

WHAT DO KEY INFORMANTS THINK ABOUT INFORMATION QUALITY IN ACUTE
CARE IN RELATION TO INFORMATION TECHNOLOGY: AN EXPLORATORY STUDY

Elizabeth Keay
MD from University of Toronto, 1985
MHSc from University of British Columbia, 1998
MPA from University of Victoria, 2004

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the School of Health Information Science

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Supervisory Committee

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Dr Andre Kushniruk, Health Information Science, **Supervisor**

Dr Elizabeth Borycki, Health Information Science, **Departmental Member**

Dr Scott Macdonald, Health Information Science, **Departmental Member**

Dr Anthony Marley, Psychology, **Outside Member**

Abstract

Supervisory Committee

Dr Andre Kushniruk, Health Information Science, Supervisor
Dr Elizabeth Borycki, Health Information Science, Departmental Member
Dr Scott Macdonald, Health Information Science, Additional Departmental Member
Dr Anthony Marley, Psychology, Outside Member

The published literature indicates that large information system implementations are often expensive failures with costs to human safety largely because of missing or corrupt information. This has generated the overall research question of “What do Key Informants think about Information Quality in Acute Care?”

This dissertation research examined information quality using a Grounded Theory analytic method for coding and analyzing semi structured interview responses from ten clinical (nurses, physicians, pharmacist) and ten non-clinical (IT support) interviewees in several public sector health organizations across Canada. The semi structured interview questions focused on five key areas: information quality, acute care setting, information systems, risk (as a function of poor information quality) and patient safety.

A key finding from the interview data is that information is missing and unstable within the two key health care information systems: the paper chart, the main repository of narrative unstructured data, and the electronic health record system, of structured data.

The interviewees mentioned pressure to information standardization such as fixed patient identity information anchoring patient data in the rest of the patient record. However, there is resistance to standardizing other information because the users, nurses and physicians, resist fettering in order to be able to tell the patient’s story in narrative unstructured data form.

A descriptive socio-technical model, the Systems Engineering Initiative for Patient Safety (SEIPS) Model that organizes elements for analysis under the headings of person, task, technology and tools, organization, external environment and patient outcomes, was considered for further discussion in the context of the study. The SEIPS Model analysis also helps to identify gaps in the Model including what missing and uncertain information might mean. Key points from this discussion include how the information system maps to the real world, the

patient, and to the user's perception of the real world. This mapping can never be totally accurate and complete so gaps exist.

The discussion of information and information flow lead to enhancements of the SEIPS Model, placing information and information quality in its rightful place as a "glue" for the acute care system. This is an important contribution to knowledge that can lead to future research so there can be a better fit between the real world, information, information systems and people to provide safer care.

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Acknowledgments

I am grateful to the interview interviewees for their insight and experience and for the support and patience of my supervisor, committee members.

Chapter 1: Introduction

1.1 The Problem: Is Information Quality a Factor in Expensive Information System Failure?

The safety track record of health information systems¹ in acute care is not clear cut or “evident”(Shortell & Singer, 2008 p. 445). Furthermore, it would be valuable to understand the role of information quality in these systems. We will see that, although the acute health care sector, information systems, risk as a function of poor information quality and patient safety are each complex; they have a common thread or glue of information and its quality. The quality of information is central and critical for enabling and sustaining safe health care.

This dissertation proposes that the common glue embedded in these key topic areas is the concept of information quality in the Canadian healthcare sector.

Canada has a publicly-funded healthcare system. The federal government provides funding to the provinces; the latter provide additional funding. Each province is divided up into regions that are funded by their respective ministries of health to provide acute care and other services to residents. There is universal access to these services. Acute care staff are paid either by salary or by a service provider model (most physicians).

The dissertation proposes to understand knowledge gaps better through a qualitative study of interviewees’ perceptions about information quality, including risk as a function of poor information quality, information systems, and patient safety within the Canadian health care system. This research uses a Grounded Theory analytic approach involving semi structured interviews to discover if there is a framework or model to explain information quality effects on patient safety.

¹ The literature speaks of health information systems, information systems and systems. Please note for consistency, this research will use the term information system to refer to any health information system both electronic and paper/chart in the acute care context. A specific system term such as electronic or paper/chart will be used when it is necessary to refer to the specific type of information system. If key informants use the term health information system, it will not be changed.

This dissertation looks at information quality in five different ways or lenses² to understand how these lenses might explain how information quality could be related to patient safety by:

- Firstly, looking at information quality as the glue that flows through the health care system and its users.
- Secondly, looking at the context of information quality, that is, the Canadian acute care setting.
- Thirdly, looking at information systems as a vehicle for information quality.
- Fourthly, looking at risk as a function of poor information quality because poor information quality can contribute to adverse events. Adverse events could be rare³ with low risk probability and varying impact(s), wicked (ill-defined), complex with multiple causation, or uncertain with unknown probabilities.
- Fifthly, looking at considering patient safety as a source for models or frameworks for data analysis taking into account a number of levels (from the individual to the organization) with a fit information system being a safe information system i. e. a system with fewer adverse events with information quality as the glue holding it all together.

These five lenses will form the basis for the semi structured interview questions. We first need to see why this research is important by looking at the problem of information system failure at a financial level and at the human cost level.

1.1.1 Financial Cost of Information System Failure

The literature on healthcare information systems contains reports of high failure rates, “around

² This dissertation speaks of five different lenses or ways but they can also be thought of as the first four lenses are really different exposures and the fifth, patient safety, an outcome that could be a health care adverse event. This exposure-outcome organizational structure *does not* imply causation but a context because the exploratory dissertation methodology was not designed to establish causation.

³ Renn (1998 p. 51) provides the following definition of risk: “the possibility that human actions or events lead to consequences that have an impact on what humans value”. “Risk is based on a known probability as it is traditionally calculated as the probability the event will occur times the impact of the event should it occur” (Ritchey, 2011 p. 99). Risk can also be assessed qualitatively as seen below in section 2.5. The literature review also mentions risk more generally.

70%” (Pan, 2008 p. 259) or even 100% (“zero” success rate) for New Zealand projects costing over NZ\$ 10M (Goldfinch, 2007 p. 917). Kaplan and Harris-Salamone (2009 p. 292) note that about 20% of healthcare information technology projects are “outright” failures. Larger projects have a higher probability of failure (Hidding & Nicolas, 2009 p. 2). These failures have an enormous cost, for example, Gauld (2007 p. 103) comments that “around \$US 150 billion is wasted per annum on information system failures in the United States and \$US 140 billion in the European Union”⁴. For example, Johnson described a 2007 major server failure in the US Veterans’ Affairs VistA (architecture)/Computerized Patient Record System that was down for 9 hours at 17 hospital sites (2009 p. 2). The primary cause was centralization of the servers with no redundancy combined with political decisions to increase this central control (Johnson, 2009 p. 5-6). Johnson (2009) did not provide a cost for this major failure. In fact, large-scale information management⁵ and information technology “initiatives in health care are in danger of becoming ‘runaway projects’ into which stakeholders continue to pour money even when the project is sunk”, raising the question about risks and how can they be contained (Greenhalgh et al., 2008 p. 94). Not only is this financially costly but the safety record and human cost these systems is uncertain.

1.1.2 The Human Cost of Information System Failure

There is a growing literature suggesting information systems may contribute to adverse events in their own right. Borycki et al. (2012 p. 95) note technology induced errors “arise from: a) the design and development of technology, b) the implementation and customization of a technology, and c) the interactions between the operation of a technology and the new work processes that arise from a technology’s use”.

Further causes include as summarized from Borycki et al, 2012 p. 98 Table 1 and Williams and Weber-Jahnke, 2010 p. 78): human-computer interface difficulties, weak privacy and security

⁴ There do not appear to be updates to these figures, please see Anthopoulos et al., 2016 p. 162.

⁵ “Information technology (IT) is the application of computers to store, retrieve, transmit and manipulate data”: please see the link: https://en.wikipedia.org/wiki/Information_technology. “Information management (IM) concerns a cycle of organisational activity: the acquisition of information from one or more sources, the custodianship and the distribution of that information to those who need it”: please see the link https://en.wikipedia.org/wiki/Information_management . These are considered equivalent for presenting the cost information in this section. “IS management focuses on blending the available technologies, resources and people so that a firm’s IS investments reliably produce value” (Butler & Gray, 2006 p. 219)

safeguards, failure to integrate information from all relevant information systems, lack of interoperability mechanisms, improper customization or configuration of features, and data overload (Borycki et al, 2012 p. 98 Table 1; Williams & Weber-Jahnke, 2010 p. 78). Inadequate health information technology may increase the likelihood of error as a result of “faults in the software itself introduced during development or unintended operation of the software by the user” (Despotu et al., 2012 p. 44).

System failure refers to a fault, breakdown or dysfunction within an organization’s operational methods, processes or infrastructure (Runciman et al., 2009 p. 21). Factors contributing to system failure can be “latent (hidden or apt to elude notice) or apparent, and can be related to the system, the organization, staff or a patient” (Runciman et al., 2009 p. 24). System project failures can happen at any time from project conception to project end (Anthopoulos et al., 2016 p. 163 Figure 1).

We now begin to examine the human cost of these failures and the importance of information as a factor in these failures in different jurisdictions. One review found that at least “two thirds of adverse events in cardiac surgery were classified as non-technical or information system issues” (Shortell & Singer, 2008 p. 445) while another review of commercial clinical information systems showed “missing or incorrect data, data displayed for the wrong patient, chaos during information system downtime, and information system unavailable for use with adverse events to patients including delay in diagnosis or treatment, unnecessary procedures, treatment, medications, disability and death” (Myers et al., 2011 p. 66). One can see that data or information issues are documented contributors to adverse events: diagnosis and treatment, the medical decision making, need quality information for optimal care.

Reporting systems for the UK and US, a UK systematic review and US litigation also show the human cost of information failure in the next section.

UK Experience

The UK National Health Service’s (NHS) *Guidance on the Management of Clinical Risk relating to the Deployment and Use of Health Software* (2009 p. 6) document notes that a contributing factor for adverse effects of systems on patients is “often missing or incomplete information”. This

document also describes other causes that can contribute to adverse events (2009 p. 75-77): (We shall see more on this below in section⁶ 2.7.4 (Patient Safety Concepts & Frameworks), patient safety concepts and frameworks)

- decision support system design: “poor evidence base for design; failure in design logic to properly represent design intentions; failure in logic to represent good practice or evidence in the design phase; poor or confusing presentation of information or poor search facilities; and, failure to update information and systems in line with current knowledge” (p. 75-76).
- clinical data migration between systems, “particularly from old to new products, can be the source of serious risks which users should be addressed carefully with a documented plan which should include: field level data mapping; specification of proper data reconciliations; examination of batch controls applied by the data supplier; examination of exception handling and close collaborative working with any supplier of data”... (p. 77).
- Time: “many aspects of clinical care and accurate record keeping depend on accuracy in the recording of time. It will be important that interoperating systems run on the same time and can cope with time changes”: (p. 77).
- Turnover: “the turnover of clinical staff can in some organizations be substantial...this flux in staff can be a considerable hazard” (p. 77).

UK Reporting

Kushniruk et al. (2013 p. e 155) note that the NHS’ Clinical Safety Management System, established in 2005 as a safety incident management process to report and log incidents related to health information technology (with close to 1000 such incidents having been reported), has examples of errors including the following: data “entry and retrieval (using health information technology) of the wrong patient, access of the wrong notes, wrong results and wrong procedures... along with problems due to data migration and data corruption issues (e.g. overwriting of patient information in an electronic health record)” (see also Magrabi et al., 2015 p. 200 Figure 1).

⁶ Note: The section title will be added for reference (in abbreviated form in some cases)

Magrabi et al. (2015 p. 201) reviewed 850 incidents reported in the NHS initiative, the National Programme for IT. “These events were reported primarily by clinicians at NHS trusts (62%), by information system vendors (24%)” and by implementation teams and others (14%) (Magrabi et al. 2015 p. 201). “Eighty nine percent of events were made safe within 24 hours” (Magrabi et al. 2015 p. 201).

There were 22 events involving “patient harm” with “three recorded deaths”, all associated with human factors problems (patient misidentification, failure to treat through software use errors, and treatment delay because of a missing test) and three moderate harm events (software interface, wrong information system medication mapping, and legacy data migration) all related to medication (Magrabi et al. 2015 p. 201 3.1).

There were 16 “low harm” events involving software interface with medication concentration or imaging interface; and 36 near miss events such as prescription error detected by pharmacy and wrong alert for medications (Magrabi et al. 2015 p. 201 3.1).

There were “1606 separate contributing problems identified” among the 850 events; “92% were predominately technical issues” “dominated by software issues causing errors in the display of clinical information (45%)” (Magrabi et al. 2015 p. 201). The implementation phase was the phase in the information system lifecycle that accounted for 48% of the incidents (Magrabi et al. 2015 p. 201). Human factors, such as use errors or contributing factors e.g. cognitive load, were associated with 8% of incidents (Magrabi et al. 2015 p. 201). Furthermore, human factors were over-represented in the events reporting some degree of harm, and were four times as likely to harm patients than technical problems (25% vs. 8%; $p < 0.001$; OR 3.98, 95% CI 1.90–8.34) (Magrabi et al., 2015 p. 201 3.2).

There were also 191 large scale events (22%) usually involving data storage and backup, data migration, computer viruses and transaction overload (Magrabi et al. 2015 p. 202 3.3).

Warm and Edwards (2015) examined a small sample of 149 events in Wales, none of which resulted in major harm or death to a patient. There were examples of poor access (56%), radiology images for the wrong patient on file (dentistry, 16%), wrong data inputs (10%) and slow connection speed (5%) (Warm & Edwards, 2015 p. 251).

UK Systematic Review

An extensive review of eHealth⁷ for the NHS' Connecting for Health initiative examined the different electronic information systems such as the electronic health record (Car et al., 2008).

The authors make the following conclusions about the risks and benefits (Car et al., 2008):

- “There is moderate evidence that electronic health records can help improve patient outcomes, particularly in relation to provision of preventative care” (p. xix).
- “Standardised and widely accepted measures of data quality in electronic health records are lacking and their development should be a priority” (p. xix).
- “There is moderate evidence that data collected electronically in a computer history taking system (part of the electronic health record) tends to be more accurate and contain fewer errors than data captured manually with traditional pen and paper techniques; such data are also more legible” (p. xx).
- “The major finding from reviewing the empirical evidence—which is of variable quality—however, is that there is very limited rigorous evidence demonstrating that these technologies actually improve either the quality or safety of health care” (p. xxv-xxvi). This conclusion is similar to Walker et al., 2008.

Why Proving a Benefit is Difficult

The literature describes some of the factors such as the following that make proving a benefit difficult.

- The considerable government funding is provided based on promised expected benefits in another jurisdiction such as the US, and not on strong evidence of a clinical benefit within the home jurisdiction (Clarke et al. 2015 p. 7).
- The lack of clear evidence may also be related to publication bias and conflict of interest (Clarke et al. 2016 p. 1).
- Another issue is the presence of confounders not related to the technology such as

⁷ Car has the following definition: “E Health is defined as follows: a relatively recent term for health care practice which is supported by electronic processes and communication. The term is inconsistently used: some would argue it is interchangeable with health care informatics, while others use it in the narrower sense of health care practice using the Internet. The term can encompass a range of services that are at the edge of medicine/health care and information technology” (Car et al., 2008, p. 578).

training, underfunding, changing leadership and poor use of incident reports (Abramson et al., 2014 p. 1253); Mitchell et al. 2016 p. 5). Related to this is poor study design and lack of “statistical power” (Barnett et al. 2016 p. 8).

- A further issue is the fact that system reporting variables do not specifically require reporting that has a direct impact on safety (Paez et al., 2013 p. 417).

Even though these systems might protect against error, they introduce new risks on their own arising from cognitive overload, loss of oversight, errors in data entry such as copy and paste and retrieval, excessive trust in electronically held data, and conflating data entry with communication (Bowman, 2013 p. 2-4; Greenhalgh et al., 2009 p. 759). In addition, large integrated systems may create more disorder elsewhere in the system (Greenhalgh et al., 2009 p. 759).

US Experience

US Overview and Litigation

There is some work on the US experience. Systematic reviews of the impact of the electronic medical record on ICU mortality and length of stay in the US did not show a benefit because of study “population heterogeneity” and therefore lack of power (Thompson et al., 2015 p. 1276) or the presence of “confounders” (Yanamadala et al., 2016 p. 2). Moja et al. (2014 p. e 15) (using a larger sample based on a meta-analysis of randomized control trials of clinical decision support) did not show a statistical increase of mortality but did show a marginal decrease in morbidity (RR = 0.82; 95% CI = 0.68, 0.99).

Another source of evidence for the importance of information system safety is the US legal literature describing case law around information systems and patient adverse events. A response to a medical error includes medical practice litigation that alleges an individual practitioner deviates from a “standard of care” and causes an injury (Hoffman & Podgurski, 2009 p. 1534). This is at variance from the systems-based approaches to medical error.

US case law suggests that “if a court finds that a reasonable physician” complained about the “institution’s faulty electronic health record but did not implement clinical safeguards to avoid patient harm, the individual practitioner might be held liable in a medical malpractice case”

(Hoffman & Podgurski, 2009 p. 1554). This could be compounded by “vendors’ “hold harmless” contract clauses that shield them from liability and shift responsibility for harm to health care providers” (Hoffman & Podgurski, 2009 p. 1554). Conversely, information systems will likely establish a higher a “standard of care” because of the volume of information available to make clinical decisions (Hoffman & Podgurski, 2009 p. 1528).

The legal literature suggests systems contribute to error. Mello and Studdert (2008 p. 605 Table 1) found that individuals contributed to “96%” of cases involving “error”, however, “system factors” were found in “56%” of cases “involving injury”, of these, “40%” were problems with “teamwork or communication”. “Claims with system factor involvement were significantly higher (median of \$292,875 vs. \$142,500, $P=0.0001$) as these tended to be more severe with a mean severity score of 7.3 (out of 9), compared to 6.8 for individual-factor only cases ($P=0.003$)” (Mello & Studdert 2008, p. 611). Medication-related system errors were statistically significant “($P=0.001$)” (Mello & Studdert, 2008 p. 612 Table 3). Deaths, in particular, occurred more frequently when system factors were involved, but with less significance ($p=0.03$)(Mello & Studdert, 2008 p. 612).

The medical record is the prime source of evidence, but system factors are generally not documented, so there may be an underestimate of the true significance (Liang & Ren, 2004 p. 525; Mello & Studdert, 2008 p. 600).

At least for medication errors, approximately “18% of patient safety errors happened because the information was not available when the medication decision was made and up to 70% of medication errors could be prevented if the right information about the right patient was available at the right time” (Kaelber & Bates, 2007 p. S40). Electronic health record implementation is also a factor, for example, Han et al. (2016 p. 579) found that although the rate of medication errors in an ICU increased after implementation, the severity of the errors was “reduced” in her prospective observational study.

US Reporting

The US Federal Drug Administration (FDA) has statistics on adverse events related to commercial information systems such as missing or incorrect data, data displayed for the wrong

patient, chaos during system downtime, and system unavailable for use. The adverse events to patients included “delay in diagnosis or treatment, unnecessary procedures, treatment, medications, disability and death” (Myers et al., 2011 p. 66). Although information failures are a common element in disasters generally it takes some time after implementation for some impacts to occur despite warning signs (MacIntosh-Murray & Choo, 2006 p. 358; Van Der Meijden et al., 2003 p. 241).

FDA Reporting

Myers et al. (2011 p. 66) found “120 unique reports” (from 1.4 M records) in the FDA commercial system incident reporting databases as reported by health professionals, vendor companies and user facilities. This shows how rare recording of these events in error databases is.

The data, with percentages of total errors in brackets, on these commercial systems were as follows (Myers et al, 2011 p. 70 Table 1 p. 72 Table 3):

- “Functionality-a particular system feature was assumed by users, but was not present, or the system behaved in an unexpected manner. This type of error includes drug or allergy rules that were not triggered as expected or in process (vs final) notes that are available for sign out, incorrect delivery of messages within the system or updated orders not being discontinued under certain circumstances (13.3%)”.
- “Incorrect calculation-incorrect values derived from available data or missing data or values assigned to the wrong patient, included errors in calculation such as date of delivery or incorrect drug dose calculation as well as interchange of data between patients (15%)”.
- “Incorrect content- Rule based logic is incomplete or incorrect, and includes drug-allergy or drug-drug alerts, incorrect test reference ranges, system allowing absurd combination of drugs or doses that are not possible with existing pill sizes etc. (19.8%)”.
- “Integration-pertaining to data exchange between products which may or may not belong to the same vendor (17.5%)”.
- “User interface-poor display of information or difficult to use system (52.5%)”.

