Putting Interoperability on Health-information-systems' Implementation Agenda

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Abstract

The increasing demand of past patient medical information at the point of care, creates new data sharing and exchange demands on health information systems (HIS). However, a number of existing HIS have data exchange challenges given that they are ordinarily designed as vertical silos without interoperability obligations. Yet, to have data exchange within HIS and across health facilities, participating systems ought to be interoperable. However, interoperability is usually not considered a key design requirement during HIS implementations. Therefore, relying on exceptional existing practices to create benchmark design knowledge, the author employs a sense making perspective to analyze how HIS implementers arrive at their interoperability design requirements. Through this approach, an initial set of interoperability design prerequisites for purposively designing HIS' interoperability is proposed. These include: knowing who, knowing what, knowing how and knowing which. A further study implication is the use of a sense-making perspective in exploring system design requirements.

1. Introduction

Health Information systems (HIS) have a great role to play in patient care continuity by availing past patient medical information [1, 2] at the point of care to facilitate ongoing treatment more than ever before [3]. However, HIS are ordinarily designed as vertical silos [4, 5] with no interoperability obligations [6, 7], and therefore have no capacity to exchange patient medical information across facility boundaries [8, 9]. Yet, to meet the current data sharing information needs, a number of researchers recommend implementation of HIS that move away from vertical silos to horizontally integrated systems [4] that can foster cross-boundary information exchanges. However, given the tradition of designing vertical silos systems [4, 5] and the lack of coordination efforts among HIS initiatives [10], little information is known on how to purposively design for HIS' interoperability [4, 11-13]. In practice, Software developers rarely depend on 'interoperability architectures and business model benchmarks' to guide the design and development of interoperability between different applications [14]. Thus, very often interoperability proponents engage in HIS ventures without knowing the contextual interoperability problems they are dealing with and how best to solve them [15-17]. This has resulted into a number of failed HIS interoperability ventures as noted by [18].

In his design-reality gap model, [19] contends that, there are higher chances of HIS implementation failure whenever design objectives are not matched to reality objectives. Similarly, there are higher chances of system implementation failure whenever the interoperability principle is not matched to the context of integration [20], or is missing [6]. Thus, several authors argue for a thorough analysis of the context of integration in order to get a clear prescription of interoperability design prerequisites that must be inherent to all participating entities [21], into a set of system design requirements [22]. From a software engineering perspective, to arrive at well-defined system design requirements, [23-26] argue for goal driven requirement elicitation processes, and [27] argue for a more collaborative view that encompasses contextual factors and best practices. The goal driven approach is preferred so as to motivate interoperability inclusiveness onto future HIS implementation agendas. However, the elicitation process is not just a collection of design requirements but a process that involves discovery, emergence and new developments. Therefore, [28] highly recommend good communicative approaches from the field of organizational studies that can foster collaborative requirements' elicitation approaches.

According to [29] sense-making is among the best communicative approaches, that can be used in practice to construct procedural (step by step)

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knowledge [30] for further action [31]. In the same vein, [32] asserts that organizational actors usually make sense of the happenings in their environments in order to develop shared meanings that can serve as a context for further action. Indeed, making sense of the context of integration would lead to identification and retention of actionable meanings [31] that can be drawn into a set of technical requirements for implementation improvements [22]. Just as [14] argues for a strong analysis of the 'deep knowledge' of a target domain during information systems' interoperability implementations. Consequently, in pursuit of practical and deep knowledge for purposively designing HIS' interoperability, this study addressed the following research questions:

1. How do HIS implementers arrive at interoperability design prerequisites?
2. What attributes can make up an initial set of HIS interoperability design prerequisites?

In the next section the concept of designing for interoperability is introduced. This is followed by a discussion of the research approach and the analysis framework employed respectively. Results are then detailed in section five followed by a discussion of the research findings. The final section presents the paper conclusion and recommended future works.

