of specified amounts of information with **common terms and concepts** that is what we did we built a model together"*.

Respondent R5: *"We say if you are going to do this you need to **accept DICOM** as the mechanism of sharing or distribution" "But we had a very strict rule it (Patient Identification number -PID) should be twelve digits nothing else"*.

Respondent R3: '***Use of standards it is mandatory**, we had to tighten the use of the DICOM standard". "We allowed hospitals to have different systems but we said you have to store in a standardized way"*.

5. Discussion: Initial Set of Best Practices

In this section, we discuss how the identified critical incidents and the relationships between them (see Figure 1) contribute to the initial set of best practices.

The first incident of discovering the need for interoperability reflects pre-BFR and BFR initiation phase. This implies that interoperability implementations depend on context [20], [43]

and the need to the change status quo. In this case the need for interoperability was discovered from the data sharing challenges that were being faced [44]. The poor data sharing practices forced them to search for new data sharing solutions, thus the decision to implement BFR- one central repository for all imaging solutions [41], [45]. This decision was well embraced by the imaging departments since the projected outcomes were made known to them. Participating imaging departments were highly motivated for the implementation as it promised positive seamless collaborations, although the system vendors needed more discussions to be on board. Subsequently, the BFR project kick started with a notion to manage change and any anticipated resistance right away, since great management techniques reduce anticipated resistance and lead to quality project outcomes [46]. In BFR, a particular important technique to manage resistance was path dependence [47], whereby there was emphasis on using and promoting existing technologies like Digital Imaging and Communication in Medicine (DICOM), Health Level Seven standard (HL7), Picture Archive Communication Systems (PACS) and Radiology Information System (RIS) [44]. This implies that good change management skills are key in the HIS interoperability implementation process [45]. Furthermore, during the implementation phase an appropriate interoperability strategy was adopted in order to create a communication link between participating systems [27]. So for BFR the strategy adopted was the 'use of standards' [13] through data harmonization. The data harmonization strategy [48] emphasized the use of strict vital DICOM-standard, same metadata for vital information [45], different heterogeneous systems but all store the same vital data in the same way [41] [45]. This is a characteristic of the 'intersection interoperability strategy' mentioned by [36], [27] as a strategy that promotes sharing of identical system properties. Therefore, during HIS interoperability implementations appropriate interoperability strategies should be adopted to create communication links between participating systems.

Furthermore it was discovered that these incidents relate to each other in a covariance-contingent-consequence relationship because in such a relationship the outcome/consequence of the intervention highly depends on the contingent conditions [49]. Likewise in the BFR case the first incident of discovering the need for interoperability leads to the decision to implement BFR in order to improve the data sharing practices. As the implementation team discusses about this new interoperability proposal and its benefits, the imaging departments embrace the proposal and the implementation starts. However, despite some challenges, the implementation team contingently manages the project to success. Just as in any action led project where the prevailing conditions greatly determine the outcome [50]. Consequently, in BFR the contingent conditions that led to success included great change management skills, path dependence and adoption of an appropriate interoperability strategy.

This discovered incident relationship depicts that the success of any project implementation highly depends on contingence management. Therefore, for HIS interoperability implementations contingence management skills employed and interoperability strategies adopted greatly impact the project outcome. This study therefore, has identified critical incidents and their relationship to each other as shown in Figure 1, which together form the initial set of HIS interoperability implementation best practices.