It is important to note that these findings are based on 120 records indicating that these incidents

are under-reported.

Magrabi et al. (2012) also looked at the FDA's Manufacturer and User Facility Device Experience (MAUDE) reporting system first, using no filtering, then, filtering based on the Australian incident management system, free text review and adding radiology and blood bank data. They found "436 events showing 712 problems: 96% were computer-related and 4% were problems at the human-computer interface. Forty-six percent of the events related to hazardous circumstances and 11% were associated with patient harm with four deaths" (Magrabi et al., 2012 p. 45).

The most common causes of error were technical (Magrabi et al., 2012 p. 47 Table 1):

- Information output which showed a machine output display error (28%)
- General technical (60%) causes with the system down or slow (16%) and software functionality (32%) which was related to patient record display such as viewing multiple records.

Castro et al. (2016 p. 70) report on "3375" incidents voluntarily reported to the Joint Commission between 2010 and 2013 and analyzed by root cause analysis (a technique to examine the direct contributors to an event) were found. One hundred and twenty were IT-related⁸ of which "53%" were fatal (Castro et al., 2016 p. 72). The most common event types were medication errors, wrong-site surgery (including the wrong side, wrong procedure, and wrong patient), and delays in treatment, while the IT-related factors were issues with human-computer interface, workflow and communication, and clinical content (Castro et al., 2016 p. 73 Table 1 Table 2). Castro et al. (2016 p. 73) describe the interface factors as involving "ergonomics" or usability issues associated with how users interact with health IT -and leading to inaccurate data entry or erroneous data selection-representing 32% of the contributing factors relating to the human-computer interface. Other human-computer interface issues involved difficulty "locating information (14%), problems in the display of information or interpretation

⁸ Castro et al. provide a useful list of IT-related factors contributing to an adverse event (2016 Appendix 2). See also Mokkarala et al., 2008).

of that information (13%), unexpected software design related to the human-computer interface (11%), and the location of the hardware (10%)” (Castro et al., 2016 p. 73).

Palojki (2016 p. e 13) had similar findings involving the user interface errors, “40%”. Ratwani et al. (2015 p. 1181) note that although there are US user centred design standards, it is difficult for some vendors to incorporate these standards in their products because individuals with clinical knowledge and usability experience are hard to find.

There is the issue of data overload because it is hard for people to find meaning in the huge amounts of data because “the ability to make sense of data has not kept pace with the ability to produce and display it” (Dekker, 2011 p. 89). The solution to reduce data on the screen means that “critical” data may be hidden in lower screens (Dekker, 2011 p. 89).

Incident Reporting Systems

Several jurisdictions, including British Columbia, have developed in-house reporting systems that will be another source of “patient safety incident” reporting (Howell et al., 2017 p. 150-1), however, the role of these systems on a national level need to be determined.

1.1.3 What are the Types and Degrees of Failure?

Failure means that the system does not meet its “established goals, yielding predicted results or operating as intended” (Nakamura & Kijima, 2009 p. 31). System failure also suggests a breakdown in information quality. If we look at Nakamura and Kijima’s (2009 p. 33) three technical classes of failure, we see that the social and organizational causes of failure are in class III, which are “outside the system boundary and are unpredictable in the design phase”. Class I failures are failures of deviance where the “root causes are within the system boundary, and conventional troubleshooting techniques are applicable and effective” (Nakamura & Kijima, 2009 p. 33). Class II failures are “failures of interface where the root causes are outside the system boundary but predictable in the design phase” (Nakamura & Kijima, 2009 p. 33). While we will not be interested in causation per se, these classes of failure may be important at the data analysis stage.

There are also degrees of failure as Heeks (1999 p. 2) notes: “there is the total failure of a system

that has never been implemented...; the partial failures with undesirable outcomes...; the sustainability failure of a system being operational for a short time then failing...; and, finally, the replication failure of a successful pilot in one location failing in another...”. This research will have the context of systems that have been implemented and are operating. The system may work perfectly, however, it may not be used or, if used, will neither “increase productivity” nor show other expected improvements (Goldfinch, 2007 p. 919). These mismatches show that the system and its information does not fit with what they are designed or supposed to do.

1.1.4 Sources of Failure

While purely technical reasons can cause failure, the literature suggests that the prime underlying causes are:

- Social and organizational (Heeks, 2006, Kaplan & Harris-Salamone, 2009; Nakamura & Kijima, 2009; Pan, 2008; Shortell & Singer, 2008; Van Akkeren & Rowlands, 2007).
- Political, especially for the public sector (Gauld, 2007; Greenhalgh, 2008).
- Underfunding compared to other sectors (Koru et al., 2007).

Technical failures are most easily identified in “relatively simple” information systems (Nakamura & Kijima, 2009 p. 30)(the types of information systems are described further below in section 2.5.2). Greenhalgh (2008 p. 8) makes the important comment in the context of discussing a National Health System (NHS) system in the UK that organizations “running at, or close to, maximum capacity with limited slack”, magnify technical and operational problems. This can make systems unsafe for patients.

1.1.5 Why is Failure a Problem

Failed information systems have huge financial and social costs as we saw in the introduction. Failed information systems can also contribute to patient adverse events. Despite considerable research on failure, failure and adverse events remain a problem. This may be because the research has:

- focused on quantitative risk assessment methods in a subject area that is complex and

may not be amenable to these methods because of unknown probabilities.

- not fully recognized that adverse events are difficult to describe because they can be rare with low probability and varying impact(s), wicked or ill defined, complex with inter-related causal links, or uncertain with unknown probabilities: these characteristics make understanding and designing research difficult.

Now that we have a high level understanding of the problem, the financial and human costs of information failure, we now can look at information failure in several ways to analyze it in a more manageable way.

1.1.6 What We can do about It?

The first thing is to review the scope of the problem in several ways by developing a plan for research. Of particular interest for this dissertation is understanding what information quality is. This primary question will be answered by examining: information quality (1), including risk as a function of poor information quality (2), information systems (3), patient safety (4), and Canadian acute care (5). This highlights the five subject areas of the literature review.

The literature review will show that there are gaps or vague descriptions of information quality in the five subject areas. Gaps form the basis for the research and semi structured interview questions, data gathering and analysis in this dissertation. Gaps are important. They show that the system does not have a good “fit” with what it is supposed to do especially if information is the “glue”.

The focus of this research will be looking at a basic step that seems to be missing from the research: examining information quality because information is central, a glue, for health care and information systems.

The research framework below sets out at a high level the organization of the literature review and semi structured interview question for the interviewees. Please see Chapter Four (section 4.7.1 (Semi Structured Interview Script)) for the semi structured interview questions and Chapter Five (section 5.2.1 (Demographic Characteristics of Interviewees)) for information about the interviewees.

Research Framework

Figure 1 shows the overall plan for the research adapted from the format of Verschuren and Doorewaard (2010 p. 101 Figure 4.2):

- column a is the literature review of the five key areas for the research.
- column b is the research plan: the research objective in this dissertation is to ask the interviewees what they think about the five key areas and analyze their responses using a Grounded Theory analytic approach. The interviewees are the research objects that became organized into clinical and non-clinical interviewees during the analysis as represented here.
- column c is the data analysis section. This involved comparing and contrasting the understandings and interpretations from the interviewees using a Grounded Theory analytic approach. The objective is to examine similarities and differences about information quality, acute care, information systems, risk as a function of poor information quality and patient safety.
- column d is the results and next steps section: is there a framework that can show a relationship or provide insight about information quality? Are there further conclusions?

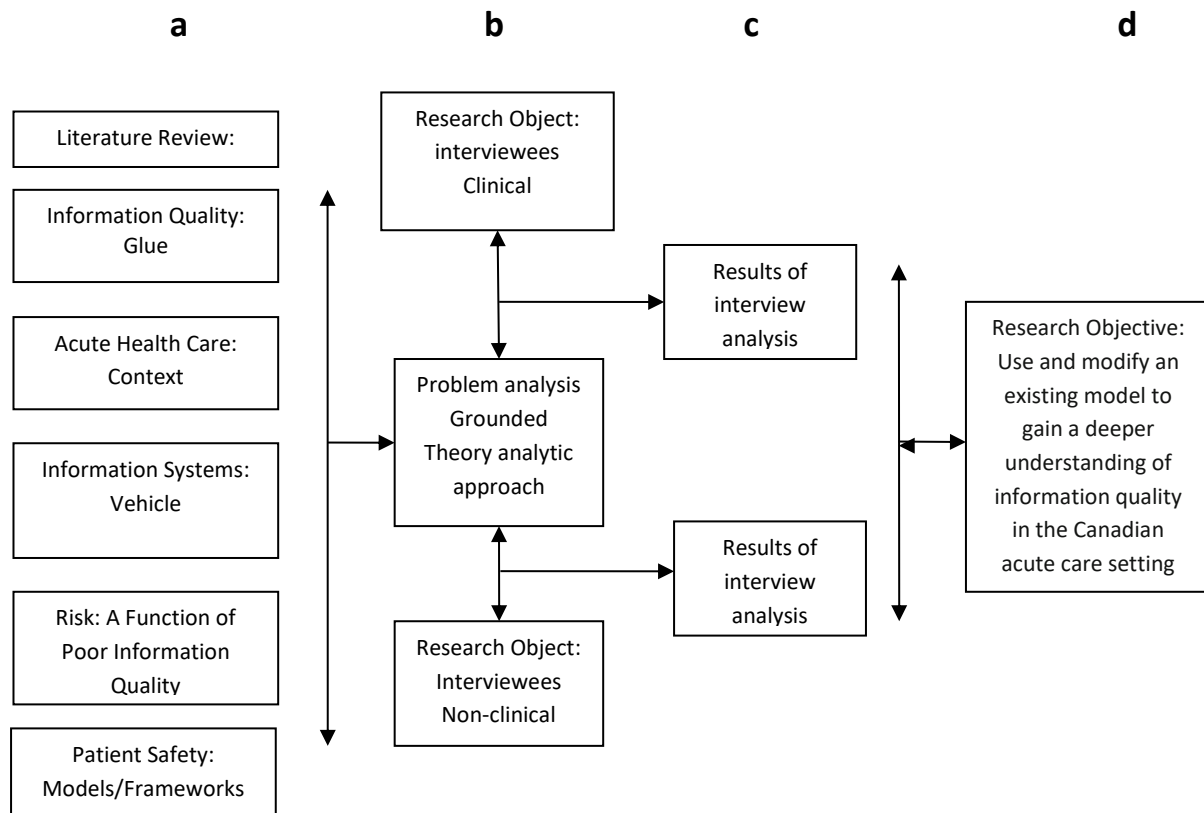


Figure 1: Overall Research Framework. Adapted from Verschuren and Doorewaard (2010) Figure 4.2.

This diagram provides the structure for the research and interview questions as a series of semi structured questions:

The 1st central question [columns a-b in diagram above-data collection]: What do Key Informants think about Information Quality in Acute Care? The interviewee’s responses to the semi structured interview questions will provide insight on information quality.

The interviewees in this dissertation represent implementers or users of systems in the province where health care is provided.

The semi structured interview questions are based on the literature review and help organize the early steps of “initial observations” in the Grounded Theory analytic approach (Corbin & Strauss, 2008 p. 38).

1.2 Summary

This introduction sets the stage for the rest of the research: it is not clear why expensive information systems fail so this needs further investigation. Part of the failure relates to information that is missing or wrong because of information system or user issues. Missing or unavailable information will be a common theme in the literature review and in the qualitative analysis of the interviewee understandings and interpretations. Information that is missing or unavailable contributes to patient adverse events.

This dissertation will now move to the Chapter Two Literature Review that will show the ambiguities and gaps the research (via the semi structured interview questions) will attempt to fill. The literature review is about information quality, including the risk as a function of poor information quality, information systems, and patient safety in Canadian in acute care. The literature review will address each one of these five areas in the order that they appear in the research framework in Figure 1 starting with information quality.

Chapter 2: Literature Review

2.1 Introduction

This chapter will cover the five main areas relevant to the dissertation:

- **Information quality:** is information quality the glue central to patient care and can poor information quality have adverse effects on organizations and patients? Information quality is difficult to define, therefore, qualitative methods may be preferable.
- **Acute care sector:** provides the context for the information quality in this dissertation which considers how it is a system and how information use and quality provided by an information system are central to the functioning of the overall system.
- **Information system:** we will consider the types of systems and potential for error propagation by the flow of information within the system that acts as a vehicle for information, the non-functional requirements of well-functioning systems, safety issues of poorly functioning systems and information quality as a non-functional requirement.
- **Risk:** adverse events can have a known probability (in our case they are usually rare with low probability and varying impact(s), be wicked (ill-defined), complex with inter-related causal links, or uncertain with an unknown probability⁹. These factors are problematic for quantitative risk assessment so there is now a shift away from quantitative techniques to a qualitative approach. Risk assessment techniques with emphasis on qualitative techniques are optimal for looking at risk as a function of poor information quality.
- **Patient safety:** research in this area provides models for information quality because of the many definitions used in the patient safety and adverse events literature; causation theories with emphasis on the system view of safety; and some concepts such as “levels” and “fit”.

Some concepts reappear over and over in the literature indicating their importance (Corbin & Strauss, 2008 p. 37). We shall see that information quality is one such concept that has not been explored fully in the context of acute care information systems in Canada.

This dissertation then explores how the five areas, information quality, acute care, information systems, risk as a function of poor information quality and patient safety, as described in the

⁹ The terms rare events, wicked (ill-defined), complex with inter-related causal links, and uncertain with unknown probability are defined below in section 2.6.4 (Classification of Adverse Events)

literature review, relate to what the interviewees say in the semi structured interviews in the Chapter Six Discussion section (6.2.2). The Chapter Six Discussion is based on the Chapter Five analysis of the interviewees' coded responses to the semi structured interview questions. The Chapter Five analysis used a Grounded Theory analytic approach that is described more fully in Chapter Four. The following is a brief summary of the Grounded Theory analytic approach.

A Grounded Theory analytic approach was used to analyze the interview data. Grounded Theory is an established qualitative technique to discover or generate theory about a phenomenon. In our case, we applied a Grounded Theory analytic approach applying codes or terms to the interviewees' understandings and interpretations and then comparing and contrasting these codes or terms. The pure Grounded Theory method has three principles: first, "emergence" [the research process and the theory arising both emerge from the research process], "second", constant comparative analysis within and between texts, and, third, "theoretical sampling" to saturation (Matavire & Brown, 2013 p. 120). This research will use a Grounded Theory analytic approach because it will use only constant comparative analysis within and between the interview texts.

Within the Grounded Theory analytic approach the literature review can provide topics for both early interview questions and early coding (Corbin & Strauss, 2008 p. 38). Matavire and Brown (2013 p. 122) note that the literature review can provide a "justification for the study", the Grounded Theory analytic approach and satisfies research ethics processes. However, the researcher should not allow the literature review to steer the researcher into testing hypotheses instead of allowing the data to provide concepts and theories within the Grounded Theory analytic approach. The interview data in this research provided concepts for further analysis and discussion in Chapter Six.

The next section will present first, a brief outline of the literature review methodology and then, literature reviews for each of the five areas beginning with information quality in the next section, 2.3, since it has a central role in health care.

2.2 Literature Review Methodology

The main research databases used in this research were the Web of Science™, the IEEEExplore®, PubMed, CINAHL® and Google Scholar.

2.2.1 Search Terms

Please see Appendix B for the search terms and approaches used for searching the different databases. These databases were used to find the literature in the following Chapter Two sections and literature used in Chapter Six, Discussion and Conclusions.

2.3 Information Quality: the All-important Glue

Information flows around a system from its source to its target; the “sending and receiving of that information requires action and interpretation” (Bryant, 2002 p. 38). Those targets can have different uses for the information according to the type of information.

2.3.1 Information Purpose and Use

There are three purposes for information for health care that are relevant here (Stine et al., 2008 vol. 2 p. 167-172). The first is for access to care, the second is for health care administration and the third is for health care delivery services. Stine et al. (2008 vol. 2 p. 167) note for access to care and health care delivery services “unauthorized modification or destruction of health care information integrity may result in incorrect, inappropriate or excessively delayed treatment of patients. In these cases, serious adverse effects can include legal actions and danger to human life”.

Some information for access to care “could be deemed time-critical requiring immediate access for care” (Stine et al. 2008 vol. 2 p. 168). Stine et al. (2008 vol. 2 p. 168) comment “delays in the communication of specific situations may cause serious impacts to the patient or care provider” because health care decisions are delayed or based on erroneous information. For health care administration a loss can result in “inappropriate allocation or deployment of health care services and possible loss of human life” (Stine et al., vol. 2 p. 170).

Health care information has several uses. Greenhalgh (2008 p. 33) notes that it can be used for “service planning..., research, clinical care and patient access” to his or her own information.

The risks of poor information quality are highest in clinical care: the risks associated with poor quality data in the clinical setting are not so much that the likelihood of a clinical error will “increase (although that is a real possibility)” but that the Summary Care Record (SCR) system may fail to deliver any benefit to users because clinicians “fail to trust or use it” (Greenhalgh, 2008 p. 33). A further complication is that information is not “100% complete or accurate” (Greenhalgh, 2008 p. 33).

“A large information system’s most valuable asset is not its hardware or software, but rather the information of greatest value to major stakeholders” (Hole & Netland, 2010 p. 24).

2.3.2 Information Quality

Health care relies on good quality information. The literature makes a distinction between data quality and information quality. However, for the purpose of this research using a Grounded Theory analytic approach, this dissertation and its qualitative analysis will follow Bryant (2002 p. 37) who states that there is really no hierarchy of data, information and knowledge because individuals apply “meaning” to every piece of information they encounter “rather than extract information from this raw material”. This research adopted Bryant’s interpretation because the focus is on all types of information weighted equally (rather than a hierarchy) that are used in health care and what the interviewees thought about the quality of all types of information equally.

Information quality also implies an earlier logical step to populate the information system itself with information fields for the users. Ahn et al. (2013 p. 409) call the clinical information embedded in the decision support system and other parts of the electronic health record the detailed clinical model. Although there are system requirements for detailed clinical models including: “1) the addition of elements and attributes to the clinical model without the necessity of changing the underlying software or database schema; 2) use an existing formalism/syntax for the representation of the model; 3) tight binding of model attributes to standard terminology systems; and 4) the existence of a mechanism for stating ‘negation’”), the qualitative and quantitative attributes of the detailed clinical models themselves are not well defined (Ahn et al., 2013 p. 409).

Pierce (2005 p. 4) notes that information quality depends on the type and quality of “knowledge” needed for decision making in the first place either at the individual level or in a health care decision support system. This generates the data “standards” and information quality fit for use (Pierce, 2005 p. 4) as a “given” in the light of Ahn et al.’s comments. It will be difficult for this research to assess this earlier step of the type and quality of knowledge for decision making either within an individual or system given the specialized requirements described by Ahn et al. (2013 p. 409)so will not be discussed further.

Liaw et al. (2013 p. 11) cite that about “5%” of health organizations’ records have poor data quality. This implies that there is poor information quality in these records also. It is not clear from this study how quality was measured but Liaw et al. suggest that data quality is fitness-for-purpose or -use. This is consistent with the International Standards Organization’s (Liaw et al. 2013 p. 15) quality definition: “the totality of features and characteristics of an entity that bears on its ability to satisfy stated and implied needs”.

Pierce (2005 p. 7-8) provides a good description of the characteristics that make up information quality:

- “Intrinsic quality-the dimensions of believability, accuracy, objectivity, and reputation. Information has quality in its own right. Can we trust the information?”
- “Contextual quality-this includes the dimensions of value-added, relevancy, timeliness, completeness, and appropriate amount of data. It highlights the requirements that information quality be considered within the context of the task at hand”.
- “Representational quality-this includes the dimensions of interpretability, ease of understanding, representational consistency, and concise representation. It addresses the way the computer system stores and presents information”.
- “Accountability quality-this includes the dimensions of accessibility, access and security. It emphasizes the computer system must be accessible but secure: this security feature is out of scope for this research”.