2. Designing for interoperability

According to Healthcare Information and Management Systems Society (HIMSS), "interoperability is 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" [33]. However, for health information systems to possess the ability of working together across organizational boundaries there are prerequisites. For example according to ISO (2004) standard [34], all systems intending to collaborate by exchanging information must do so according to a prescribed method. This ISO standard points to an important consideration of prescribing and designing a method of information exchange between systems to be involved in any information exchanges.

According to [7] interoperability capabilities can inherently be designed into systems or can be retrofitted into systems whenever need arises. However, HIS projects centred on designing interoperability capabilities between systems are rare in practice [35] given that interoperability is usually not a design prerequisite [6, 7]. Notably, extant related literature [12, 19, 36] mainly focus on HIS implementations and adoption, with a few [35, 37, 38] focusing on HIS interoperability interventions. However, interoperability is a capability [39] that ought to be inherently designed within systems [7]. According to [40] good designs and solutions do not just emerge they must be purposively designed, thus the proposal to design HIS interoperability capabilities. Expediently, several authors agree to this proposition of inherently designing interoperability capabilities within systems [7, 41-44]. Interoperability capabilities must be designed to enable and enhance semantic interoperability between the systems. As semantic interoperability will enable same interpretation and meaning of the exchanged/shared information, which [45] refers to as information heterogeneity.

Consequently, for any information exchange between systems, a communication link known as an 'interoperability principle must be present [46]. In this paper three main interoperability principles namely: unification, intersection & inter-linking [20, 46] are discussed. With unification a 'one common system' principle is applied. Under the intersection principle a common shared information space for all participating systems is designed. Under inter-linking, systems are designed to exchange messages between participating systems. Therefore, the participating systems can remain independent but be able to share and exchange the needed information through platform independent technologies [18].

Ultimately, focusing on interoperability driven interventions [6] through the 'design attitude' [47] could yield interoperability design knowledge and advance interoperability onto HIS implementation agendas. In addition, to arrive at better design solutions [48] argues that making sense of the context of integration might surface new possibilities for future HIS interventions. Therefore this study further argues for a focus on systems' contextual interoperability [49] during HIS implementations.

3. Research approach

Through a case study approach [50] the researcher conceptualized participants' responses according to the study objectives [51]. Data was collected through qualitative research methods that included; semi-structured interviews and document reviews [52, 53]. The collected data was inductively analyzed in order to identify key interoperability design decisions that were later grouped according to the sense making analytic framework [54, 55]. A practical case that met the study objectives was chosen in order to explore and illustrate the

'interoperability' phenomena in action [52, 56]. This case was a successful 'HIS interoperability' project that had integrated several radiology departments of Västra Götaland Region in Sweden, termed as BFR (Bild- och funktionsregistret) in Swedish, henceforth referred to as BFR.

3.1. BFR case description

The study followed a case from Västra Götaland Region (VGR) in West-Sweden that had implemented a single virtual central repository for critical imaging information referred to as the 'VGR radiology information infrastructure' termed as BFR. Västra Götaland Region - VGR is the second largest region in Sweden with an average of 1.5 million residents operating 121 healthcare centers and 17 hospitals among others. The BFR projects' major participants were the imaging healthcare centers and the 17 hospitals within VGR. Within VGR, the great Sahlgrenska University Teaching Hospital in Göteborg is known for its highly specialized radiology services throughout Western Europe. At the time of BFR implementation Sahlgrenska University Teaching Hospital was in pursuit to meet its present and future patient care needs, thus the decision to implement BFR. The aim for this single VGR radiology information infrastructure was to improve information transparency, harmonize patient medical information and increase efficiency [57]. At the time of this study BFR had been in operation for over 12 years and was deemed successful by many who had tasted its benefits. The study participants were the initial four BFR steering team members and other three BFR key informants who had joined the team at a much later stage. These consisted of the BFR -Chief Information Officer-CIO who was interviewed several times, Chief Medical Information Officer of VGR, two Radiologists at Sahlgrenska hospital, two IT managers and one project manager.