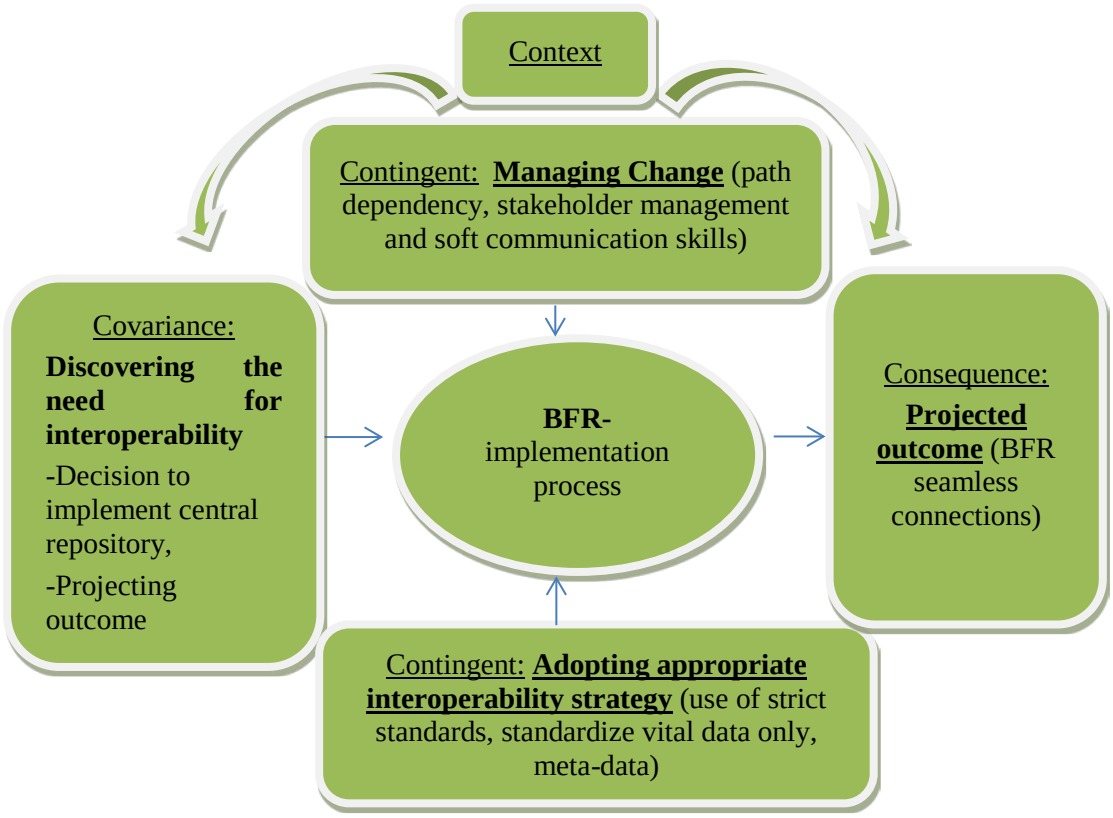

Fig. 1. Initial set of HIS interoperability implementation best practices.

6. Conclusion and Future Research

This study examined the implementation process of one successful HIS interoperability project. Through an interpretative case study approach, the study revealed four critical incidents that were fundamental in the project implementation namely: discovering interoperability need, projecting outcome, managing change and adopting an appropriate interoperability strategy. The study further revealed the concept of contingence management as depicted from the relationship between the identified critical incidents. Consequently, this study concludes that the critical incidents and the concept of contingence management together can form the initial set of HIS interoperability implementation best practices. Subsequently, this initial set of best practices can enlighten future HIS interoperability implementations and should be further investigated.