However, researchers have used different techniques to describe the many other terms or criteria for information quality with no consistent definitions(Choquet et al. 2010 (using a concept model for analysis), Gorla et al., 2010 (using the Delone and McLean Model and Chief Information

Officers), and Liaw et al., 2013 (using a literature review)). For example, Choquet et al. (2010 p. 702 Figure 2) has the terms “correctness”, “completeness”, “flexibility”, “understandability”, “simplicity”, “integration”, and “implementability”. Gorla et al., (2010 p. 213) has these terms: “accuracy”, “timeliness”, “completeness”, “relevance”, and “consistency”; while Liaw et al., (2013 p. 10) has these: “completeness”, “accuracy”, “correctness”, “consistency” and “timeliness”. McCormack and Ash used a grounded theory approach to conclude that several descriptive terms be used with an overall quality characteristic that the data be fit for use (2012 p. 1307 Table 2). The concept fit for use is discussed further below in the section 2.7.4 (Patient Safety Concepts and Frameworks).

The intent of the research was to ask the interviewees about quality generally and not guide them to any specific terms. This addresses a gap in the literature above where the information quality terms are not derived from health care interviewees.

Quality can be measured quantitatively and qualitatively because it is “difficult to measure quality with metrics” (Choquet et al., 2010 p. 700). Liaw et al. found 4 of 61 (6%) articles mentioned a qualitative approach to information quality of which only two were cited in Table 4, section 3 (correctness) (2013 p. 16). This suggests relatively few qualitative studies for information quality compared to quantitative studies.

Standards

The UK Royal College of Physicians has information standards in the medical record; these standards will be described in the section 2.5.8(Information System Reduction Remedies) because they have a technical component.

Information Quality and the Information System

There is a close link between the information system and the information contained in it. Information quality depends on the information system presenting the information so it is “interpretable, easy to understand, easy to manipulate, is represented concisely, consistently and is accessible and secure” (Lee et al., 2002 p. 135). Fitterer et al.(2010 p. 4) and Winter and Struebing (2008 p. 417) note that information systems should ensure information is:

- Valid because information is consistent without redundancy.
- Traceable.
- Available inside and outside the organization.
- Trustworthy.

Information Quality and the Organization

Gorla et al. (2010 p. 321) provide a wider context for information quality by adding “system quality and service quality” and assess the organizational impact of these three qualities.

Although they found that service quality had the most impact on the organization, information quality, as measured by a user satisfaction instrument, plays a mediating role for both system quality and the organization (Gorla et al., 2010 p. 222).

Information quality at the organizational level has also be described in the context of three different systems (Chung et al., 2005 p. 232-237):

- “The mechanical system such that organizations create bureaucracies and operating procedures... Data quality can be maintained using statistical process control methods, computer algorithms and database design... Data has the quality elements of correctness, completeness, unambiguousness, meaningful usefulness (p. 234).
- The open system explains that systems interact and exchange information: this introduces complexity and uncertainty into the organization (p. 234).
- The third system is the human system which is also an open system because people interact with the organization and with each other... People must be satisfied with the information” (p. 236-237).

2.3.3 Poor Information Quality

Poor Information Quality-Information Causes

Pierce (2005 p. 9) and Liaw et al. (2013 p. 18) list some causes of poor information quality such as: multiple data sources of the same information can contain different values of the same information; data collected using subjective judgements can lead to biased information being reported; volume of data make it difficult to access in a reasonable time; nonnumeric data is difficult to analyze; wrong diagnoses; incomplete or inaccurate data entry; and, errors in spelling

or coding. Missing information affects information accuracy and completeness (Laranjeiro, 2015 p. 186 Table III).

Poor Information Quality- Information System Causes

Pierce (2005 p. 9) and Liaw et al. (2013 p. 18) list some information system causes of poor information quality including as summarized in the following: distributed heterogeneous systems can lead to inconsistent definitions, formats, and values and excess time aggregating; automated content analysis across information collections are not developed so it is difficult to detect patterns; changing data needs changes information needs; security – accessibility trade off; limited computing resources can limit access; lack of coding rules leading to much of the data being incomplete or in relatively inaccessible text format; corruption of the database architecture or management system; and, non-compliance to the organisational data protocols and errors in data extraction. Poor information quality means the information does not meet the requirements and is not “fit for use” (Laranjeiro, 2015 p. 1).

Poor Information Quality-Organization Effects

Poor information quality can have the following effects on the organization (Gorla et al., 2010 p. 215): “customers will be dissatisfied and employees will lack job satisfaction because of inaccurate or incomplete information; ...quality of decision making will be adversely affected by irrelevant information; ...selection and execution of a sound business strategy will become difficult because of inaccurate or delayed information”.

Laranjeiro (2015 p. 180) outlines the three costs of poor data or information quality in a business context (the costs are also applicable to health care): “a) data entry; b) data processing; and c) data use”. Data entry quality costs may either be caused by the low quality of data (e.g., cost of correcting), or preventive costs (e.g. training, defect prevention)(Laranjeiro, 2015 p. 180-1). Data processing quality costs are also organized in two subgroups: costs of re-processing dirty data (e.g., re-work, rolling back) and process improvement costs (e.g., costs of detecting, analyzing, and reporting dirty data (Laranjeiro, 2015 p. 180-1). There is also the indirect cost of mistrust in, and poor satisfaction with, the data (Laranjeiro, 2015 p. 180).

And of course, poor information quality can cause adverse events!

2.3.4 Summary

We have seen in this section that information is a glue generated by humans for specific purposes that flows among information systems. This glue can be high or low quality. The fact that the literature does not describe the effect of these characteristics on information quality is a gap this research will address. Information quality that is poor quality because information is missing, corrupt or inaccessible can contribute to adverse events.

2.4 The Acute Health Care Sector: Information Quality Context

2.4.1 What is Health Care?

Tan and colleagues (2005 p. 38) call health care a complex adaptive system because it is a collection of “individual semi-autonomous agents acting in ways that are not always predictable” yet seeking to maximize a measure of fitting together by evolving over time. They also note that these “systems evolve to a level of organization through self-adaptation rather than central control” (Tan et al., 2005 p. 39). Health care could even be described as hyper-complex because of the “complexity of human physiology and disease,... the magnitude of human activity devoted to it,... and the explosion of biotechnology and medical knowledge” (Nemeth et al., 2004 p. 689).

Health care has also been described as a “loose collection of independent microsystems that have given health care a cottage industry approach” (Battles, 2006 p. i 2). These clinical microsystems are essential organizational units where clinical “care” is actually “delivered” to patients (Battles, 2006 p. i 3). The delivery of health care within the microsystem is governed by “human performance” (Battles, 2006 p. i 2) and “human-human interaction” (Lyons et al., 2004 p. 225). “The process of care can also be thought of as a clinical work system” (Battles, 2006 p. i 2). Clinical work is an interaction of teams of health care providers working in microsystems within a “built environment using tools, devices”, and information systems to care for the system’s focus point, the patient (Battles, 2006 p. i 2).

We shall see in Chapter Five that the interviewees provide their own real world experiences of health care as professionals embedded in the acute care setting as being busy and intense.

2.4.2 What is a Healthcare System?

We speak of a healthcare system but what does this mean? A system is a set of functionally-related parts forming a whole. The elements of the system include: “the components or parts of the system; attributes or characteristics or configuration... of system components; and, relationships between pairs of linked components by engineering the attributes... to contribute to the system’s purpose” (Blanchard & Fabryky, 2010 p. 3). Bryant (2002 p. 26, 27) makes the

important point that “ there are no simple answers” so it is very difficult to define a system boundary beyond the “stakeholders” whom he calls an early boundary “in the first instance”. The interviewees are the actors delimiting the system boundary for this research.

Health care has also been described as a complex system with specific characteristics. Lipsitz (2012 p. 243, 244) describes what these characteristics are as compared to a mechanical system with components that interact linearly to produce an output. The complex system:

- Has “nonlinear interactions” to produce unexpected results.
- Has a dynamic output that changes according to initial conditions and feedback and is “greater than the sum of its parts”.
- Has “emergent self-organized” behaviours.
- Can follow the “simple rules” of aims, limits and incentives.

Another characteristic of health care is the presence of gaps because of its “hierarchical structure ...and temporal-spatial separation processes (Dekker, 2007 p. 464). Gaps are a sign that the health care system is “loosely coupled with activities and conditions in one part of the system” not much affecting other parts of the system (Cook & Rasmussen, 2005 p. 130). Dekker (2007 p. 464) says that gaps produce loss of information and responsibility, while Cook and Rasmussen (2005 p. 130) say that loose coupling provides buffering for changes in demand. Healthcare professionals ensure there is a smooth veneer or “mask” that hides the complex and uncertain care demands (Nemeth & Cook, 2005 p. 689).

2.4.3 Summary

We have seen how acute care’s complexity and porous nature provides a context for potential harm to information quality. An important gap is the lack of real world experience of these characteristics in Canadian acute care We shall see the complexity concept further below in section 2.6.4.

The next section, 2. 5 (Information Systems), will look at the systems in more detail: are there types of systems that contribute to poor information quality and adverse events, how information

quality is a non-functional requirement of those systems, and some remedies to control these non-functional requirements.

2.5 Information Systems: Information Quality Vehicle

An implemented information system represents a set of “choices made by designers” based on “assumptions” or instructions or requirements about how the system’s working environment, in our case, health care, is organized and how the users interact with the system (Orlikowski & Barley, 2001 p. 149). This interaction means using both the system and the information the system displays to the user (Vest & Jaspersen, 2010 p. 302).

2.5.1 What is Information Technology?

Orlikowski and Barley (2001 p. 149) suggest that technologies are “social and physical” artefacts because they represent a set of “design” choices. A given set of design choices either “constrains or “enables its use as well as the users integrating the technology into their workplace (Orlikowski & Barley, 2001 p. 149). Information technology research is often about design and use, and Orlikowski and Barley (2001 p. 153) note that institutional theory may be useful for us as it examines how institutions influence the “design, use, and consequences of technologies, either within or across organizations”.

Orlikowski and Iacono (2001 p. 122-128) show in their review how information technology can fit into five metacategories: the tool view (the engineered or designed artefact to replace or augment labour), the proxy view (user perceptions and cost), the ensemble view (application management and policy sociotechnical context), the computational view (algorithms and computational power), and the nominal view (IT not mentioned). The nominal view will not be considered further because IT was not discussed.

The ensemble view of technology focuses on the “dynamic interactions between people and technology-whether during construction, implementation, or use in organizations, or during the deployment of technology and society at large” with questions such as: “how do users appropriate the social structures embodied in a given technology and with what outcome is, what are the intended and unintended consequences of using a given technology” (Orlikowski & Iacono, 2001 p. 126, 127).

Blanchard and Fabrycky (2010 p. 4) categorize system components into three groups by their attributes: flow components, structural components, and operating components. “Flow

components are materials, energy, objects, data, or information being flowed or altered; structural components are the static parts or objects that facilitate the processes; and, operating components are the parts or objects that perform the processing or affect the processing indirectly” (Chuang et al., 2009 p. 220; Blanchard & Fabryky, 2010 p. 4). Health care in this context is:

- A “human-made system in which human beings have intervened through components, attributes, or relationships”, and is a
- A “dynamic system in which uncertainty often occurs in both inputs and the distribution of these inputs over time”, and is an
- An “open system in which information, objects, and matter crossing boundaries are allowed” (Chuang et al., 2009 p. 221).

2.5.2 Types of Systems

Not all systems are alike. Wilcox and colleagues have developed a taxonomy of health information exchange system design options based on the degree on integration (2006, p. 815-817 and Figure 1) as shown below in Figure 2:

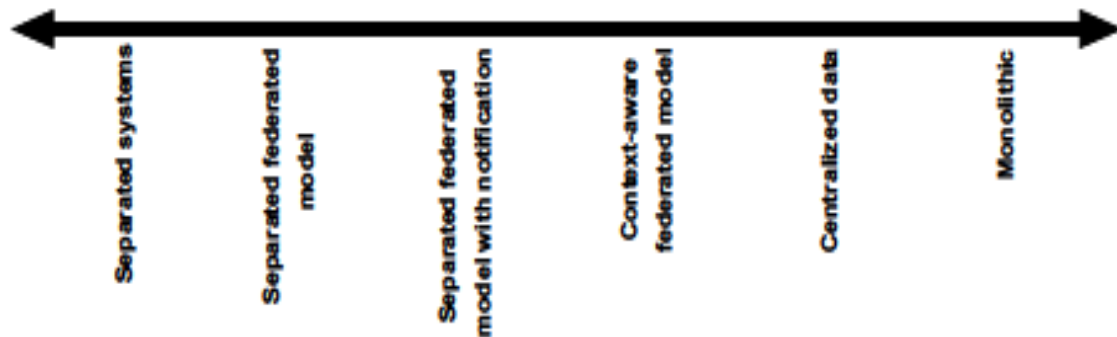


Figure 2: Types of Information Systems. Reprinted from: Wilcox, A., Kuperman, G., Dorr, D. A., Hripcsak, G., Narus, S. P., Thornton, S. N., Evans, R. S. (2006) Figure 1.

The types of information systems are (in order from the least integrated on the left to the most integrated on the right):

- Separated systems. Separated systems represent the “pre-electronic information system health care environment, where information is communicated across providers and sites via telephone or fax rather than by computer interface. Such communication is dependent on synchronous participation, or a response by the sending party to a recipient’s request”(Wilcox et al. 2006 p. 815-816).
- Separated federated model. “Organizations can move from a separated model to a separated federated model by giving clinicians outside a health care institution access to that institution’s electronic medical record. The technical burden of information exchange is with the clinician user, who must authenticate into the system, and select the appropriate patient. The institution must only provide a method to access the system””(Wilcox et al. 2006 p. 816).
- Separated federated model with notification. “This model adds notification functionality from the previous model. Examples include standard peer-to-peer information exchanges. Other examples include physician-patient communication systems, where one party receives notification of the presence of data in a less-secure but more accessible platform (e.g., standard email), but must access and authenticate within a more secure system to obtain the data. The notification allows providers to be alerted to the presence of data on separated systems, to avoid searching fruitless and labour-intensive searches for information. To accomplish this notification, the implementation must centralize and automate some level of patient identification across systems. Users still carry the burden of authentication, and patient selection in the separate systems” (Wilcox et al. 2006 p. 816).
- Context-aware federated model. “The context-aware model addresses the logon and patient selection tasks of the previous model, which can be barriers to use. Beyond the technical requirements of the previous model, it requires some level of centralized control or coordination of users, and robust patient matching between systems, which is a significant barrier in information system initiatives. It also requires the use of applications that can appropriately handle clinical context messaging. This model maintains the context of clinician user and patient across different systems... However, it reduces all the major barriers to information access” (Wilcox et al. 2006 p. 816-817).
- Centralized data. “The centralized data model extends previous models by centralizing actual patient data. While this extension can be relatively simple technically, if only text data are being shared, it typically involves sharing of both structured and unstructured data. With a centralized data-sharing model, organizations must transmit data to a centralized source, where data can be combined in structured form” (Wilcox et al. 2006 p. 817).

- Monolithic system. “Monolithic data exchange systems currently only exist within large integrated delivery organizations that also use a monolithic electronic medical record. This approach requires that all participants in the health information exchange use the same electronic medical record, which is usually only possible where organizational control is centralized. Migrating to monolithic systems is thus the most disruptive change on the continuum” (Wilcox et al. 2006 p. 817).

Labkoff and Yasnoff (2007 p. 104) note that there is a “natural progression” away from systems relying on free text data entries to centralized integrated systems. The implication is that information flow improves and information about a patient is shared more quickly, “a positive asset” (Labkoff & Yasnoff, 2007 p. 104). It also means that information about an adverse event propagates widely. This can mean either faster containment or dissemination of erroneous information related to an error.

There are other “risks or negative effects” with the more integrated systems including: false sense of security about the system, effect of widespread downtime, loss of patient privacy, time cost for health care providers to learn a complex system and the time lag between implementation and time to show a benefit or cost (Hripcsak et al., 2007 p. S 5 Figure 1, S 6 Figure 2).

There are different specialized information systems for different purposes. Brender et al. (2006, p. 129) provide a list of the most common (this research will not include administrative systems):

- Administrative systems: clerical systems including booking.
- Production support systems: laboratory information systems, radiology information systems, clinical systems: electronic health care records.
- Decision support systems: knowledge-based systems, decision support systems and expert systems.

Not only must these systems be private and secure but Hoffman and Podgurski (2008 p. 137) note that electronic health care records systems must be “safe” and efficacious. These qualities should exist throughout the following system core functionalities (Hoffman & Podgurski, 2008 p. 108):

- Health information and data: “the system should display laboratory test results, allergies, lists of other medications the patient is taking, medical and nursing diagnoses, patient demographics, and providers’ notes”.
- Results management: “the system should provide laboratory test results, radiology procedure results, and other treatment results electronically to enhance provider access to needed information and promote efficiency and easier detection of abnormalities”.
- Order entry and management: ”computerized medication orders and other care instructions can reduce or eliminate lost orders, duplicate orders, mistakes caused by illegible handwriting, and delays in filling orders”.
- Decision support: “computer reminders and prompts can improve preventive care, diagnosis, treatment, and disease management”.
- Electronic communication and connectivity: the “systems should facilitate online communication among medical team members, other providers such as laboratories or pharmacies, and patients through e-mail, web messaging, integrated health records within and across treatment settings, telemedicine, and home telemonitoring. Communication should be possible among providers in different geographic locations and medical organizations”.

2.5.3 Information System Elements and Characteristics for Safety

The US National Institute of Standards and Technology (NIST¹⁰) defines the term “information system” as a “discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination or disposition of information” and “information resources as information and related resources such as personnel, equipment, funds and information technology” (Stoneburner et al., 2012 p. 8-5). Information technology is defined as “any equipment or interconnected system or subsystem that is used in the automatic acquisition, storage, manipulation, management, movement control display, switching, interchange, transmission or reception of data or information....(Stoneburner et al., 2012 p. 8-7).

These definitions are useful because they have the triad of information, technology and personnel (users). Information systems are composed of both software programs and information. A well-

¹⁰ NIST is the National Institute of Standards and Technology. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. For more information please see the following link: http://www.nist.gov/public_affairs/nandyou.cfm for example, health care: <http://www.nist.gov/healthcare/index.cfm>

functioning system has the necessary characteristics so it runs smoothly and safely.

Lowry et al. (2016 p. 5) have produced a NIST guidance document based on a grounded theory and human factors processes to create a set of two use cases or scenarios to test electronic health care system usability and safety in the three critical use risk areas: “1) consistently display information critical to patient identification in a reserved area to avoid wrong patient errors 2) provide cues to reduce the risk of entering information and writing orders in the wrong patient’s chart, and 3) support efficient and easy identification of inaccurate, outdated, or inappropriate items in lists of grouped information by having information presented clearly and in a well-organized manner”. The two use cases were validated by teams of experts and led to a series of guidelines for safety enhanced design (Lowry et al, 2016)¹¹.

Lowry et al. (2016 p. 22 Table 3) provide test scenarios to evaluate system and information issues in acute care (use case 1) and primary care follow up (use case 2). This research addresses a gap by asking interviewees about system and information issues in a real world setting of Canadian acute care rather than in a use case scenario.

The Pew Charitable Trusts (2016 p. 2) note that the NIST use cases are for summative testing after the design phase as mandated by the Office of the National Coordinator for Health Information Technology. The Pew Charitable Trusts (2016 p. 2) recommend that use cases be used for formative testing be used throughout the design phase and after implementation. It is clear IT safety testing is a rapidly evolving area. The UK does have standards for clinical risk management at the design and implementation phases (National Health England, 2016)¹².

2.5.4 Software

The type of software used in health care is called safety-critical software because failure could “cause loss of life, serious harm, or have widespread negative social impact” (IEEE, 1994 p. 1). Software failure happens in the context of its associated “hardware, environment, and operators”

¹¹ For example Zhang and Walji (2014) have developed a system called TURF (Task, User, Representation, and Function) based on the NIST guidelines; the Office of the National Coordinator for Health Information Technology (n.d.) (a private-public consortium) has the Health IT Playbook, section 7 for Quality and Patient Safety.

¹² The compliance assessment templates are now available. Please see the National Health England links in the references.