3.2. Data collection

Data was collected through semi-structured interviews and document reviews [53]. Open-ended questions were used in order to steer deep interactions between the researcher and the respondents. Interviews focused on extracting participants' responses regarding step by step key interoperability decisions taken during the early stages of the BFR implementation process. All interviews were recorded with permission and each session approximately lasted 70 minutes. In particular, the BFR-CIO was interviewed four times in order get rich data and insights of what transpired during the initial BFR implementation phases. As constant validity checks for credibility, transferability, dependability and confirmability of qualitative data [51] relevant documents were reviewed. These included; 'General Electric' BFR company documents, BFR implementation planning and progress reports, annual, and status reports. Thought-out the field investigations major research ethics of confidentiality, integrity and anonymity [58] were adhered to. For example, the researcher promised interviewee confidentiality and anonymity during publications.

3.3. Data analysis

The analysis stage consisted of two phases. During the first phase data was inductively analyzed [59]. In the second phase the sense making theory was applied as an analytical framework according to [58] who recommends theory use during data analysis. According to [58], the researcher can use theory to guide the analysis process by linking the data to theory as was done is this paper.

The first analysis phase consisted of verbatim transcription [60], that was followed by reading the interview transcripts over and over in order to make sense of the study objectives by constructing meaning [59]. This phase helped in the identification and creation of initial categories [59] illustrating key interoperability design decisions taken during the requirements elicitation phase of BFR. The initial inductively generated set of decision-categories involved; realizing existing interoperability challenges and deciding to design for interoperability in order to overcome them, deciding to build a central archiving system, identifying and managing stakeholders, emphasizing a unique patient identification number, defining a standard patient record to be shared, and above all deciding to adhere to policies, standards, and organizational and legal regulations. These were re-examined during the second analysis phase and refined into working categories under the four sense making analytic framework attributes of situation, gaps, bridges and outcomes. Eventually, through further analysis the working categories were later refined into final categories as interoperability design prerequisites (see figure 2).

4. Sense making analytic framework

The theory of sense making in this study has been used to analyse and validate the field data collected.

Extant literature presents various strands of sense making [61-65], 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. Actions of sense making arise from gap identification within the current situations [63] and the desire to improve that situation [65]. This actually happens in everyday human actions as we try to make sense of the situation in order to drive a plan of activities that can improve the current situation [48]. According to [64] people organize to make sense of equivocal inputs and enact this sense back into the real situation to improve status quo. In practice sense making applies well as a process of organizing when questions like 'what is happening here? What is the story here? What next? surface [31]. To arrive at potential analogic explorations in such situations, there are constant agreements and disagreements, however, [54, 66] argue that in such circumstances interpretation not choice should be the central focus. Thus, sense making involves making, defining, constructing ideas, cognitions, conclusions, procedures, values, intuitions, stories and narratives [66, 67], into plausible meanings that are later retained through the Donald Campbell's framework of enactment, selection and retention [31].

Consequently, the retained meanings materialize into a springboard of identity and further action [31] in order to improve the current state [64]. 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 [29, 54, 63, 68]. Such patterns of organizing are located in human actions and conversations which usually begin in acts of noticing and bracketing [31] into 'verbings' [55, 67, 69].

Therefore, in practice it can be used to make sense of human actions [70] of knowledge construction [61], and by asking respondents to describe the situation, gaps, bridges and outcomes [55, 63] (see figure 1). According to [54] sense making can be employed in project needs assessments and evaluations. Thus, as a methodology, sense making relies on the foundational concepts of time, space, movement, situation, gap, bridge, outcome, step-taking and gap bridging [54, 55, 63]. Sense making has indeed been applied to different studies, for example in library and information science [63], information use in organizations [32], information technology in organizations [71], process design studies [72] among others. Therefore, due to its potential [72] proposes its uptake in future process design studies.