References

1. Adebesin, F., et al., *A review of interoperability standards in e-Health and imperatives for their adoption in Africa.* South African Computer Journal, 2013. **50**(1): p. 55-72.
2. Masethe, H., et al. *Integration of Health Data using Enterprise Service Bus*. in *Proceedings of the World Congress on Engineering and Computer Science San Francisco*. 2013.
3. Unertl, K.M., et al., *Bridging organizational divides in health care: An ecological view of health information exchange.* JMIR medical informatics, 2013. **1**(1).
4. Walker, J., et al., *The value of health care information exchange and interoperability.* Health affairs, 2005. **24**: p. W5.
5. Berg, M., *Implementing information systems in health care organizations: myths and challenges.* International journal of medical informatics, 2001. **64**(2): p. 143-156.
6. Abbott, P.A., et al., *Complexity and the science of implementation in health IT—knowledge gaps and future visions.* International journal of medical informatics, 2014. **83**(7): p. e12-e22.
7. IEEE, *(Institute of Electrical and Electronics Engineers).: Standard computer dictionary a compilation of IEEE standard computer glossaries.* 1990.
8. Bygstad, B., O. Hanseth, and D.T. Le. *From IT Silos to Integrated Solutions. A Study in E-Health Complexity*. in *ECIS*. 2015.
9. Jardim, S.V., *The electronic health record and its contribution to healthcare information systems interoperability.* Procedia Technology, 2013. **9**: p. 940-948.
10. Naudet, Y. and D. Chen, *eHealth interoperability evaluation using a maturity model*. Quality of Life Through Quality of Information: Proceedings of MIE2012, 2012. **180**: p. 333.
11. Benson, T., *Principles of Health Interoperability*. HL7 and SNOMED. 2010: Springer London.
12. Otte-Trojel, T., et al., *Characteristics of patient portals developed in the context of health information exchanges: early policy effects of incentives in the meaningful use program in the United States.* Journal of medical Internet research, 2014. **16**(11): p. e258.
13. Barbarito, F., et al., *Implementing standards for the interoperability among healthcare providers in the public regionalized Healthcare Information System of the Lombardy Region.* Journal of biomedical informatics, 2012. **45**(4): p. 736-745.
14. Heavin, C., *Health Information Systems–Opportunities and Challenges in a Global Health Ecosystem.* Journal of the Midwest Association for Information Systems| Vol, 2017. **2017**(2): p. 1.
15. Adenuga, O.A., R.M. Kekwaletswe, and A. Coleman, *eHealth integration and interoperability issues: towards a solution through enterprise architecture.* Health information science and systems, 2015. **3**(1): p. 1-8.
16. Alkhaldi, B., et al., *Barriers to implementing eHealth: a multi-dimensional perspective.* Studies in Health Technology and Informatics [e-Health-For Continuity of Care], 2014. **205**: p. 875-879.
17. Cresswell, K. and A. Sheikh, *Organizational issues in the implementation and adoption of health information technology innovations: an interpretative review.* International journal of medical informatics, 2013. **82**(5): p. e73-e86.
18. Fölster, S., Hallström O., Morin A., Renstig M (2003) *Den sjuka vården. Stockholm. Ekerlids in Jin, Ai Ahlfors, Lars "Interoperability in electronic medical records"*. Department of informatics, Lund University, 2012.
19. Henningsson, S., *Managing information systems integration in corporate mergers and acquisitions*. Vol. 101. 2008: Lund Business Press.
20. Panetto, H. and J. Cecil, *Information systems for enterprise integration, interoperability and networking: theory and applications*, 2013, Taylor & Francis.