(IEEE, 1994 p. 1). Software failure can produce several types of “organizational risks” including liability and adverse events (Ross et al., 2011 p. 1). Wears (2012 p. 4486) notes information systems software has improved but is not yet free from defects; nonetheless, there is an ISO software quality evaluation model (ISO/IEC 9126) and other standards available (Ahn et al. 2013 p. 411).

2.5.5 Non-Functional Requirements

Non-functional requirements refer to the qualitative attributes of a software program. These attributes are difficult to measure and as a result they are usually measured only after the software has been implemented. The non-functional requirements relevant for this research are reliability, safety, and quality:

Reliability

This is a measure of whether a user can depend on the software. This notion can be defined qualitatively based on user perceptions gained through focus groups. It can also be defined quantitatively in terms of statistical behaviour, that is, the probability that the software will operate as expected over a specified time interval.

Reliability in engineering is defined as the “probability that a component satisfies its specified behavioural requirements over time and under given conditions” (Leveson et al., 2009 p. 234). “Redundancy [is] only one of many ways to protect against unreliable components leading to accidents” (Leveson et al., 2009 p. 236).

Virginio and Ricarte applied the ISO standard 25010 [System and Software Quality Requirements] against EHR errors reported in the literature (2015 p. 55). The characteristic of functional suitability fits in with reliability because both of these are geared to user goals. Virginio and Ricarte (2015 p. 56 Table 1) found three types of concerns: lack of functionalities that support clinical workflow, lack of coding, standardization, and structuring data, and lack of features to detect duplicate patient records. Systems that are deficient in these qualities encourage “workarounds”, do not “issue alerts” when they should and create inaccurate patient information with “gaps” (Virginio & Ricarte, 2015 p. 57).

Safety

This can be “defined as freedom from unacceptable losses (accidents)” (Leveson et al., 2009 p. 234). “Safety is a system property, not a component property (i.e. related to an input device processor, memory or output device), and must be controlled at the system level rather than the component level” (Leveson et al., 2009 p. 235). “There can also be safe systems with unreliable components if the system is designed and operated so that component failures do not create hazardous system states” (Leveson et al., 2009 p. 236). Reliability and safety are not equivalent at the system level and they often conflict: increasing system reliability through redundancy such as checking for errors may decrease system safety because increasing system complexity may still not prevent an error from happening (Leveson et al., 2009 p. 236). The converse is also true: “increasing system safety may decrease system reliability” (Leveson et al. 2009 p. 236). Leveson et al. provide an example of this with an aircraft carrier that loads its aircraft in calm weather only, however, this may make the ship slower to deploy in an emergency (2009 p. 236). A health care example would be a system failing a penetration test that is designed to make the system crash or fail.

Johnson and Willey (2011 p. 35) looked into healthcare data leakage problems arising from system usability failure using observation and interviews. They found that there were two types of files: the “born-vulnerable” that were generated directly from direct patient care and the “moved-vulnerable” that were ad hoc creations (workarounds) by staff because the integrated enterprise system¹³ was difficult to use. Johnson and Willey (2011 p. 40) found that there were four categories of “moved-vulnerable” files: employee data, operational data such as scheduling, financial data for billing and collection, and, research and analysis data. The “born-vulnerable” file group suggests an inherent vulnerability to adverse events.

Quality

Hoerbst and Ammenwerth (2010 p. 331 Table 19) did a literature review with a series of

¹³ An enterprise system corresponds to the monolithic system above in section 2.5.2 (Types of Systems) where applications and processes are centralized and standardized.

eighteen telephone and face-to-face interviews and comparison with norms such as EuroRec¹⁴ Repository and CCHIT¹⁵ about electronic health record quality; they came up with 1191 unique non-functional requirements and assigned them to 59 categories and sub-categories in their study (which did not include specialized functionalities such as order entry).

The results were grouped into eleven major categories: global requirements, functions (general), data security, content, usability, interoperability, reliability, privacy and data protection, maintainability, performance/efficiency and portability. Descriptions of safety were not mentioned. This is likely because clinical functionalities such as order entry were not reviewed. It is not clear what the experts were asked or how the initial categories were created; however, this study shows that patient safety is missing in the Hoerbst and Ammenwerth non-functional requirements. Ahn et al. (2013 p. 412, Table 1) also compared the different clinical data structures such as “EuroRec” to describe a standardized clinical element such as blood pressure for reliability assessment. They also did not look at patient safety per se but they did note that the agreement for blood pressure had a kappa coefficient of 0.73 that they described as “good” (Ahn et al., 2013 p. 413). If an organization adopted a standard with poor agreement then the quality of the clinical information for decision making would be questionable and could impact patient outcomes if a blood pressure reading was falsely either too high or too low. Ahn et al. do not discuss this point.

Security Objectives

Stine et al. (2008, vol. 1 p. 9) speak of three main security objectives for information systems under US federal jurisdiction. Although it is a context different from this research, the objectives are the same in the health care setting. The three objectives are listed below (Stine et al., 2008, vol. 1 p. 9 Table 1) and note the impacts they have on information quality:

- Confidentiality, which is “preserving authorized restrictions on information access and

¹⁴ EuroRec Institute is a non for profit organization promoting electronic record systems and standards. Please see the link: <http://www.eurorec.org/>

¹⁵ CCHIT is the Certification Commission for Health Information Technology. It was an industry-based Electronic Health Record certification organization in the US that ceased operation in 2014. Please see the link: <http://www.cchit.org/>

disclosure, including means for protecting personal privacy and proprietary information. A loss of confidentiality is the unauthorized disclosure of information”.

- Integrity, which is “guarding against proper information modification or destruction, and includes ensuring information non repudiation and authenticity¹⁶. A loss of integrity is the unauthorized modification or destruction of information”.
- Availability, which is “ensuring timely and reliable access to and use of information. A loss of availability is a disruption of access to, or use of, information or an information system”.

Availability and integrity are the most relevant for our purposes. This research will not be concerned with issues of confidentiality and security around confidentiality, because that will broaden the scope beyond what is reasonably achievable in the research timeframe. While adverse events could arise through breaches of confidentiality, they are more likely to occur because of loss of information integrity because the information is “modified” and availability through lack of “access” (Stine et al., 2008, vol. 1 p. 21, 22).

2.5.6 Information System Assumptions

Dekker (2011 p. 83) describes the substitution myth about technology, including information systems: “that technology can do a task better, faster or cheaper than a human” and it can catch “errors”. Another part of the myth is that there are “quantitative changes” , however, he notes that measurement is difficult because it covers costs, effects and time and that “qualitative” methods are preferable for capturing benefits or issues (Dekker, 2011 p. 88). This is because the information system is a complex system that is “never fully knowable” or static (Dekker, 2011 p. 236). We shall see the complexity concept further below in the risk section, 2.6.4.

2.5.7 Information System Risk Categories: They are Multifactorial

Risk assessment research on information systems has created a variety of categories that emphasize individual and organizational factors that could contribute to adverse outcomes. These

¹⁶ Non-repudiation is defined as “Assurance that the sender of information is provided with proof of delivery and the recipient is provided with proof of the sender’s identity, so neither can later deny having processed the information”. Authenticity is defined as “The property of being genuine and being able to be verified and trusted; confidence in the validity of a transmission, a message, or message originator. (Stine et al. (2008, vol. 1 Appendix A Glossary of Terms).

categories include (Chua, 2009 p. 35 Table 1; Pare et al., 2008 p. 3 Table 1):

- People related, process related, technical.
- Life Cycle: initiation, development and implementation.
- Specific Project: (1) lack of effective project management skills/involvement, (2) lack of adequate user involvement, (3) lack of top-management commitment to the project, (4) lack of required knowledge/skills in the project personnel (5) poor/inadequate user training, and (6) lack of cooperation from users.
- General project: failure includes insufficient awareness of organizational issues, poor alignment of information technology adoption to the business strategy, changed user requirements and the project size and complexity.
- Technological: hardware and software complexity is a critical information technology project risk factor.
- Human: resistance to change is a phenomenon that is pervasive and widely recognized .
- Usability: perceived system usefulness is important in the case of critical organizational activities such as clinical care; the validity and pertinence of information, as well as factors such as system downtime, display speed and user-friendliness.
- Organizational: support from upper management.

We will now look at some regulatory tools to mitigate information system risk categories.

2.5.8 Risk Reduction Remedies for Information Systems

Different jurisdictions apply different legal instruments to mitigate the risks of information systems. Magrabi et al. (2013 p. e140-e 141) reviewed the set of advisories, recommendations, guidelines, or standards potentially addressing safe system design, build, implementation or use for England, Denmark, the Netherlands, the USA, Canada and Australia.

Magrabi et al. (2013 p. e 142 Table 1) grouped the 27 patient safety projects or initiatives for information systems in the following mitigation groups as shown on the Table 1 below. We have seen one of the initiatives, the Connecting for Health (CfH) from the UK above in section 1.1.2 (The Human Cost of Information System Failure). Seven initiatives are for medical diagnosis and treatment software that have oversight regulations in England, Denmark and Canada.

There are also unregulated systems that rely on “guidance” and “standards” and/or “oversight using certification, regulation and incident monitoring” (Magrabi et al., 2013 p. e 141). “With the exception of diagnostic, prognostic, monitoring and treatment software, that are subject to medical device regulations in some countries, [such as Canada], the safety of the most common types of electronic information systems such as electronic health records or computerized physicians order entry without decision support is not addressed” (Magrabi et al., 2013 p. e 140 and Table 2¹⁷). Table 1 provides an overview of the different standardization initiatives showing that Canada has a oversight model for implementation and IT vendor certification and a regulation model for medical devices.

Table 1: National and Regional Initiatives

Country/region	Standardization			Oversight		
	Guidance	Standard	Regulation Mandated Standard	Certification	Regulation	Incident Monitoring
European Union			X [e.g. ISO ¹⁸ [medical device]			
England	X [Connecting for Health]	X [Connecting for Health]			X	X [Connecting for Health]
Denmark					X	X
Netherlands						X
USA	X [NIST]			X (not patient safety focus)		X
Canada				X (not patient safety focus) [Canada Health Infoway] ¹⁹	X [Health Canada] [medical device]	
Australia	X			X		

Note: adapted from Magrabi et al., (2013) p. e143 and Table 2.

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¹⁸ The ISO, the International Organization for Standardization, is an independent, non-governmental international organization with a membership of 163 national standards bodies to share knowledge and develop voluntary, consensus-based, market relevant International Standards. There are 21000 standards, for example: ISO 25010 Systems and Software Quality, ISO 27001 Information Security, ISO 13485 Medical Devices. Please see the following link for more information: <http://www.iso.org/iso/home.html>

¹⁹ “Canada Health Infoway [Infoway], established in 2001, is an independent, not-for-profit organization funded by the federal government. Infoway helps to improve the health of Canadians by working with partners to accelerate the development, adoption and effective use of digital health solutions across Canada including funding provincial IT projects and certifying vendors”. For more information please see the following link: <https://www.infoway-inforoute.ca/en/about-us> and <https://www.infoway-inforoute.ca/en/what-we-do/progress-in-canada/project-list>, and Rozenblum et al. 2011.

The following diagram, Figure 3²⁰, shows, Magrabi’s visual estimate of the small overlapping subset of diagnosis and treatment software “legally required to be safe” as compared to the larger software set with Guidelines, Standards and Certification listed above in Table 1:

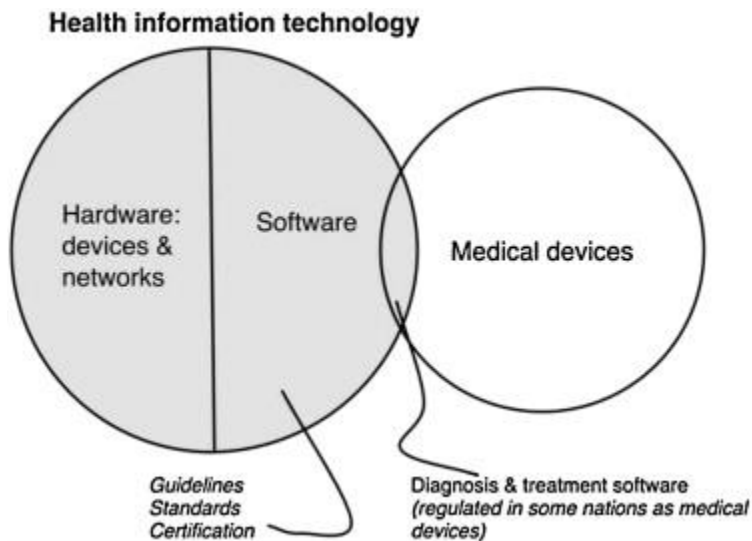


Figure 3: Current Safety Initiatives primarily address Software with limited Oversight. Reprinted from Magrabi et al. (2013) Figure 1.

Medical Device Regulation

Medical devices can do different things in health care: they can be producers of data for care or they can be consumers of data generated by other medical devices such as an analgesic pump that uses patient information to titrate a treatment dose “without human intervention” (“closed-loop devices”) (Williams & Weber-Jahnke, 2010 p. 83). Williams and Weber-Jahnke (2010 p. 83) note that regulators are unwilling to regulate devices that are consumers of data because safety of autonomous systems” is difficult to test.

Several jurisdictions, including Canada since 2009, have added some types of software to their legislation regulating medical devices (Kushniruk et al., 2013 p. e 152). Canada has four “risk categories” of medical devices ranging from the minimally-invasive such as wound care to the

²⁰ (c) Reproduced by permission of Elsevier Publishers. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

most invasive such as pacemakers (Snowdon et al., 2011 p. 8). Medical software in Canada can be either a “class I” device (“storing, acquiring, transferring or viewing data or images”) or a “class II” device (functionality beyond level I) (Williams & Weber-Jahnke, 2010 p. 90).

Williams and Weber-Jahnke (2010 p. 102) note that “software safety is significantly different from the hardware safety” that relies more on physical properties such as stability under different temperature conditions or sterilization: software safety is more about updating and retesting or de-bugging.

Hoffman and Podgurski (2008 p. 143) suggest that safety will be improved with extensive “field testing of all new products” with “post market” surveillance so more accurate safety data is collected.

Standards

Canada Health Infoway has developed national “privacy and security” standards for information systems and some provinces have created their own certification programs (Williams & Weber-Jahnke, 2010 p. 98). Magrabi et al. (2013 p. e143) note that Canada Health Infoway's certification “criteria focus on privacy, security, and interoperability (based on international and Canadian standards)... while a fourth set of criteria focusing on manufacturer practices for managing risk, data, system security, as well as third party solutions and services are noteworthy from a safety perspective”.

The US had voluntary standards such as the Certification for Health Information Technology (CCHIT) and is developing usability standards for electronic health records (Kushniruk et al., 2013 p. e 151).

The UK also has system standards but is looking at information standards in the electronic medical record. As an example, the Royal College of Physicians²¹ (2012 p. 13-14) has drafted a report about why standardizing information quality is important for information transfer between systems:

²¹ The Royal College of Physicians (UK) has developed standards for Clinical Structure and Content of Patient Records and other standards. Please see the link: <https://www.rcplondon.ac.uk/projects/healthcare-record-standards>

- “The transfer of meaning between electronic record systems, specifically where the data is stored in structured form, is problematic without a bilateral agreement about context (for each pair of systems) between originating and recipient systems”.
- “This problem can be considerably simplified by the clinical/health/social care professions agreeing on standard clinical/professional representations for the content of medical/health/social care records”.
- “In the clinical domain, such a clinical representation is known as the core clinical structure or model. If this core clinical model is declared as a professionally assured NHS standard, then the electronic records, adherent to this standard, which represent the patient record, can be stored and retrieved throughout the NHS safely with faithful preservation of meaning”.
- “Technical standards are then able to ensure that there is a secure level of interoperability and messages can be sent safely and without loss or change of meaning from one computer to another in the care system, with appropriate security”.
- “Technical standards alone do not ensure the ability for systems to transfer coded health concepts or text around the NHS so that they can be reliably manipulated and understood, safely and coherently, on target (recipient) systems”.

The International Medical Device Regulators Forum, and its predecessor, the Global Harmonization Task Force (GHTF), has published a series of documents about adverse event data transfer and reporting²².

2.5.9 Summary

We have seen that there are more or less integrated systems that hinder or enable information flow and possibly allow the propagation of poor information quality throughout the system in an environment that does have some oversight by Canada Health Infoway. Information quality can be considered a non-functional requirement. The safety of these systems is not proven conclusively.

We now move to the next section to examine risk as a function of poor information quality that

²² Please see this link to see the reports: <http://www.imdrf.org/documents/doc-ghtf-sg2.asp> and <http://www.imdrf.org/documents/documents.asp#imdrf>

can contribute to an adverse event. Are adverse events rare with low probabilities and varying impact(s), a wicked (ill-defined), complex with inter-related causal links, or uncertain with unknown probabilities ? We will also see that research in risk assessment is moving from a probabilistic quantitative process to a qualitative one.

2.6 Risk a Function of Poor Information Quality

This section provides an overview of risk generally. Risk is a difficult concept of its own accord, partly because of the unclear terminology used to describe it, however, the following sections provide the definitions for this dissertation. This section will also show that there are different ways of characterizing the adverse events that are an outcome of poor information quality. These different characterizations mean that mitigation is difficult.

2.6.1 Risk Definitions

Renn (1998 p. 51) provides the following definition of risk: “the possibility that human actions or events lead to consequences that have an impact on what humans value”. Risk is usually based on a known probability as it is traditionally calculated as the probability the event will occur times the impact of the event should it occur (Ritchey, 2011 p. 24). If risk can be accurately calculated or has “a well-grounded probability”, then there is less uncertainty (Ritchey, 2011 p. 24).

However, the randomness of events and outcomes makes them uncertain with unknown probabilities. As Aven and Renn (2010 p. 4 Figure 1.1) note lung cancer is an adverse outcome associated with smoking exposure (from the human action or activity of smoking). One hundred percent of exposed smokers do not get lung cancer i.e. there is uncertainty about who will get lung cancer from smoking. If we use this analogy, a patient’s adverse event is analogous to the lung cancer and the poor information quality is analogous to the smoking exposure. In each case specific acts produce the exposure, smoking in the case of lung cancer and programming flaws or data entry errors, for example, in the case of the adverse event. Vulnerability is the susceptibility of a system or organization to absorb risk of poor information quality, “the risk agent” (Aven & Renn, 2010 p. 9).

2.6.2 Assessing Risk: Technical and Non-Technical Methods

If we can, it is important to get an understanding of the likelihood of an adverse event so that remediation can be put in place. One can try to estimate the likelihood of adverse events using either a) quantitative prospective or retrospective techniques or b) qualitative opinions or

“perceptions”. Renn (1998 technical p. 53 columns 1-3 Figure 1; perception p. 54 columns 4-7 Figure 1) classifies these two assessment methods as “technical” and “perceptual” or respectively.

Renn (1998 p. 49) provides a context for his risk assessment framework (Table 2 below) with the following statement: “Are risks social constructions of different societal actors that can be checked at best against standards of consistency, cohesion and internal conventions of deduction, but cannot claim any validity outside of the actor’s logical framework? Or are technical estimates of risk representations of real hazards that can and will affect people as predicted by the statistical values regardless of the beliefs or convictions of those who conduct the assessments”? This research will make the underlying assumption that risks are social constructs of different social actors who create and use information of varying quality.

Another influence on the likelihood of an adverse event is the individual or organizational intent behind “shortcuts” and “workarounds” that may either contribute to or prevent an adverse event when people are using unworkable “technical or social systems” (Busby & Bennett, 2008 p. 797; Flanagan et al., 2013 p. e 59). There is also a “political-ethical” process of judgment calls made about certain types of events or “outcomes” and what to do about them (Busby & Bennett, 2008 p. 798). Organizations might even pay lip service to risk assessment to preserve the organization’s reputation rather than deal with substantive risks “to society” (Busby & Bennett, 2008 p. 798).