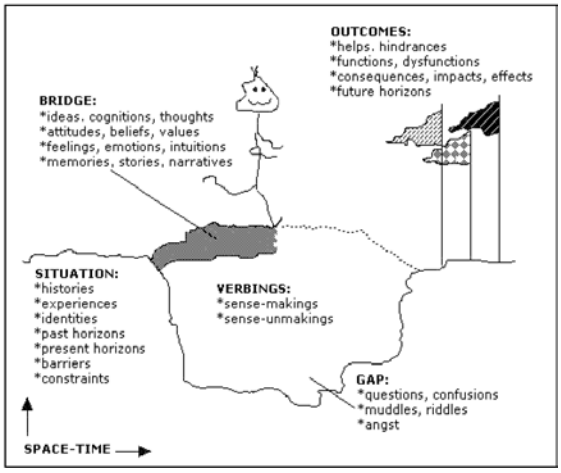

Figure 1. Sense making analytic framework (adopted from [55]).

5. Results

In order to understand how the BFR implementers made sense of their system interoperability design prerequisites, a sense making analytical perspective was employed. The sense making attributes of situation, gaps, bridges and outcomes were used to gain an understanding of the step by step major interoperability decisions taken during the BFR implementation process. With reference to the four sense making attributes, BFR study results were thus identified starting from the challenging situations, through the existing gaps, through proposed bridges unto the final outcomes as BFR design horizons as presented in the following lines.

Situation/challenges: these were the ongoing challenges within the VGR region by then, they included: missing updated patient information at the point of care- (at the main - Sahlgrenska University Hospital), use of CD, phone calls, and post to transfer radiology patient information among departments. Suddenly there was a realization of the current data sharing challenges among radiology departments, which was followed by the desire to improve data sharing practices through interoperability. These are evident in the following respondent verbatim quotes. "*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.*" "*At Sahlgrenska University hospital we needed to access their data and we 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".

Upon discovering the ongoing challenges and deciding to design for interoperability, questions of 'how' and 'what about' came up. Which according to the sense making framework are categorised as 'Gaps' (worries/questions). Therefore, BFR gaps included: what about non-interoperable systems at radiology centers, what about lack of a standard patient record to be shared, what about resistance to change, what about existing investments, what about vendors, what about inconsistent Patient ID, what about the different DICOM standard formats, and what about legal & policy procedures. As depicted in the following verbatim quotes *"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." "If you do not do manage change, you will not see any difference at all." Etc.*

At this stage the implementers had to think of various strategies to bridge the identified gaps. Which according to the sense making framework are termed as 'Bridges' (ideas/strategies), these included: desire and decision to 'purposively design for inter-departmental interoperability, through a central repository storage for vital radiology data, support old investments – to minimize resistance, define our demands to the vendors, enforce standards already in use, enforce strict use of vital uniform standards- DICOM - Digital Imaging and Communication in Medicine and HL7 – Health Level Seven. Enforce strict Patient ID format, enforce an informatics focus not a technological focus -not to mind about uniform systems but about data to be shared, define & enforce a standard record to be shared (only minimum data requirements), enforce the format for the record attributes (mandatory/optional), be simple step by step, have a good communication strategy- negotiate with the stakeholders, adhere to legal & policy procedures. As expressed by respondents through the following verbatim quotes. *"Upper management decided that, all x-rays produced in the region should be digital". "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." "We say… accept DICOM as the mechanism of sharing… but we had a very strict rule it (Patient Identification -PID) should be twelve digits nothing else". "We had experience from the x-ray domain prior to this, so we know all the challenges with in….."*