21. Berg, M., *Patient care information systems and health care work: a sociotechnical approach.* International journal of medical informatics, 1999. **55**(2): p. 87-101.
22. Bush, M., et al., *The alignment of information systems with organizational objectives and strategies in health care*. International journal of medical informatics, 2009. **78**(7): p. 446-456.
23. Oak, M., *A review on barriers to implementing health informatics in developing countries.* Journal of Health Informatics in developing countries, 2007. **1**(1).
24. Legner, C. and B. Lebreton, *Preface to the focus theme section:'business interoperability'business interoperability research: present achievements and upcoming challenges.* Electronic Markets, 2007. **17**(3): p. 176-186.
25. Heeks, R., *Health information systems: Failure, success and improvisation.* International journal of medical informatics, 2006. **75**(2): p. 125-137.
26. Mignerat, M. and S. Rivard, *Positioning the institutional perspective in information systems research.* Journal of Information Technology, 2009. **24**(4): p. 369-391.
27. Solotruk, M. and M. Krištofič, *Increasing the degree of information system integration and developing an integrated information system.* Information & Management, 1980. **3**(5): p. 207-212.
28. Jin, A. and L. Ahlfors, *Interoperability in electronic medical records.* Department of informatics, Lund University, 2012.
29. Niazi, M., D. Wilson, and D. Zowghi, *A maturity model for the implementation of software process improvement: an empirical study*. Journal of systems and software, 2005. **74**(2): p. 155-172.
30. Rowlands, B., *Employing interpretive research to build theory of information systems practice*. Australasian Journal of Information Systems, 2003. **10**(2).
31. Jardim-Goncalves, R., et al., *Systematisation of Interoperability Body of Knowledge: the foundation for Enterprise Interoperability as a science.* Enterprise Information Systems, 2013. **7**(1): p. 7-32.
32. Chen, D. and N. Daclin. *Framework for enterprise interoperability*. in *Proc. of IFAC Workshop EI2N*. 2006. sn.
33. Pagano, P., L. Candela, and D. Castelli, *Data interoperability*. Data Science Journal, 2013. **12**: p. GRDI19-GRDI25.
34. Berre, A.J., et al., *The ATHENA interoperability framework. In Enterprise interoperability II (pp. 569-580). Springer London.* 2007.
35. Hugoson, M.-Å., T. Magoulas, and K. Pessi. *Enterprise architecture design principles and business-driven IT management*. in *International Conference on Business Information Systems*. 2010. Springer.
36. Hugoson, M.-Å., T. Magoulas, and K. Pessi, *Interoperability strategies for business agility*, in *Advances in enterprise engineering I*. 2008, Springer. p. 108-121.
37. Sagiroglu, O. and M. Ozturan, *Implementation difficulties of hospital information systems.* Information Technology Journal, 2006. **5**(5): p. 892-899.
38. Giuse, D.A. and K.A. Kuhn, *Health information systems challenges: the Heidelberg conference and the future.* International journal of medical informatics, 2003. **69**(2): p. 105-114.
39. Walsham, G., *Interpretive case studies in IS research: nature and method.* European Journal of information systems, 1995. **4**(2): p. 74-81.
40. Klein, H.K. and M.D. Myers, *A set of principles for conducting and evaluating interpretive field studies in information systems.* MIS quarterly, 1999: p. 67-93.
41. GE, *Healthcare Västra Götaland Region (VGR) & GE's Vendor Neutral Archive: Case Study:*. 2012.
42. Thomas, D.R., *A general inductive approach for analyzing qualitative evaluation data*. American journal of evaluation, 2006. **27**(2): p. 237-246.
43. Tu, Z., G. Zacharewicz, and D. Chen, *A federated approach to develop enterprise interoperability*. Journal of Intelligent Manufacturing, 2016. **27**(1): p. 11-31.

44. Lindblad, E., *Designing a framework for simulating radiology information systems. in Editor (Ed.)^(Eds.): 'Book Designing a framework for simulating radiology information systems' (2008, edn.), pp.*, 2008.
45. Lindsköld, L., *Designing and using an information infrastructure in radiology: prepare-share-compare IT*. 2012: Inst för klinisk vetenskap, intervention och teknik/Dept of Clinical Science, Intervention and Technology.
46. Plesk, P. and T. Wilson, *Complexity, leadership, and management in healthcare organizations.* BMJ, 2001. **323**(7315): p. 746-749.
47. Mahoney, J. and D. Schensul, *Historical context and path dependence.* The Oxford handbook of contextual political analysis, 2006: p. 454-471.
48. Fenton, S.H., et al., *Data standards, data quality, and interoperability.* Journal of AHIMA, 2007. **78**(2): p. extended online edition.
49. Glaser, B.G., *Theoretical sensitivity: Advances in the methodology of grounded theory*. 1978: Sociology Pr.
50. Böhm, A., *Theoretical coding: text analysis in grounded theory. Dans U. Flick, E. von Kardorff, & I. Steinke (Éds), A companion to qualitative research (pp. 270-275)*, 2004, London: Sage.