Renn notes that there are, in fact, seven risk assessment methods, three technical and four perceptual, as shown on Table 2²³ below. Please note that the perceptual social theory in the bold and light grey column best captures the risk assessment scope of this research because it encompasses a social context of patient care in the acute care setting, surveys (which suggest direct feedback from individuals similar to an interview), has a multidimensional scope of risk concepts and includes the problem area, complexity:

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Table 2: Risk Assessment Approaches

INTEGRATED APPROACHES							
	"Technical"			"Perceptual"/Non-technical			
	Actuarial	Epidemiology	Probabilistic	Economics	Psychology	Social Theory	Cultural Theory
Base Unit	expected value (EV)	modelled EV	synthesized EV	expected utility (EU)	subjectively (EU)	perceived fairness & social context	Shared Values
Predominant Method	extrapolation	experiment population studies	event & fault tree analysis	risk benefit balancing	psychometrics	surveys	grid group analysis
		structural analysis					
Scope of Risk Concept	Universal	health & environment	safety	universal	individual perceptions	social interests	cultural clusters
	one dimensional	one dimensional	one dimensional	one dimensional	multi-dimensional	multi-dimensional	multi-dimensional
Basic Problem Areas	averaging over space, time context			preference aggregation		social relativism	
	predictive power	transfer to humans	common mode failures	common denominator	social relevance	complexity	communicability
background noise							
Major Application	Insurance	health	safety engineering	decision making	policy making		
		environmental protection			conflict resolution (mediation)		
					risk communication		
Instrumental Function	risk sharing	early warning		resource allocation	individual acceptance	political acceptance	cultural identity
		standard setting	improving systems			acceptability	
Social Function	assessment risk reduction & policy selection political application						

Note: Adapted from Renn, (1998) Figure 1.

Note: social relativism means that the risk assessment approach is dependent on the social setting the assessment is done in. For example, something that is seen as high risk in one organization may not be interpreted in the same way by another similar organization.

Technical Methods

There are limitations to the technical or probabilistic methods of risk assessment because the “interactions between human activities and their consequences are more complex than the average probabilities used in technical risk analyses are able to capture” (Renn, 1992 p. 59). This also points to the serious limitation that causal events in probability must be independent of the effect. This “independence” may not be possible in the “closed loop” system of a human-computer interaction (Sheridan, 2000 p. 6 Figure 3 a; Sheridan, 2008 p. 422). “The institutional structure is prone to organizational failure and deficits that may increase the likelihood of an

adverse outcome” (Renn, 1992 p. 59). “The interaction between organizational malfunctions and risk is usually excluded from technical risk analyses” (Renn, 1992 p. 59).

Technical risk assessment requires that there be sufficient statistical data to make a meaningful prediction and that the causal agents responsible for the negative effects are stable. This can be a problem for uncontrolled rare events with low probabilities and possibly unknown impacts (Bannerman, 2008 p. 2119; Renn, 1992 p. 61; Sheridan, 2008 p. 422). Even technical risk assessments may be “subjective judgements” and should not be the only method for risk assessment (Aven, 2012 p. 1650). This subjectivity is why qualitative approaches were selected for the research in this dissertation.

Quantitative Methods

A quantitative estimate implies certainty with a known “observable” probability; however, there is typically variation in measurement in areas such as health care so judgment is used (Aven, 2004 p. 8-9). Utkin and Coolen (2007 p. 1) note two very stringent conditions must be met for complete and accurate probabilistic estimates: “first, all probabilities or probability distributions are known or are perfectly determinable and second, the system components are independent or the dependence is precisely known”. Even if these conditions are met, different risk prediction methods can produce different estimates with simpler methods performing better with real-world “noisy” data that is not derived in a laboratory setting (Goldstein et al., 2017 p. 2761).

Uncertainty makes it impossible to estimate the probabilities of events. The difficulty of estimating probability is compounded when we are dealing with rare events with low probabilities and varying impact(s) (likely because of under-reporting), wicked (ill-defined) problems, complex problems with inter-related causal links, or uncertain problems with unknown probabilities. We also cannot assume that the system components, the users, and information system are independent.

Rasmussen explains this further. He categorizes events into frequent small-scale inexpensive accidents, major accidents, and large-scale costly accidents. “Frequent” accidents can be defined using epidemiological analysis and are controlled by removing causes; “medium infrequent” accidents are defined by past accidents, while very rare unacceptable” accidents are defined by

predictive modelling analysis because they are so rare (Rasmussen, 1997 p. 198).

Electronic information systems may behave differently because software errors “may not fail again” once they are corrected (Jones, 2002 p. 247). Further, it is very difficult to assign a probability to software faults because software does not suffer from “fatigue or other random failure (Jones, 2002 p. 247). Most software risk is assumed to have a “high probability” (Jones, 2002 p. 253). Jones (2002 p. 240, 253) notes that medical device failures “rarely have catastrophic consequences”, so severity is based on the degree of “injury” caused by the defective software.

We have seen in the introduction section 1.1.2 (The Human Cost of Information System Failure) the effects of the system errors: there may be some fatalities, but there is also under-reporting and a generally unproven safety record of these systems.

Non-Technical Methods

Renn’s sociological perspective is the most appropriate for our study because it examines complexity, as reflected in the health care environment (Renn, 1992 p. 70). Qualitative methods are valuable when quantitative data is lacking (Cox et al., 2005 p. 652). Adverse events cannot always be explained by individual behaviour alone, but are “often unintentional effects among individuals” (Renn, 1992 p. 69). It is important to use real-world examples with qualitative techniques such as ethnographic techniques²⁴ since those settings show “how and why” systems succeed or fail in a given setting (McMullen et al., 2011 p. 300).

Qualitative Methods

Heemstra et al. (2003 p. 1) recommend a team approach to counteract the biases and lack of knowledge in decisions about the likelihood of an adverse event. Heemstra et al. (2003 p. 4) see this as a form of “knowledge management using the group to create superior knowledge through

²⁴ “Ethnography is a qualitative research technique. Ethnography’s unique contribution to qualitative methods is that it deeply examines the context in which activities occur, usually involving work by the researcher with participants as they go about their daily lives. An ethnographer also describes a situation by asking multiple people about an event, or by analyzing multiple types of documentation, such as policies or historical records”. Please see the following link for more information: <http://www.erialproject.org/for-librarians/what-is-ethnography/>

the interaction of specialized individuals who share their knowledge and by turning private knowledge into public knowledge and tacit knowledge into explicit knowledge”. Sittig et al. (2014) have developed qualitative group self assessment tools with the US Office of the National Coordinator for Health Information Technology²⁵ using groups of specialized individuals.

Cox et al. (2005 p. 652) suggest that quantitative methods should still be used where necessary if “adequate data are available”, however, qualitative methods, such as is used in social theory, must be used when there is no quantitative information about probability such as is the case with much of the research about information quality.

Heyman et al. (2010 p. 21) explain the social theory aspect further by stating that risks cannot be mitigated or managed unless they are turned into a concept or interpretation that “underpins risk. This reasoning fits well with the Grounded Theory analytic approach used for analysing understandings and interpretations about information quality.

Poor information quality is manifest either by an adverse event or by quick user action detection to prevent an event from happening because the user interprets the information as wrong. Poor information is embedded in a health care system that relies on its users and information system to function. Heyman et al. (2010 p. 21) provide a useful table to help think of risk as a qualitative entity of interpretation by contrasting this with the more probabilistic interpretation of natural or better known phenomena. Note that Heyman et al. (2010 p. 21) specifically considers information representation as part of risk management in Table 3 below; this research will assume that this includes information quality, both good and poor:

²⁵ These tools using team assessment of scales were published in November 2016 and cover the following topics: high priority practice, contingency planning, system interfaces, computerized provider order entry with decision support, clinician communication, organizational responsibilities, system configuration, patient identification, test results reporting and follow up. For more information please see the link: <https://www.healthit.gov/safer/>

Table 3: Two Views of Risk

Two views of risk	
Risk viewed as referring to natural phenomena	Risk viewed as referring to interpretations
Risk construction	
Event	Category
Adversity	Negative value
Probability	Expectation
Time period	Time frame
Risk management	
Service delivery	Service organization
Evidence based practice	Practice encoding
Information giving	<i>Information representation</i> [emphasis added]
Regulation and safety	Control

Note: adapted from Heyman et al. (2010) Table 1.1.

Qualitative Risk Assessment Techniques

There are a number of qualitative risk assessment techniques: direct information gathering, “checklists, analytical frameworks, process models” (these seem to be used most in systems research), “and risk response strategies” (Bannerman, 2008 p. 2120). Two of these will be used in this research:

- Direct information gathering from the interviewees with possible use of written material.
- Analytical frameworks to structure the interview data analysis.

Direct Information Gathering

Bannerman (2008 p. 2120) and Stoneburner et al. (2002 p. 11, 12) outline that there are major techniques that can be used to identify risks (such as an adverse event) through interviews and document review. The use of several methods will provide a more detailed risk assessment and verification by triangulation if different methods identify the same risks. Interviews allow a more in-depth examination of operations while documents and records can provide good information about system risks (Stoneburner et al., 2002 p. 12). The researcher’s direct information gathering is a subjective collection and assessment of the interviewee’s risk “perceptions” (Mohaghegh & Mosleh, 2009 p. 1402). This approach was used in this research. This research did not use a review of interviewees’ documentation.

This research addresses a gap in qualitative risk assessment using interview data in the Canadian acute care setting. The research emphasis on information quality builds on Heyman's "information representation" in Table 3 and what it might mean in the Canadian setting.

Analytical Frameworks

Sherer and Alter (2004 p. 42) note that organizing frameworks both assist in risk assessment and show how risks are related more broadly beyond the IT system. "Categorical and non-process analytical risk management frameworks can be very helpful tools... for risk identification and analysis at a higher level of abstraction" (Bannerman, 2008 p. 2121). One of the purposes of "these interpretive models" is to link organizational factors to individual actions (Le Coze, 2008 p. 136 Figure 1). Some of these frameworks will be provided below²⁶ as they may provide useful overarching analytic themes (in addition to other models) that may be available after analysis.

Process Models

These models specify "individual activities and steps are believed to be necessary" to mitigate risk (Bannerman, 2008 p. 2121). Although this is not the focus of this research, process models will be discussed briefly to show that they also have inconclusive evidence for effectiveness further strengthening the emphasis on the qualitative interview approach in this research.

Jones (2002 p. 249) has identified some hazard analysis tools that have been used in the health care software setting that are basically judgment calls based on "intuition, experience and insights". The preliminary hazard analysis and the fault tree analysis are called "top-down methods because the analyst names the system outcomes or faults and then decides on which hardware/software elements contributes to each" one at finer granularities (Jones, 2002 p. 248).

Scott et al. (2008 p. 45 Table 1) note that many of the patient safety process models such as sentinel event reporting, root cause analysis, formal risk registers and risk management programmes, external hospital accreditation surveys and programmes, quality/safety or clinical governance units, open disclosure policies, public reporting of quality and safety indicators"...

²⁶ For example, the Despotu framework in section 2.7.1 and Patient Safety Framework in section 2.7.4.

“lack hard evidence of effectiveness” despite having “face validity”. Some positive aspects of these methods are that these methods “contribute to priority setting, emphasize the system and not the individual, and localize weak spots and risks in the organization of care” (Dückers et al., 2009 p. 101 S). Scenarios are also useful for software risk assessment analysis.

2.6.3 Risk Management or Mitigation

Risk management is underused in public sector projects. Bannerman (2008 p. 2124) found in a review of public sector software projects (such as would be the case in the British Columbia health care system) that “formal risk management was practiced in five projects (29%), no risk management was practiced at all in another five (29%), while the remaining seven projects (41%) adopted a range of semi-formal or informal practices”. “No agency reported using quantitative risk assessment” (Bannerman, 2008 p. 2125). “Agencies that assessed risk used qualitative scales “(Bannerman, 2008 p. 2125). The implication of the lack of risk management is shown by the finding that “15 of the 17 encountered unanticipated threats and 89% of projects were considered to be strategically important” (Bannerman, 2008 p. 2125).

Further, Bannerman (2008 p. 2130) found that “risk was not well understood or well managed in many agencies, and risk management tended to be unsystematic and informal, even when projects were otherwise formally managed”. “In nearly a third of projects, risk was not intentionally managed at all” (Bannerman, 2008 p. 2130). Bannerman (2008 p. 2130) was surprised by the findings given the “high level of scrutiny and accountability that usually operates in this sector”. Another issue is IT managers relying on “intuition” that can lead to “suboptimal or counterproductive decisions” rather than a recognised framework (Benaroch, 2006 p. 853).

The next section of this dissertation will explain why the potential for an adverse event is so difficult to minimize. This is because adverse events arising from poor information quality can be characterized in several different ways that make it difficult to prescribe remedies.

2.6.4 Classification of Adverse Events: Difficult to Describe and Quantify

Patient adverse events in health care are difficult to describe because they can be : rare events

with low probabilities and varying impact(s) (likely because of under-reporting) or wicked problems that are vague and ill-defined, or complex with inter-related causal links, or uncertainties with unknown probabilities. Each of these terms will be described in turn.

The research begins to explore the information aspects of adverse events as rare events with low probabilities and varying impact(s) (likely because of under-reporting) or wicked problems that are vague and ill-defined, or complex with inter-related causal links, or uncertainties with unknown probabilities. These are gaps in the research literature.

Rare Events

We need to distinguish between the rare random catastrophic events, the “unknown-unknown,” that cannot be predicted or calculated from the slightly more common predictable events, the “known-unknown”. Hole and Netland (2010 p. 21), following the work of Taleb, has called the “unknown-unknown” a black swan and the “known-unknown” a grey swan respectively. The probabilities of these rare events cannot be easily predicted but, because complex systems have many points where a grey swan can happen, the chance of a grey swan disrupting a “vulnerable” system at some point is more likely (Hole & Netland, 2010 p. 22). Medical systems are high-risk systems where a grey swan event such as a denial of service attack can have serious impacts (Hole & Netland, 2010 p. 26). Information systems can have a “single point of failure from hardware or software error, user or administrator mistakes, or an internal or external attack” (Hole & Netland, 2010 p. 22).

One would like to think that these events could be predicted using the probability of quantitative risk assessment to prevent an adverse event (such as might happen as a result of poor information quality) from happening. However, Goodwin and Wright (2010 p. 359 Table 1) explain why rare events, most likely grey swans, are difficult to predict. They identified six causes:

- Sparsity of reference class: rare events are rare because there is little data about them. Rare events need to be analysed with before and after studies that may need to continue for years so enough data can show an effect, or use a very large sample size (see also Brown, 2008 part 3 p. 172).
- Reference classes are outdated or do not contain extreme events(reference classes are bound to be incomplete because they are samples of the past).

- Use of inappropriate statistical models: the wrong assumptions have been made about the data such as the data have a normal distribution or that a model does not reflect the complexity of the data.
- The danger of misplaced causality: most models will be based on the assumption about the causal relationships between variables using correlation alone which does not prove causation.
- Cognitive biases: human judgment is used to estimate probabilities when there is insufficient data. These estimates are based on heuristics or mental strategies. The most common heuristics are: availability where the most vivid or recent are given a higher probability; or anchoring on a single event that is used to predict future events (see also Renn, 1998 p. 54 Table 1).
- Frame blindness: structuring a problem in one way means that the importance of other events is missed (see also Renn, 1998 p. 54 Table 1).

Goodwin and Wright (2010) then review the different ways to improve prediction, that is, to try and estimate a probability. They conclude that organizations should have “redundancy” and flexibility to respond to an event and should use group techniques such as scenario planning, devil’s advocacy and Delphi methods to predict them (note these are all qualitative risk assessment methods) (Goodwin & Wright, 2010 p. 365 Table 1, p 367; Heemstra et al., 2003 p. 4, 8). Goodwin and Wright (2010 p. 367) conclude that expert judgement about rare events cannot be trusted because rare data means that there is no feedback to validate the assumptions and reduce bias. It is interesting to note that Goodwin and Wright (2010 p. 367) do not consider quantitative methods useful to improve predictions of these grey swan events.

Wicked, Vague and Ill-defined Problems

Ritchey (2011) defines a wicked problem as being the opposite of a tame problem. A tame problem (Ritchey (2011, p. 19):

- “Has a relatively well-defined and stable problem statement”.
- “Has a definite stopping point, i.e. we know when the solution or a solution is reached”.
- “Has a solution which can be objectively evaluated as being right or wrong”.
- “Belongs to a class of similar problems which can be solved in a similar manner”.
- “Has solutions which can be tried and abandoned”.

In contrast, wicked problems are ill-defined or ambiguous with several possible interpretations or

meanings. Wicked problems are often about “people”, “politics” and “competing stakeholders” (Ritchey, 2011 p. 21).

There are two approaches to studying a wicked problem: either the objective perspective where observers use “extrinsic criteria” such as statistics or (standard) measurement to evaluate the phenomenon; or the subjective “intrinsic” perspective where observers evaluate, and interact with, “perceptions” or motivations (Ritchey, 2011 p. 23).

Subjective approaches include qualitative methods such as a Grounded Theory analytic approach. Health care knowledge experts are key to understanding health care wicked problems because the interviewees’ own understandings and interpretations tease out wicked problems such as information quality issues in acute care.

Ritchey (2011 p. 27, 28) suggests that wicked problems are more amenable to the subjective approaches because these approaches use peoples’ perceptions and mutual interactions for clarification and can:

- “Accommodate multiple alternative perspectives rather than prescribe single solutions”.
- “Function through group interaction and iteration rather than back office calculations”.
- “Generate ownership of the problem formulation through transparency”.
- “Facilitate a graphical (visual) representation for the systematic, group exploration of a solution space”.
- “Focus on relationships between discrete alternatives rather than continuous variables”.
- “Concentrate on possibility rather than probability (an objective or quantitative approach)”.

If we look at the context of information system failures and poor information quality as wicked problems we see that the personal-social aspect of wicked problems underlie these failures.

Clarke et al. (2006 p. 124) note that failure becomes “complex” and difficult to recognize “when computer-based systems are used by groups or teams of people... (who have different ideas on how the system should behave)..., usually in conjunction with other systems”. Public sector system failure has the “political complexity” overlay to their failures (Gauld, 2007 p. 109).

Wicked problems seem to be similar to the systemic risks that Aven and Renn (2010 p. 18) describe as being at the crossroads between “natural events (partially altered and amplified by

human action), economic, social and technological developments and policy driven actions”. Further, policy makers are often not aware or not willing to accept that risk relates to both the physically measurable outcomes (“facts”) and the socio-cultural attributions (“values”)” (Aven & Renn, 2010 p. 19). It is this “soft” aspect of risk that will be central to this qualitative research and will be explained further below in the non-technical risk methods in section 2.6.2 of this dissertation.

Complex Problems

Complex problems have many inter-related causal links as Aven and Renn (2010 p. 12) describe: “complexity refers to the difficulty of identifying and quantifying causal links between a multitude of potential causal agents and specific effects”. “The nature of this difficulty may be traced back to interactive effects among these candidates (synergisms and antagonisms), positive and negative feedback loops, long delay periods between cause and effect, inter-individual variation, and intervening variables” (Aven & Renn, 2010, p 12). These interactions are “non-linear” (Venkatasubramanian, 2011 p. 3) which means they can be difficult to analyze and model. Stame (2004) outlines more characteristics of complexity. “Complexity...“is stratified” “with actors embedded in their own contexts” and there is “multi-level governance” (Stame, 2004 p. 7, 8). This creates further difficulties for research and “measurement” (Benn et al., 2009 p. 1769).

Uncertainty

Uncertainty describes events that do not have known probabilities because they are difficult to predict in the first place and/or are based on “incomplete or invalid data”, ...or “unclear causal chains” or “modelling” (Aven & Renn, 2010, p. 12). Uncertainty characterizes risks within “social, political, organizational and ideological systems” (Ritchey, 2011 p. 24). Uncertain events are also part of wicked problems and may explain why wicked problems are difficult to predict and solve, as Ritchey (2011, p. 25) explains:

- They “cannot be ascribed a (well-grounded) probability (therefore the “odds” of certain things happening” i.e. cannot be predicted).
- They do “not have a well-defined or complete outcome space, but is full of “unknown

unknowns” and emergent processes (so one cannot even predict what might happen)”.

- They involve “subjective, self-referential behaviour (which means that actors can consciously decide to do unexpected, surprising things)”.

Simple Problems

Simple problems are problems or events such as simple car accidents with low complexity, uncertainty and ambiguity (Aven & Renn, 2010 p. 12). This research is not likely dealing with simple problems as healthcare is inherently complex.