Upon traversing through situations, gaps and bridges, outcomes were finally arrived at. These were the decided and agreed upon actions/horizons that would guide the ongoing BFR implementation project. Inspired by Landgren [73], who came up with design implications for emergency information systems as 'knowing where' and 'knowing what' upon applying a sense making perspective. This study grouped the identified outcomes into four categories of knowing who, knowing what, knowing how and knowing which, as discussed below. **Knowing who**: identify and set up skilled steering and implementation teams. Secure upper management involvement and funding. **Knowing what**: Identify current interoperability (data sharing) challenges. Decide to purposively design for interoperability. Know the current gaps in the context of integration that might hinder or promote interoperability. **Knowing how**: Analyse the context of integration, and evaluate alternative interoperability principles and identify an optimum interoperability principle to pursue. Plan for semantic interoperability: - adopt interoperability standards like terminology and messaging standards e.g. HL7, or other sharing strategies like APIs. Devise good communication plans, manage change, stakeholders and entire project. **Knowing which**: Focus on informatics – define vital minimum data requirements; - define a standard patient record to be shared (attributes, format-mandatory/optional). Adhere to legal & policy procedures. In essence, outcomes are agreed upon 'helps' or future horizons (see figure 1) that are retained to guide future improvements. Particularly, for this study the identified outcomes were proposed as an initial set of interoperability design prerequisites (see figure 2), that can guide future HIS interoperability implementations. A further study implication is the analytical power of the sense making framework in examining design requirements during system implementations.

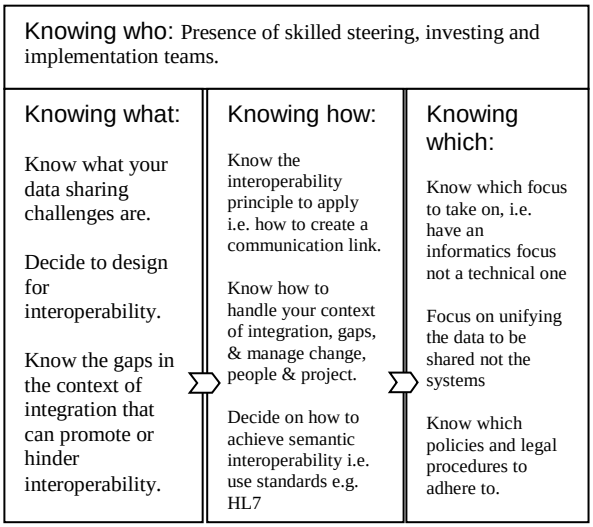

Figure 2. Proposed initial set of interoperability design prerequisites

5.1 Interoperability design prerequisites

Knowing who: The first aspect of consideration that is usually taken for granted concerns the steering and implementation teams. It is important to know who the stakeholders are, as successful projects depend on how skilled and prepared the steering, the management and implementation teams are [74, 75], and how committed the funders are [74]. Therefore, for successful HIS interoperability implementations, securing funding and installing skilled personnel and committed top managers is key.

Knowing what: Under this prerequisite, the actors need to know what they are going to be dealing with in the set project. To begin with, they have to identify the current interoperability/data sharing challenges they are facing [76]. This leads them to appreciate the need for interoperability, and decide to purposively design for HIS interoperability. In order to effectively design for interoperability the actors ought to analyse the current gaps in the context of integration that might hinder or promote interoperability.

Knowing how: Under this prerequisite, the actors need to know how they are going to operate within the set project. Here the actors have to take into consideration the identified gaps in the context of integration and brainstorm on alternative interoperability principles and eventually take on an optimum interoperability principle. Depending on the context the actors have to think of how semantic interoperability ought to be achieved across all participating entities [77]. To ensure sematic interoperability they either plan to adopt a data harmonization strategy [20, 46] or apply interoperability standards [78] like Health Level Seven (HL7) [79], or application programing interfaces -API [80] among others. Bearing in mind the several stakeholders on board the implementers ought to devise good communication, project management and change management tactics [35].