2.6.5 Summary

Researchers have classified risk assessment as either quantitative or qualitative. Both approaches can be used in a health care setting, however, qualitative methods are the most useful for this research because patient adverse events tend to be rarely reported and could be described as rare with low probability and varying impact(s). Patient adverse events are wicked (ill defined), complex (with inter-related causal links), or uncertain with unknown probabilities. A qualitative approach towards studying these types of events reflects a shift from describing risk as a purely quantitative probability-based measure to an analysis that includes a qualitative assessment (Aven, 2012 p. 42). Poor information quality is one of the factors that can contribute to a patient adverse event. The next section will look at adverse events in more detail in the context of patient safety.

2.7 Patient Safety: Models of Information Quality

The previous section, 2.6, presented risk at a high level with emphasis on risk embedded in a wider social context of human activity. This section will look first, at patient safety in general and then, at the individual level of patient adverse events. There are well-known statistics on the incidence of adverse events in health care. For example, the notable 2004 Baker and Norton study used a retrospective chart review to estimate an “overall incidence rate of adverse events of 7.5% suggesting that, of the almost 2.5 million annual hospital admissions in Canada similar to the type studied, about 185,000 are associated with an adverse event and close to 70,000 of these are potentially preventable” (Baker et al., 2004 p. 1678).

Further conclusions from this paper are:

- “Most (64.4%) of the adverse events resulted in no physical impairment or disability, or in minimal to moderate impairment with recovery within 6 months. However, 15 (5.2%) of the adverse events resulted in permanent disability, and 46 (15.9%), occurring in 40 patients, resulted in death. When these results were adjusted for the sampling strategy, we estimated that death would be associated with an adverse event in 1.6% of patients with similar hospitalizations in Canada” (p. 1681-2).
- “For 51.4% of the adverse events, the service most responsible for the delivery of care was surgery, for 45.0% it was medicine and for 3.6% it was another service (e.g., dentistry, physical therapy, podiatry)” (p. 1683).
- “The most common types of adverse events were related to surgical procedures, and the next most common were associated with drug- or fluid-related events. In the medicine service, adverse events resulting from errors of omission (the failure to carry out necessary diagnosis or treatment) were more common than those resulting from errors of commission (57.1% v. 42.9%). In the surgery service, the frequency of these errors was assessed as being roughly equal (50.8% v. 49.2%)” (p. 1683).

A recent study estimates an alarming “400,000 deaths” per year. This is the “third” leading cause of death in the US (Makary & Daniel, 2016 p. 1, 2).

2.7.1 Patient Safety Definitions

There are many confusing definitions in the patient safety literature²⁷. The following are the key

²⁷ For example: Patient safety research has created many definitions that are becoming standardized by the World Health Organization (WHO, 2009). The WHO has created a taxonomy for patient safety: <http://www.who.int/patientsafety/implementation/taxonomy/en/>

ones that provide context for this research.

Safety

This “is the reduction of unnecessary harm to an acceptable minimum” (Runciman et al., 2009 p. 19). Brown et al. (2008, part 1 p. 159) comment that safety issues are characterised as “very rare” and serious while more frequent events with low immediacy and causality (such as not following guidelines) are usually called “quality” issues.

Adverse Event

An adverse event or accident is usually defined “as an unintended injury or complication resulting in prolonged hospital stay, disability at the time of discharge or death and caused by health care management rather than by the patient’s underlying disease process” (de Vries et al., 2008 p. 216). This broad definition will be used in this research because it captures both intrinsic patient factors and non-patient factors such as information quality and information system.

Patient Safety

Patient safety can be defined either “narrowly to include only issues specifically related to patient adverse events and their prevention, or more broadly to include any aspect of health care and health services that may lead to patient injury, and any interventions, including clinical, organisational and policy changes that aim to reduce injury” (Stroetmann et al., 2007 p. 12). We shall use the broader interpretation for this research as it points to the sharp (direct care interface) and blunt ends (organizational care support) of the patient safety spectrum..

Error

Sheridan (2008 p. 419) and Stroetmann et al. (2007 p. 15) define human error as an action that fails to meet some implicit or explicit criterion such as a standard of care. There are different types of error: “(a) omission, a failure to act; (b) commission, a failure of action taken; (c) errors in sensing, remembering, deciding, and responding; (d) slip, an unintended execution of an act; and, (e) mistake, an execution as intended that turns out to be incorrect” (Sheridan, 2008 p. 419, 420).

Human error has also been classified on the basis of the cognitive error: “either skill-based

(typically unconscious errors of what is normally automatic activity), rule-based (errors occurring when the wrong rule is chosen to govern an activity), or knowledge-based (errors occurring because of a lack of knowledge or misinterpretation)” (Stock et al., 2007 p. 370).

Errors can be caused by “defects in design procedures, training, maintenance or management at the “blunt end” ...of the organizational structures lying behind the health care task a person is providing for the patient at the “sharp end” (Sheridan, 2008 p. 420). Errors most often result either from a lack of “feedback” or “an incorrect mental model of how a system works”... causing “mental workload” or “emotional stress” (Sheridan, 2008 p. 420).

2.7.2 Technology-Induced Errors

Technology-induced errors are a class of errors in scope for this research because they characterize electronic information system adverse events. Technology-induced errors can be defined as those “sources of error” or exposures that arise from: “(a) the design and development of a technology, (b) the implementation and customization of a technology, and (c) the interactions between the operation of a new technology and the new work processes that arise from a technology’s use “(Borycki & Kushniruk, 2008 p. 95). They are the types of error likely produced by the electronic information systems described in this research.

Technology-induced errors have their origins in the technology and technology-human interactions rather than the entire medical management process. Therefore, technology-induced errors may be considered one type of unintended consequence or error arising at “specific time points” from the design, development, implementation, at which point errors caused by “workflow arising from the interactions between software, devices and organization”, for example, health professionals using the technology during the process of providing health care (Borycki et al., 2010 p. 1). We should assume that information quality is part of these flows.

The literature does not examine technology induced errors in a Canadian health care setting. This research begins to address this important gap.

Technology induced errors also can be construed as a risk factor, harm or hazard:

- Risk factors where Pare et al. (2008 p. 252) define risk factors as “contextual issues that

can influence the probability that an undesirable result” will occur such as a system not achieving its expected benefits. Risk factors can be controlled by “managers” (Pare et al. 2008 p. 252).

- Harm where “health care-associated harm is harm arising from or associated with plans or actions taken during the provision of health care, rather than an underlying disease or injury” (Runciman et al., 2009 p. 21 Table 1) or as a “hazard, a circumstance, agent or action with the potential to cause harm” (Runciman et al., 2009 p. 21 Table 1).

Despotu’s Technology Error Framework

Despotu et al. (2012 p. 46) make a valuable distinction in the information technology realm between hazard and a fault. A hazard is an action directly causing an adverse event. An example of a “health IT hazard could be the act of ‘administering the wrong dose to patient’ as it can directly result in an accident, whereas a ‘corrupt data record’ can be thought of a system specific fault or failure and contributing factor to the hazard” (Despotu et al. 2012 p. 46). While “a fault or failure within the system may be a contributing factor to an accident, it may not necessarily be a hazard” (direct cause) (Despotu et al, 2012 p. 46). “Hazards are states that result from the manifestation of one or the combination of more than one fault” and “hazards may occur without any faults in complex systems” (Despotu et al., 2012 p. 46).

In Despotu’s example in the previous paragraph, the act of administering the wrong dose causing an adverse event is the hazard. The faults leading to the wrong dose selection (poor information quality in a corrupt data record) could have been from a confusing drop down box or wrong screen calculation as system-specific faults or failures. We have seen a similar logic above in section 2.6.1 (Risk Definitions).

Despotu et al. (2012, p. 45 Figure 1) show the relationship between the failures or faults leading to a hazard or act that causes an accident (adverse event) in a bow tie diagram in Figure 4²⁸ below:

²⁸ (c) Reproduced by permission of Institute of Electrical and Electronics Engineers. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

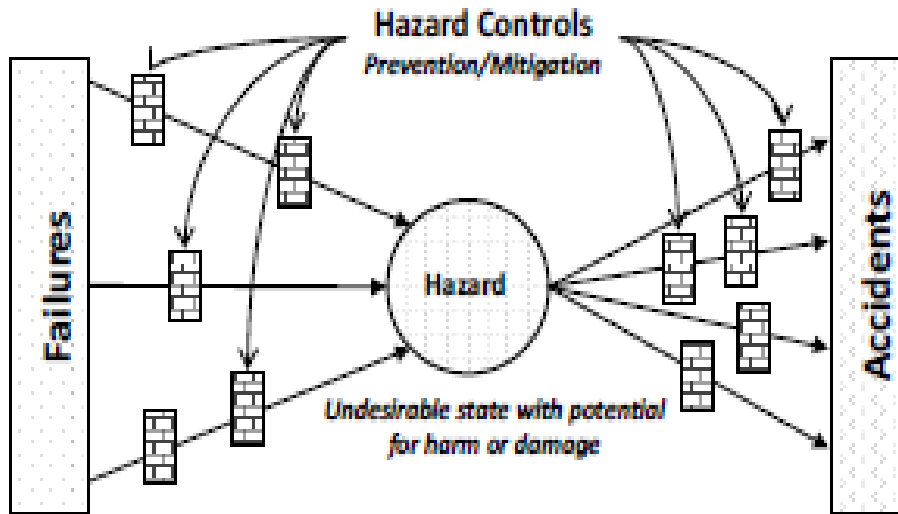


Figure 1 – Bow Tie diagram

Figure 4: Bow Tie Diagram. Reprinted from Despotu et al. (2012) Figure 1.

Risk assessment looks at the “likelihood (probability) and the severity (impact)” of a hazard (Despotu et al., 2012 p. 45). Despotu et al. (2012 p. 46) confirm the information discussed in the previous section (2.6.4 (Classification of Adverse Events)) (i.e. that likelihood is very difficult to quantify). Risk assessment also looks at the controls to mitigate the hazard of the direct action. These controls could include bar coding or double checking of medications in the context of the medication error example.

The WHO document, *More than Words: Conceptual Framework for the International Classification for Patient Safety Technical Report*, confirms technology is an external contributing factor to an adverse event where a contributing factor means “a circumstance, action or influence that is thought to have played a part in the origin or development or to increase the likelihood of an incident” (WHO, 2009 p. 16).

Although this research is not interested in causation per se, adverse event causations theories are important because they lead to the now-current idea that patient adverse events are the result of organizational systemic issues that include both the sharp (patient interface) and the blunt ends (non-patient organizational interfaces) of health care.

2.7.3 Causation Models

There are two major models to explain the context of accidents in organizations: High Reliability Theory and Normal Accident Theory. These models recognise the fact that “organizational factors” contribute to most accidents (Leveson et al., 2009 p. 227). However, the accidents giving rise to these theories and the concept of reliability happened in specific types of organizations such as “nuclear power plants, air traffic control systems, nuclear aircraft carriers, and electrical grid management organisations” (Schulman, 2004 p. ii 39). High Reliability Theory (HRT) and Normal Accident Theory (NAT) are seen as opposites because of the way they explain accident causation and reduction with HRT emphasising “failure” and NAT, “prevention” (Vaughan, 1999 p. 296).

High Reliability Theory

Researchers derived this theory from “air traffic control and aircraft carrier operations” where they identified features that they considered the hallmark of High Reliability Theory, “including technical expertise, stable technical processes, a high priority placed on safety, attention to problems, and a learning orientation” (Leveson et al., 2009 p. 228).

High Reliability Theory “uses technical redundancy, where parts are duplicated (e.g. backup computers) and personnel redundancy, where personnel functions are duplicated (e.g. more than one person is assigned to perform a given safety check)” (Leveson et al., 2009 p. 233). The High Reliability Theory examples of the “effective use of redundancy are in loosely coupled systems where redundancy protects against accidents caused by individual, random component failures rather than system design errors (Leveson et al., 2009 p. 234). “If the system designs are loosely coupled, redundancy can reduce accidents caused by component failure” (Leveson et al., 2009 p. 234).

An important problem with High Reliability Theory is that the practices were observed in systems with low levels of uncertainty and stable technical processes (Leveson et al., 2009 p. 239). This is not the reality of unstable systems where “managing system safety is a continuous process of trying to determine how much risk exists in particular activities and decisions (i.e. how much risk is acceptable and how to achieve multiple system goals and requirements)”

(Leveson et al., 2009 p. 240). An example is health care where there is the “trading one risk for another, that is, the risk of not getting a particular treatment versus the risks inherent in the treatment itself, such as adverse side-effects” (Leveson et al., 2009 p. 240). High Reliability Theory can relate back to the less integrated systems we saw above in section 2.5.2 and how the information flow may be impeded to help or hinder information quality and any outcomes arising from use of poor information quality.

Normal Accident Theory

The basic premise of Normal Accident Theory is that “the interactive complexity and tight coupling in some technological systems, such as nuclear power plants, leads to unpredictability of interactions and hence system accidents that are inevitable or ‘normal’” (Leveson et al., 2009 p. 228). Complexity “refers to the number of components in a system and the interactions between these components” (Stock et al., 2007 p. 370). “The second dimension is coupling, which refers to the nature of the interactions between system components” (Stock et al., 2007 p. 370). “Tight coupling between components are direct, have short time lags, and have few buffers to slow down the effects of interactions between components” (Stock et al., 2007 p. 370). This means that organizational, technical, or procedural techniques designed to prevent accidents will serve only to make the system more complex, which will just increase the chances for disaster (Leveson et al., 2009 p. 230; Stock et al., 2007 p. 370).

Conversely, “serious accidents are less likely if a complex system can be made less complex, or if a tightly coupled system can be made more loosely coupled” so there is less propagation of an error through the system (Stock, 2007 p. 370; Tamuz & Harrison, 2006 p. 1657 Table 1).

“Modern management techniques and information systems have allowed facilities to reduce inefficiencies in operation” through tight coupling that reduces “the incidence of relatively low consequence events” (Cook, & Rasmussen, 2005 p. 130, 132). Tight coupling in hospitals occurs in these four clinical processes: emergency, anaesthesia, chemical processes and automation (Tamuz & Harrison, 2006 p. 1665 Table 3).

“In complex systems, accidents often result from interaction among perfectly functioning (reliable and non-failed) components”, “when independent decisions and organizational

behaviours interact in dysfunctional ways” (Leveson et al., 2009 p. 234, 235).

Normal Accident Theory can also relate back to the more integrated systems we saw above in section 2.5.2 and how the information flow may be impeded to help or hinder information quality and any outcomes of poor information quality use.

System View: Allows for Organizational “Blunt End” Assessment

Latent errors at the “blunt end” are errors far from the health care worker-patient interaction, the “sharp end”, according to Reason’s famous Swiss cheese model²⁹.

In Reason’s model, medical errors can happen either at the “sharp end” at the level of the user interacting with the patient (e.g. the level of occurrence of adverse events) or at the organizational level as latent errors (where adverse consequences may lie dormant within an organization or system and are the predominant cause of error).

Accidents occur when “component failures, external disturbances, and/or dysfunctional interactions among system components are either not adequately controlled” so they propagate or there is inadequate enforcement of constraints on behaviour (e.g. the physical system, engineering design, management, and regulatory behaviour) at each level of the socio-technical system (Leveson et al., 2009 p. 242; Saleh et al., 2010 p. 1113; Venkatasubramanian, 2011 p. 2, 3). “Behaviour is controlled not only by direct management intervention, but also by policies, procedures, shared values, and other aspects of the organizational culture” (Leveson et al., 2009 p. 242).

“Accidents, particularly those arising from dysfunctional interactions, or behaviours, among components, frequently result from inconsistencies between the model of the process used by the controllers and the actual process state” (Leveson et al., 2009 p. 243). Addressing these inconsistencies by merging the “levels of analysis” will provide the greatest benefit (Vaughan, 1999 p. 297). This gets at the idea of good fit and poor fit.

²⁹ Please see the following link for a description of Reason’s model:
<https://psnet.ahrq.gov/primers/primer/21/systems-approach>

It appears that the critical points for error might be at the interface between levels, where there are dysfunctional interactions, failures, and flawed decision, and erroneous control actions may occur (Le Coze, 2008 p. 143 Table 2).

Although latent errors at the “blunt end” are distant from the health care worker-patient interaction, this does not imply that these errors propagate slowly through the system from the blunt end to the sharp end. This propagation can be made both by increasing the likelihood of human error through “operator failure” because of no knowledge transfer to respond to the error, but also by making the original error more difficult to detect because of situational factors such as a new IT system (Ternov & Akelsson, 2005 p. 10, 11 Table 4). Ternov and Akelsson (2005 p. 10) classify four types of latent errors causing “system breakdown: (i) creating opportunities for active failures; (ii) as a hindrance for error detection; (iii) creating disruptive situations; (iv) inducing cognitive bias”. Leveson et al. (2009 p. 235) states that “safety is a system property, not a component property and must be controlled at the system level rather than the component level”. The primary goal of health care is safety, so adopting a systems approach fits well with our health care context.

If we consider accidents as social phenomena, then these events arise from the social structure and the human agents within it. In addition, although there is randomness to human behaviour because people can act in many different ways, people in specific settings are usually very knowledgeable about what they do and create the social work environment. The blunt end provides the setting for information quality setting and risk mitigation factors such as standards and regulation mentioned above in section 2.5.8.

2.7.4 Patient Safety Concepts & Frameworks

The following is a set of frameworks from the safety literature that may be useful for data analysis coding and themes.

Risk-Based Concepts

Risk-based concepts include: rare events with low probability and varying impact(s), wicked problems (ill-defined), complexity with inter-related causal links, or uncertainty with unknown

probabilities discussed above in section 2.6.4.

Patient Safety-Based Concepts: Levels

“There exist multiple levels within most health care delivery systems, especially within hospitals ...where individuals are part of groups and groups are part of larger organizations with multiple levels of hierarchy and nested systems” (Karsh & Brown, 2010 p. 675). Karsh and Brown (2010 p. 674) state that some patient safety research is based at the “individual” level without examining the “different levels” and how they “interact” to produce a specific adverse event. It is important to remember that information of varying quality flows among the levels and from the sharp end to the blunt end of health care and back again.

“Levels are typically discussed in two ways” (Karsh & Brown, 2010 p. 674):

- “Levels of individuals, groups or organizations. Norms, policies, and decisions at the group or organization level can and almost always do impact individuals. Similarly, it is clear that individual decisions and behaviors can impact outcomes at the group and organization level, such as when the behavior of physicians or pharmacists with regard to medication orders”. This research will use this concept of level.
- “Levels as hierarchy or echelons by some where the vice president of nursing is above several nurse supervisors, who are themselves above nurse managers, who are above charge nurses and then staff nurses”.

This awareness and use of levels requires that there be care in any data analysis so that biases are not introduced from extrapolating data from one level and applying it to another level (Burton-Jones & Gallivan, 2007 p. 660 Table 2; Karsh & Brown, 2010 p. 678).

Patient Safety Frameworks: Levels

Frameworks can structure our approaches (Despont-Gros et al., 2005 p. 253). The examples here show how models such as the Eason model or fit model can frame and simplify analysis of complex systems.

Eason Model

The Eason model is one such model. Eason’s model was designed to describe the interaction

between humans and systems at three levels: 1) the person interacting at the individual level with the technology in isolation (i.e. basic usability), 2) the person performing a work task using the system, and 3) the wider socio-technological context of system use within an organization (Eason, 1991 p. 722). In health care, gaps in fit at these levels can cause medical errors.

The literature provides guidance for risk assessment corresponding to Eason's three levels: the individual, the task and the organization (the most complex). Eason's three levels, individual, task and organization, will be discussed again in Chapters Five (i. e. Results), and Six (i. e. Discussion and Conclusions).

Individual Level

This is the sharp end of health care where the patient suffers an adverse event. Patient factors include medical condition, social factors, language barriers, etc. (Vincent, 2003 p. 1051 Table 1). Staff factors include knowledge and skills, motivation, fatigue, and stress (Vincent, 2003 p. 1051 Table 1). There is also the intent of the user. "People operating hazardous systems might see quite different possibilities for what to do with them compared with what had been envisaged by the system designers" (Busby & Bennett, 2008 p. 799). "This is often important in risk assessment because of the way in which risk arises from people knowingly doing things that cause risk (for instance violating rules), but without intending the outcome of a catastrophic failure" (Busby & Bennett, 2008 p. 799, 800).

Task Level

Factors here include guidelines, protocols, and clinical data availability (Vincent, 2003 p. 1051 Table 1). A "successful human-computer interaction depends upon the degree to which the system and the user can agree on the characteristics of the tasks they are performing" (Eason, 1991 p. 727). This again comes down to the concept of fit. Since task level factors are controlled by the information system, system design has an inevitable, strong effect by assisting or constraining the possible ways that information workers can perform work (Butler et al., 2000 p. 220). If these constraints interfere with the task, the user can have a feeling of "helplessness and frustration when handling technology" so there is "increased worry, stress and uncertainty" (Liljegren, 2006 p. 346). This can create an unsafe situation for the user and patients.

Organizational Level

Factors here include staffing/workload, equipment available and maintained, managerial support, financial and other resources, policies (Vincent, 2003 p. 1052 Table 1). Organizational measures include cost reduction, due to fewer medication errors and adverse drug events occurring; improved efficiency in patient care delivery, specifically pertaining to tests and drug orders; increased use of generic drug brands; the number of consultations; and the length of waiting lists.

Organizational Level – Intent

While much of the safety research provides guidance, the research mainly focusses on outcome measures at the sharp end (some examples include incident reporting such as the MAUDE reporting system mentioned in section 1.1.2 ((The Human Cost of Information System Failure)). It does not address organizational intent. Organizational intent is qualitative. It requires identification of the “obligations and powers” that affect system “actors” and “the identification of organizational risks that arise from dysfunction, where these obligations and powers are concurrent, for example from individual intentions to meet these obligations even when they are somehow problematic in the context, or from individual intentions to set these obligations aside from some contextual reason” (Busby & Bennett, 2008 p. 802). People “build into technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define the organizationally sanctioned way of executing that work)” (Orlikowski, 2000 p. 405).

These “collective intentions or norms lie behind social objects like money, marriage, property and government” (Busby & Bennett, 2008 p. 802). Patient safety could be added as a social object subject to collective intent. These social “objects have functions because there is a collective intention that they should have a particular role in a particular context” (Busby & Bennett, 2008 p. 802) in our case, health care.

Busby and Bennett (2008 p. 812) outline “five benefits” of examining organizational intent: “1) it helps deal with particular kinds of organizational pathology; 2) it gives insight into the nature of responsibility; 3) it provides empathy for the actors in a system; 4) it provides a better vantage point more generally; and 5) it provides a better basis for mitigating risks”.

Busby and Bennett (2008 p. 802) describe a methodological approach to reviewing individual and organizational intent as a risk assessment tool:

“1. The identification of the main social object(s) in a system” (in our case this will be patient safety to start with).

“2. The identification of the collective intentions for these objects in terms of the functions that are conferred on them”. There is often ambiguity about this.

“3. The identification of the obligations and powers that these functions confer on actors in the system”.

“4. The identification of risks of organizational dysfunction that arise in these obligations and powers – for example from individual intentions to meet these obligations even when they are somehow problematic in the context, or from individual intentions to set these obligations aside for some contextual reason”.

Organizational Level – Silence

An important cause for under-reporting of adverse events is organizational silence. Henriksen and Dayton (2006 p. 1540) describe the individual, social and organizational rationales why “fewer than 10% of physicians, nurses and clinical staff directly reported” poor care that could lead to harm. An important contributor is senior leadership’s (at the blunt end) inattention to the “interdependencies of care” (at the sharp end) (Henriksen & Dayton, 2006 p. 1550).

Key and Kushniruk (2009 p. 404 Figure 1) provide an overall diagram, Figure 5 (based on Reason and Thomas), showing how the different levels fit on the model:

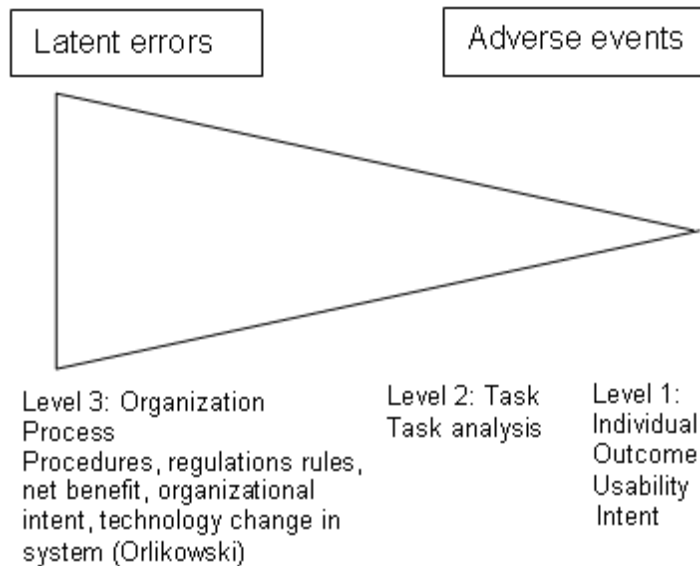


Figure 5: levels and Reason's model. Reprinted from Keay & Kushniruk (2009) Figure 1.

Patient Safety-Based Framework: Fit

The idea of levels comes into fit which is a “vertical alignment (or fit) throughout all levels of organizational hierarchy” (Holden & Karsh, 2007 p. 271). Strong and Volkoff (2010) present the concept of organization-enterprise system fit. It is “a collective construct for concepts applicable to aggregations of interdependent entities with phenomena operating simultaneously at multiple levels of analysis” (Strong & Volkoff, 2010 p. 732). Strong and Volkoff (2010 p. 732) suggest that fit is the “fit between the enterprise system and the different tasks” along with the “sum” and “interactions” among the parts. Fit may be all of these things interacting seamlessly for the system to be safe: the data analysis may point to some other frameworks for fit. Fit is made more difficult by the “complexity” of the organization’s information systems (Strong & Volkoff, 2010 p. 732).

Obviously, if there is a poor fit there is a misfit. Strong and Volkoff (2010 p. 737 Table 3) describe the different types of misfits:

- “Functionality misfits occur when the way processes are executed using the enterprise information system leads to reduced efficiency or effectiveness as compared to pre-enterprise information system outcomes”.
- “Data misfits occur when data or data characteristics stored in or needed by the

information system leads to data quality issues such as inaccuracy, inconsistent representations, inaccessibility, lack of timeliness, or inappropriateness for users' contexts".

- "Usability misfits occur when the interactions with the enterprise information system required for task execution are cumbersome or confusing, i.e., requiring extra steps that add no value, or introduce difficulty in entering or extracting information".
- "Role misfits occur when the roles in the enterprise information system are inconsistent with the skills available, create imbalances in the workload leading to bottlenecks and idle time, or generate mismatches between responsibility and authority".
- "Control misfits occur when the controls embedded in the enterprise information system provide too much control, inhibiting productivity, or too little control, leading to the inability to assess or monitor performance appropriately".
- "Organizational culture misfits occur when the enterprise information system requires ways of operating that contravene organizational norms".

There is also the "potential lack of "fit" between systems developed outside of Canada (e.g. by vendors from the United States or other countries) and health care practices, policies and organizations within Canada" (Kushniruk et al., 2013 p. e 152). This has led to "new classes of technology-induced error that result from mismatched policies, procedures, cultural and organizational processes embedded within information systems imported from other countries" (Kushniruk et al., 2013 p. e 152, e 153).

The research will address some of the misfits, such as the data and usability misfits, that are derived from a model, and the vendor issues through the semi structured interviews of Canadian users of health information systems in clinical use.

There are different ways of visualising the information system. The system can be seen either as a vehicle for data, the so called tool view, or as a set of deep, surface and physical structures as shown on this diagram Figure 6³⁰ below (Strong & Volkoff, 2010 p. 750):

³⁰ (c) Reproduced by permission of MIS Quarterly & The Society for Information Management. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law

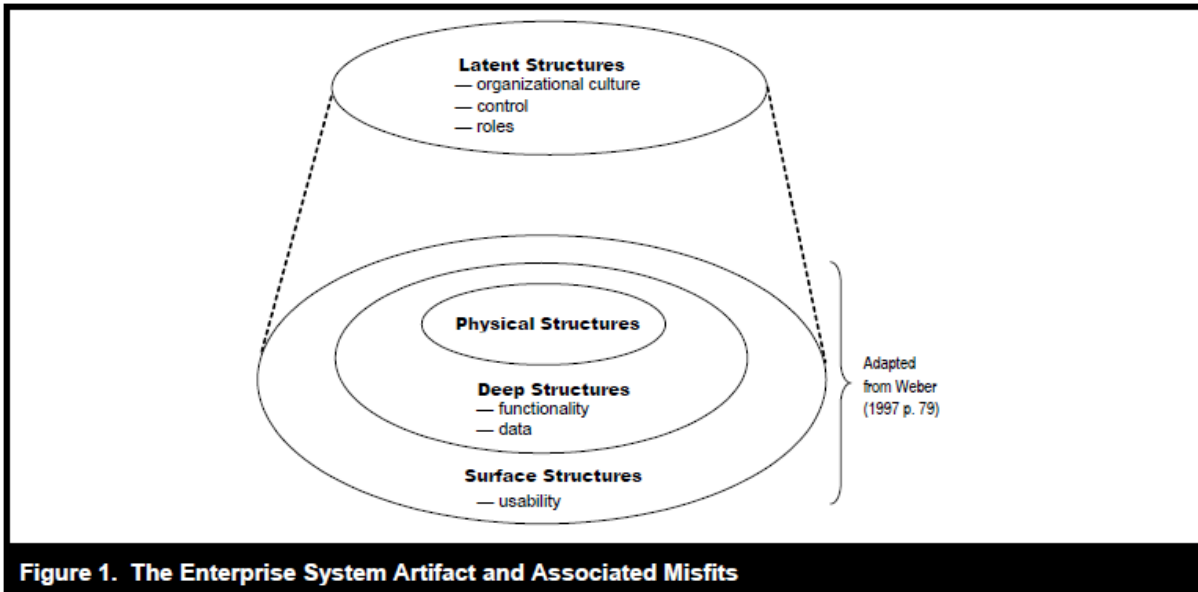


Figure 6: Enterprise System Artefact and Misfits. Reprinted from Strong & Volkoff, (2010) Figure 1.

2.8 Summary

This Chapter has shown that while information occurs frequently as a theme in the literature, there are few qualitative studies that clearly describe information quality including poor information quality (please see section 2.3.3 (Poor Information Quality)). The chapter reviewed the following:

- Information quality: is the glue central to patient care and poor information quality such as inaccurate information can contribute to adverse effects involving organizations and patients; however the literature does not provide further detail on information quality (please see section 2.3.2 (Information Quality)).
- Acute care sector: provides the context for the information quality; how it is a system and how information use and quality provided by an information system is central to the functioning of the system; acute care is a porous complex system with information losses but little detail on what this might mean (please see section 2.4.3 (Summary)).
- Information system: the types of systems and potential for error propagation by the flow of information is a vehicle for information; the non-functional requirements of well-functioning systems and safety issues of poorly functioning systems where generally usability can affect information quality (please see section 2.5.3 (Information System Elements and Characteristics for Safety)). Information quality as a non-functional requirement is described.

- Risk: there is now a shift away from quantitative risk assessment techniques using probability and impact assessment to qualitative techniques using direct information gathering and frameworks that are optimal for looking at poor information quality and adverse events. Adverse events can be described in several ways: rare with low probability and varying impact(s), wicked or ill-defined, complex with inter-related causal links, or uncertain with unknown probabilities. Heyman's (2010) information representation as a qualitative risk management method suggests that information can also contribute to risk if interpreted incorrectly, but little detail is provided. Please see sections 2.6.2 (Assessing Risk), 2.6.4 (Classification of Adverse Events).
- Patient safety: provides models for information quality. Information quality can either be good, in which case it mitigates patient adverse events or poor where it can contribute to an adverse event. Patient safety relies on many factors from the organization to the system at the blunt end to the individual patient and care provider at the sharp end. The emphasis has been on the system view and its causation theories, but there must be a vertical integration with "fit" for patient safety to be an effective mitigation. The data and usability "misfits" described in sections 2.7.2 (Technology Induced Errors), 2.7.4 (Patient Safety Concepts and Frameworks) have some clues about information quality generally but are not specific to Canadian healthcare.

In Chapter Two the literature review provided the structure to clarify information quality's central role as seen by the interviewees. Chapter Two also highlights the information gaps in the five key areas because the literature that is largely derived from concept models or literature. The interpretations of the health care providers in the real world setting of Canadian acute care address the important gap of a lack of this real world emphasis in the literature.

The next chapter, Chapter Three, will provide the research questions based on the five areas and the following chapter, Chapter Four, will describe the qualitative methods chosen to gain an understanding of information quality and the other four areas from the interviewees using a Grounded Theory analytic method.

Chapter 3: Research Questions

The literature review has provided background on the five part structure for providing a set of high-level research questions to guide the research methodology so that the methodology applied to the semi structured interview questions provide valid and reliable data for analysis and discussion. The research questions act as a filter between the literature review and the rest of the research to provide focus and scope.

The high-level research questions in this dissertation are as follows with a rationale for each:

1. “what is information quality?”

The interviewees are being asked about the terms they would use to describe good information quality and poor information quality in the acute care sector or their respective workplaces. This became the Part II semi structured interview question set in Chapter Five.

2. “what is the acute care setting like?”

This question is asking the interviewees to describe the acute care sector for someone who may not have an understanding. This question also limits the scope to the acute care sector as a context for information quality and information systems. This became the Part III semi structured interview question set in Chapter Five.

3. “what is the perceived relationship between data quality and information systems in health care?”

This question is asking the interviewees about their experience and knowledge of information systems and how they might impact information quality for better or for worse. This question is based on the expectation that most people work with information systems all the time at their workplace in acute care or elsewhere in the health care system. This became the Part IV semi structured interview question set in Chapter Five.

4. “what are the risks arising as a result of poor information quality?”

The interviewees are being asked their opinion if poor information quality can be a risk factor for, or contribute to, an adverse event in the acute care setting. It digs a little deeper than question two by asking about risk as a function of poor information quality. This became the Part V semi structured interview question set in Chapter Five.

5. “how do different stakeholders view the relation between patient safety and information systems”

This question takes the Part II questions a little further and asks the interviewees if systems can help or hinder patient safety in a context of adverse events. This became the core of the Part VI semi structured interview question set in Chapter Five.

The literature review provides many clues leading to the suitability of the qualitative approach in the research questions asking for the interviewees' opinion about acute care, information quality, information systems, risk (as a function of poor information quality) and patient safety.

The research questions set out the qualitative framework needed for collecting and analyzing the interviewees' understandings and interpretations about the five key areas without ascribing causation. The next chapter, Chapter Four, will describe the research methods used to collect and analyze those understandings and interpretations.

Chapter 4: Research Methodology

4.1 Introduction

We see from the Chapter Two literature review that there is a high probability of costly failure of systems that can have an uncertain information quality and safety record. The aim of this research is to contribute to our understanding of information quality in the contexts of acute care, information systems, risk as a function of poor information quality and patient safety.

interviewee

Since the research is focussed on the subject matter experts' understanding of, or knowledge about, information quality within the contexts of the five key areas, a qualitative method was used. The term "qualitative" can refer to both the study design and /or the data (Runeson & Höst, 2009 p. 136): this research has both qualitative design and data.

The nature of qualitative research means that it can:

- Explore meanings of social phenomena as experienced by individuals themselves (Malterud, 2001 p. 398; Weiner et al., 2011 p. 6).
- Be used where "little research has been done" so an "exploratory" method needs to be used (Creswell, 2009 p. 18).
- Describe how systems affect and/or are affected by, or embedded in, the inner workings of the organisations in which they are developed, deployed and utilised (Murphy et al., 1998 p. 200; Weiner et al., 2011 p. 6).
- Describe how "systems fit with the workflow of all users" and "what is really going on" (Ash & Guappone, 2007 p. S 34).

Qualitative research is an "iterative process" with an "emphasis on interpretive, not statistical, pattern matching" within a "messy" reality (Hoff, 2011 p. 51; Weiner et al., 2011 p. 6), such as we saw above in the literature review, for example, in section 2.6.4 describing adverse events in health care as rare with low probability and varying impact(s), wicked (ill-defined), complex with inter-related causal links, or uncertain with unknown probability.

Dekker has noted that qualitative methods are preferable for capturing health system failures and safety issues because the health system, of which acute care is a part, is a complex system that is

never fully knowable or static (Dekker, 2011 pp. 84, 236).

Qualitative approaches are used for problem solving where observers evaluate, and interact with perceptions or motivations. Finally, a qualitative approach works with risk in a “social context” as described by Renn (1998 p. 56) and Heyman et al. (2010 p. 21 Table 1.1) who specifically includes information representation as part of the interpretative risk management process as opposed to the quantifiable risk management process of natural phenomena . Qualitative approaches are also valuable for looking at any organizational issues.

Hearld et al. (2008 p. 271) note in their review of health services research (in which this research could be placed) that the number of qualitative studies in this area of research is extremely small compared to the excessive focus on quantitative designs. One qualitative example is Takian et al. (2012 p. 6) who reviewed the NHS’ Connecting for Health electronic health record with a qualitative method (case study interviews) because the depth of inquiry “can probe deeper” to build a rich explanation of many processes. Another example is Georgiou (2013 p. 652) who examined computerized order entry in emergency rooms and recommended that “qualitative studies” be used for “uncovering technical and organizational dimensions”.

Sarker et al. (2013 p. iv, vi, vii, xiii, Table 1) provide excellent guidance about some of the issues with information system qualitative research that this research will address. These include:

- “Researchers must be more conscious about including significant technology-related and/or information-related considerations in their research, as they design their study” (p. vi). This research addresses the lack of information system focus by having information systems as a key literature review topic and structured interview question. Sarker picks up on an identical conclusion made earlier by Orlikowski and Iaeono in 2001.
- “Provide an ontological and epistemological stance” (p. vii). This research does this in section 4.2.2 (Qualitative Method).
- Provide a detailed description of methodology and interview “data collection” (p. xiii). This research does this both in Chapters Four and Five and their respective Appendix sections (Appendices C, D, E and H).

4.2 Analytic Concepts Overview

There are two main analytic approaches to interview data, a quantitative approach or a qualitative method.

4.2.1 Quantitative Methods

The dominant research tradition in health informatics has been quantitative research that uses hypothesis testing and statistical analysis to determine the significance (or not) of system effectiveness, cost impacts, user satisfaction, usage and error rates (Murphy et al., 1998 p. 63).

The following studies show some of the quantitative approaches that have been used. Chai (2013 p. 980) used content analysis. Tharmalingam et al. (2016 p. 1) surveyed six Canadian provinces and territories about connected health information using a survey tool with Likert scales based on the Delone and McLean model. Palojoki et al. (2016 p. 1) used a web-based questionnaire to rate risks quantitatively of different electronic health record scenario such as availability or alerts.

The theoretical basis for qualitative research is the interpretivist paradigm that is described further below in the next section, 4.2.2 (Qualitative Method). We have seen elsewhere in this research, for example, in sections 1.1.1 (Financial Cost of Information System Failure) and 1.1.2 (The Human Cost of Information System Failure), that electronic information systems are expensive with a high risk of failure and often unproven safety. Quantitative research provides critical baseline information but does not reveal what people *think* in depth about information systems in health care. This is the role of qualitative research and its methods in the next section.

4.2.2 The Qualitative Method: Philosophical Stance, Research Paradigm, & Time Frame

Trede and Higgs (2009 p. 18) note that a “philosophical stance with its chosen ontology and epistemology provides the rationale and justification for the research methods”. The “research questions give substance to the philosophical stance and direction to the research” (Trede & Higgs 2009 p. 18). The ontology of the research’s external reality, acute care in Canada, and the proof or evidence about that external reality, the epistemology, need to be reflected in the research paradigm and approach.

The External Reality of Acute Care: Ontology

Ontology is about the “nature of reality” (Mason, 2002 p. 14; Walsham, 1995 p. 75). There can be an external “reality that exists independently of our construction of it” or a reality that is “shared” among individuals or, is constructed on an individual basis (Walsham, 1995 p. 75 Table 1). This research is broadly about the social reality of acute care in Canada as constructed by each interviewee. Mason speaks of the components of social reality (2002 p. 14 Table 1.1). The ontological properties of the social reality for this research are the *understandings* and *interpretations*³¹ of the interviewees about the quality of information used in the research social reality and not other ontological properties such as practices or legal structures (Mason, 2002 p. 15 Table 1.1).