Knowing which: Under this prerequisite, the actors need to know the specifics they are going to be dealing with in the set project. When it comes to interoperability the focus should be on informatics not on the technologies, because the ultimate goal of interoperability is that the exchanged/shared data should be understood and useful (semantic interoperability). Thus the focus should be on the informatics (data set) [77];- definition of vital minimum data requirements, definition of a standard patient record to be shared, its attributes and format (mandatory/optional). Above all legal & policy procedures should be adhered to [81].

6. Discussion

A sense making perspective is usually taken on to study how actors make sense of their situations in order to create order [54, 70]. As it highlights the different activities and decisions taken by actors during problem solving moments. This study followed the BFR case with an aim of understanding major design decisions taken during the implementation process. With reference to the sense making perspective, respondents categorically mentioned that the desire to design for interoperability was sparked off by the many data sharing challenges they were experiencing between the different radiology departments. Whereby this raised questions of how interoperability would be achieved given existing gaps that included presence of various non-interoperable systems and the lack of a standard patient record. Consequently, the actors had to devise strategies of how to bridge these gaps in order to arrive at better outcomes.

However, all this depended on the context of integration as it greatly plays a fundamental role in determining the kind of interoperability principle to be adopted. As successful interoperability ventures depend on good alignments between interoperability principles and contexts of integration [20, 46]. For example, the BFR context of integration (existing gaps) led to inter-departmental interoperability (inter-section principle). Whereby the experienced implementers opted for a central archiving mechanism through data harmonization by use of strict standards like DICOM and HL7. The BFR

implementers opted for the use of HL7 and DICOM standards out of their proven competences. These standards were maintained in order to promote path dependence and curb resistance as they were already in use within radiology departments. Among widely used standards are Health Level Seven (HL7) which are interoperability standards for the exchange, sharing, and retrieval of electronic health information across HIS and health centers [18]. Therefore depending on the context of integration HL7 or any other appropriate interoperability standards can be adopted in future HIS implementations.

Notably, all this was unfolding as an everyday process of problem solving that humans constantly go through when trying to make things better [47]. Eventually, the sense making process produced outcomes that acted as horizons for further BFR improvements. Particularly for this study they included: knowing who, knowing what, knowing how and knowing which (see figure 2). This implies that applying a sense making perspective in understanding step by step actor decisions during system implementations could yield better future design horizons. Thus the proposal to draw the study outcomes into an initial set of interoperability design prerequisites that can guide future HIS interoperability implementations. It therefore follows that a sense making perspective would offer actors a working approach on how to understand their interoperability past challenges, present actualities and eventually offer future design horizons.

Therefore, applying a sense making approach together with the identified prerequisites would bring the 'interoperability requirement onto HIS implementation agendas and would lead to an all-round interoperability solution. The knowing who and knowing what prerequisites would enhance 'contextual' interoperability. 'Contextual' interoperability here refers to systems' interoperability that takes into consideration contextual factors within the context of integration. As mentioned by [49] that systems' interoperability is contextual. The knowing how and knowing which prerequisites would enhance semantic interoperability between the different HIS. This would enhance patient medical information sharing across HIS and across the continuum of care to facilitate on-going treatment.

7. Conclusion and future research

To advance understanding on information systems' interoperability designing, this study followed a practical case – BFR that had successfully integrated several heterogeneous radiology information systems. The BFR case was followed in order to understand how its implementers had arrived at their interoperability prerequisites, and thereafter generate an initial set of interoperability design prerequisites. Eventually, with reference to the sense making framework attributes, an initial set of interoperability design prerequisites was proposed. The proposed prerequisites included knowing who, knowing what, knowing how and knowing which. Consequently, the study proposes these design prerequisites as a future guide to HIS interoperability implementations, and the uptake of the sense making perspective in exploration of system requirements during information system implementations. Eventually, through these working prerequisites the 'interoperability requirement' would be brought onto HIS implementation agendas.

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