Epistemology: Evidence for the Understanding and Interpretation of External Reality

Epistemology is about the “nature of knowledge claims” (Walsham, 1995 p. 75). The strongest evidence for understanding and interpretation of external reality will be found in the most experienced individuals who have been immersed in the social reality of acute care for a long time. Evidence collection will be by semi structured interview questions because interviews construct knowledge (or evidence) (Mason, 2002 p. 36). The researcher will use the interview to collect and assess the evidence for the social reality from the interviewees’ understanding and interpretation of information quality in the external reality of acute care in Canada because this knowledge is “situational” (Mason, 2002 p. 64).

The interview questions are designed to collect the evidence for information quality generally in the acute care social reality rather than in specific areas of care such as paediatrics or cardiology.

The ontological view and properties and its epistemological proof lead to the research paradigm for the research that will be interpretivist in this case.

Research Paradigm: Interpretivist for Evidence Meaning and Context

The researcher can use several paradigms for collecting evidence or knowledge about the

³¹ Note: these two terms will be used throughout this dissertation to describe the informants’ opinions to link the ontological properties and their interview evidence.

external reality of acute care in this case. Paradigms can be either the “critical approach that questions assumptions and power relationships”, or the interpretivist to understand “meanings” or “context” (and maybe create theory) or the positivist to focus on “hypothesis testing” or refining and generalization (Crowe et al., 2011 p. 4; Runeson & Höst, 2009 p. 135).

Walsham (1995 p. 76 Table 1) notes that positivist theory considers scientific knowledge is made up of “facts” while interpretivist or non-positivism considers scientific knowledge either as a blend of fact and values or as ideology. Combinations of approaches can be used. While a combined approach may happen during the course of this research, the starting point in this research will be the interpretivist paradigm because the research is designed to get an understanding of information quality meaning or context through the systematic collection, organization and interpretation of “textual material” transcribed from interviews (Malterud, 2001 p. 398). This is described below in section 4.2.2 (Qualitative Method).

Asking about interpretation and perception is in the hermeneutic philosophical tradition where Trede and Higgs (2009 p. 19) classify hermeneutic knowing “as a kind of being-in-the-world and as a pragmatic, involved activity or “know-how” that is more basic than reflective thinking and occurs prior to it. This knowing is embedded in unarticulated common meanings and shared background practices of groups of people” (Trede and Higgs 2009 p. 19)

This technical shared understanding fits the interviewees and the acute care context well since they work or have worked in this sector. Further, the philosophical hermeneutic tradition is suited to interviews asking, first, about the interviewee’s “perceptions” and “interpretations” about information quality in the different contexts, and then, the analysis, using the Grounded Theory analytic approach, examining what their interpretations and understandings were and how they compare and contrast (Trede & Higgs, 2009 p. 22 Table 2.3 Topic 1).

Loftus and Trede (2009 p. 61) note that this approach is especially useful for “phenomena with complex many layered meanings and viewed from a number of perspectives” such as our five key research area contexts.

Greenhalgh and Russell (2010, p. 2 Table 1) and Trede and Higgs, (2009, p. 17 Table 2.1) provide some general principles of interpretivist research that emphasises its “social science”

intent. These principles as summarized from Greenhalgh and Russell (2010, p. 2 Table 1) and Trede and Higgs, (2009, p. 17 Table 2.1) include:

- “Contextualization-observations only make sense when placed in a narrative that shows how they emerged from a social and historical background”.
- “Interaction and immersion-there is dialogue between the study participants and the researcher”.
- “Reflexivity-the researcher’s biases and interests affect the research questions, data collection and analysis”.
- “Multiple interpretations-multiple truths are explored; there are multiple constructed realities, that is, different people have different perceptions of reality”.
- “Critical questioning-critical questions may generate deeper insights; the process of inquiry changes both the investigator and the participant i.e. are interdependent; inquiry is value bound in how questions are asked and interpreted”.
- “Knowledge is both context-and time-dependent; there is a deep understanding of the particular; a pragmatic consensus”.
- “The fundamental research question is: “How do people perceive this?””

The Grounded Theory analytic approach is also well aligned with the interpretivist paradigm and the ontological approach of comparing and contrasting the interviewee’s understandings and interpretations of information quality.

Research Time Frame

Flick (2014 ch. 9 p. 126) makes the important point that much of qualitative research is a “snapshot” at a point in time (and place) with no “retrospective reconstruction of a process”. Research is concerned rather with giving a description of circumstances such as in an interview at the time of the research. This could create issues for the start and end point to “limit the material” for the analysis (Flick, 2014, ch. 9 p. 127), however, this research will consider all of the information at the point in time, where an interviewee speaks of past events these will be noted accordingly. A limitation of this design is an inability to understand a process over a period of time (Flick, 2014 ch. 9 p. 127). This is not an issue for this research.

4.3 Analytic Method: Grounded Theory Analytic Approach is Flexible

4.3.1 Other Qualitative Methods were Considered

Other qualitative methods were considered for this research but their specificity on situations or individuals precluded them from collecting evidence for the social reality of acute care in Canada generally. These methods were the case study, ethnography and phenomenology.

Case study

The case study is suited to the “detailed” analysis of “complex” practices or processes organized into “categories” that are set out in advance with “non cross-sectional” analysis (Dube & Pare 2003 p. 598; Flick, 2014 p. 123; Mason, 2002 p. 165; Meyer, 2001 p. 331). The case study results may not be generalizable because the sampling is not referable to a “population” (Blaikie, 2010 p. 192) or “transferable” from a specific case to the general (Bazeley, 2013 p. 410 411). This research was designed to glean knowledge from the interviewees about information quality in acute care generally rather than information quality in specific aspects of care or specific sites.

Ethnography

Ethnography looks at relationships or experiences in a particular “setting” by direct observation documented in detailed field notes (Bazeley, 2013 p. 68; Mason, 2002 p. 55). Field notes can be unstructured interviews, audio, video or written documents (Flick 2014 p. 325). Ethnography is about a culture or how something actually works or happens that can only be known by the researcher’s “immersion” in social settings (Flick, 2014 p. 320; Mason, 2002 p. 55). If this research were an ethnographic study it would have required the researcher to be embedded in a specific hospital and directly observing individuals interacting with the information systems as they make care decisions. This research was not about learning the acute care culture and the pan-Canadian approach did not fit with the researcher’s immersion in a specific site.

Phenomenology

The researcher examines the experience or “essence” of an individual in a specific behaviour setting such as providing care and what meaning they ascribe to that “experience” while at the same time setting aside all researcher bias such as “bracketing personal experiences” (Bazeley,

2013 p. 193; Bernard & Ryan, 2010 p. 258; Creswell, 1998 p. 55). If this research were a phenomenological study the researcher would have asked (via lengthy interviews over a period of time) a sample of care providers on how they would describe the experience of making care decisions using the information systems. Phenomenology would also require the researcher to have both a detailed knowledge of the philosophical underpinnings of phenomenology and equal experience making care decisions in a similar setting (Creswell, 1998 p. 55 112 Table 7.1)(both of which the researcher does not have).

4.3.2 What is Grounded Theory?

Grounded Theory is a qualitative technique to discover or generate theory about a phenomenon: in our case, we will apply a Grounded Theory approach to the interviewees' understandings and interpretations about information quality.

There are relatively few information system studies that use qualitative methods or adhere to the pure Grounded Theory method (DeLuca et al., 2008 p. 51; Matavire & Brown, 2013 p. 125 Table 3). The pure Grounded Theory method has three principles: emergence [the "research design process" and the "theory" arising both emerge from the research process], "constant comparative analysis" and "theoretical sampling" to saturation (Matavire & Brown, 2013 p. 120).

Theoretical sampling is data collection to fill in "gaps" in any conditions and variations (Charmaz & Belgrave, 2012 p. 359). Theoretical sampling involves asking more "specific", "even pointed, questions in interviews than researchers ordinarily ask in early interviews: obtaining further data to fill these gaps makes the categories more precise, explanatory, and predictive (Charmaz & Belgrave, 2012 p. 359; Corbin & Strauss, 2008 p. 146). Corbin and Strauss (2008 p. 145) mention that it is important to sample theoretically within the "general target population" of the study.

Urquhart et al. (2010 p. 359) and Urquhart and Fernandez (2006 p. 459) provide a good overview of Grounded Theory methods for developing high level formal concepts for information system analysis and explaining some of the myths that prevent Grounded Theory method's wider use. Grounded Theory methods have evolved into a useful set of "guidelines

rather than fixed rules” for health informatics research (Cummings & Borycki, 2011 p. 289). Urquhart and Fernandez (2006 p. 249) note that there are four categories of studies that claim to use the pure Grounded Theory Method as follows: 1) “full use of the method”, 2) “using the method to generate concepts”, 3) “mixing grounded theory with other research methods”, and 4) “studies mislabelled as Grounded Theory Method, i.e., not following any known procedures of either Glaser, Strauss or Strauss and Corbin”. This research falls into the second group, 2), because this research will not use the full Grounded Theory method (in 1) but an analytic approach only.

Here are the myths about Grounded Theory use for information system research and their rebuttal with BUT statements that confirm the value of a Grounded Theory analytic approach for this research (Urquhart & Fernandez, 2006 p. 460-462) and how this research supports the “BUT” statements:

- Myth #1: Researcher as “Blank Slate who launches into data collection without first looking at the literature”-BUT “grounded theory research does not start with a theory to prove or disprove”. The preliminary literature review examines what theory exists in the area and how other people may have addressed aspects of a research “problem” but does not then impose a framework on future theory. This research’s literature review is revisited, and extended in Chapter Six, as needed, to augment concept(s) generated from the Chapter Five analysis.
- Myth #2: “Grounded Theory Method Is Inflexible”-BUT “disciplines such as health have reported that many researchers adopt Grounded Theory Method for a purpose other than developing theory, generally data analysis”. ... *“Grounded Theory Method has great strengths as a stand-alone coding method, since the stages are well sign posted for the novice researcher”* (emphasis added). This is the case for this research that used a Grounded Theory analytic approach.
- Myth #3: “Grounded Theory Method Produces Low Level Theories that Don’t Do Much”-BUT “the low level of the theory is a natural consequence of the type of ‘bottom up’ coding, starting at the word and sentence level, which Grounded Theory Method employs”. “This produces rich theory with a very close tie to the data, and this is a major strength of Grounded Theory Methods”. “The close tie to the data means that the theory will be substantive, i.e., pertaining to that particular area”. “However, because a low-level theory is produced does not mean that there is no possibility of scaling that theory up, and indeed Grounded Theory Method places an obligation on the researcher to do so”. This is

the case for this research as the Chapter Six discussion and conclusion will show by enhancing a pre-existing model selected on the basis of the interview data.

- Myth #4: “Grounded Theory Method Is Positivist/Interpretivist”- BUT “Grounded Theory Method is in many ways neutral, and can be seen as a container into which any content can be poured”. “...the last word to Glaser (1999) who stated during a conference address: ‘Let me be clear. Grounded theory is a general method. It can be used on any data or combination of data.’” (Urquhart & Fernandez, 2006 p. 462). This supports the use of a Grounded Theory analytic approach for this research.

This research will use a Grounded Theory analytic approach (highlighted in Table 4 below) because there will not be emergence or theoretical sampling of the full Grounded Theory Method. There will be a priori grouping based on the research questions as an initial organizing device and then use of descriptive and more abstract coding or grouping for analysis with constant comparison and contrast of that portion of the Grounded Theory Method.

Matavire and Brown have summarized the major types of Grounded Theory approaches below in Table 4³²-the grey row highlights the analytic approach used in this dissertation:

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Table 4: Grounded Theory Approaches

Four Grounded Theory approaches					
Approach:	Grounded Theory Method principles ³³	Coding	A priori theory	Paradigm model ³⁴	References in Matavire & Brown
Classic	Required	Open, Selective, Theoretical	Should not be used	Viewed as one of a family of 18 theoretical codes	Glaser & Strauss (1967), Glaser (1992), and other works authored by Glaser
Evolved	Required (Glaser disputes adherence)	Open, Axial, Selective, coding for process	May be used as a sensitizing device	Recommended	Strauss & Corbin (1990, 1998). There could be references to Glaser's works
Analytical	Not necessarily	Any or all used	Often used	Sometimes used	Variety, but often Strauss's
Mixed Method	Not necessarily	Any or all used	May be used	Sometimes used	Mingers (2001), Eisenhardt (1989), Baskerville & Pries-Heje (1999) or any work claiming the creation of a Grounded Theory derived methodology

Note: Adapted from Matavire & Brown, (2013) Table 1.

The exploratory nature of the Grounded Theory analytic approach allows both for an in-depth understanding of the phenomenon of interest including its environment or context in the real world (Miles & Huberman, 1994 p. 36 Figure 2.7) and for the research stance and the philosophical ontology of hermeneutics.

³³ The Grounded Theory Method principles are emergence, constant comparative analysis and theoretical sampling

³⁴ Matavire notes (p. 122) the paradigm model is used by Strauss and Corbin; it is a set of questions the researcher asks of the data such as contextual factors (why, how, where something happens), responses of individuals and what happened as a result (see also Strauss & Corbin, 2008, p. 89). This set of questions was not used in this research because these questions imply causation. Causation was not the intent of the research semi structured interview questions.

4.3.3 Methodology Overview

This research used cross-sectional “coding” or “indexing” (Mason, 2002 p. 150-164) .This strengthens the analysis in several ways by:

- Setting the boundaries of the theory (Dube & Pare, 2003 p. 610) - this research is limited to acute care in Canada as a unit of analysis.
- Providing diversity across “contexts”, within different environments to illustrate complexity (Stake, 2006 p. 12) - this research used interviewees from different provinces in Canada.
- Permitting comparison, contrast and rich textual detail (Dube & Pare, 2003 p. 619; Meyer, 2001 p. 334) - this research used comparison and contrast analysis of semi structured interviews.
- Making the results more transferable that is, with stronger external validity (Meyer, 2001 p. 333) - this research analysed interview data from different provinces and clinical and non clinical interviewees. This is addressed further in the discussion chapter, Chapter Six 6.4.1 “Interview”.

This is shown in Figure 7 below that is adapted from Runeson and Höst (2009 p. 139 Figure 1):

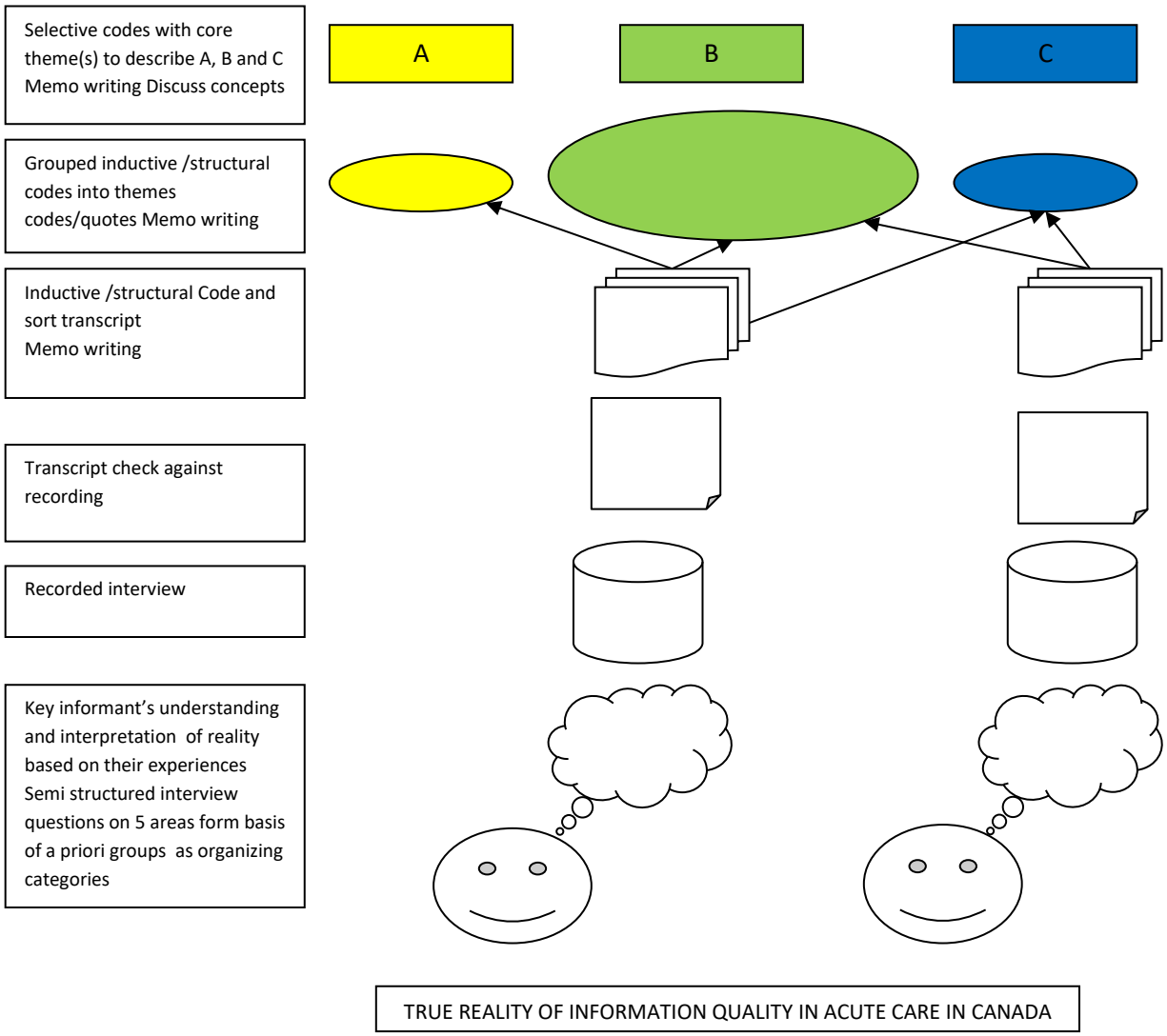


Figure 7: Overview of Grounded Theory Analytic Approach Methodology for this Research. Adapted from Runeson & Höst (2009) Figure 1.

4.3.4 Approaches: Link Research Questions and Interview Questions

We have seen that the basic research question in this dissertation is: “What do Key Informants think about Information Quality in Acute Care?” and the interviewees were asked about their understandings and interpretations of information quality in the acute care setting and aspects of information systems, risk as a function of poor information quality and patient safety derived from the Chapter Two literature review. The semi structured interview questions themselves

become the a priori groups of interview data into large chunks for further analysis.

The interviewee's understandings and interpretations about these five areas are documented in the transcriptions and are coded first in the interviewees' own words as basic descriptions or terms they use for these understandings and interpretations. The codes used at this first look at the interview data is by inductive, structural coding.

4.3.5 Coding

Coding is a first step to “reduce” the volume of data by labelling the text of interest into “chunks” and ignoring the rest (DeCuir-Gunby et al., 2011 p. 144; Dube & Pare, 2003 p. 616; Miles & Huberman, 1994 p. 57). DeCuir-Gunby and colleagues (2011 p. 138) note that coding also allows data to be expanded later by linking concepts or reorganized into new ideas.

As mentioned, three types of codes were used in this research: a priori grouping of the semi structured interview questions, based on the five contexts of the literature review; inductive or structural coding based on a close initial reading of the interview transcripts, and higher level codes or themes. The steps are outlined below starting with a priori grouping . [Appendix H](#) outlines an example of the coding methodology steps for the Part II interview question three, poor information quality, for one interviewee, interviewee one.

A Priori Grouping

Since the a priori grouping is based on the five key areas or contexts of the literature review it means that the codes themselves are “directly” related to the “research questions and goals” (Soldaña, 2013 p. 62). This initial coding structure applied to the interview data also means that the data can then be analyzed more deeply with inductive and higher coding (Silver & Lewis, 2014 p. 207 Table 9.1). The use of a priori grouping is a categorizing strategy designed to group data into large chunks or “bins” that do not “provide much insight” into the data (Maxwell, 2005 p. 97; Maxwell & Chmiel, 2014 p. 25).

There is also the concept of not wasting knowledge, as expressed by Thornberg and Charmaz (2014, p. 163): “take advantage of knowing and using the literature, not for forcing the research into preconceived categories but as multiple possible lenses. As Dey (1993: 63) puts it, ‘There is

a difference between an open mind and empty head.' Ignoring established theories and research findings in the substantive area implies a loss of knowledge. Instead of running the risk of reinventing the wheel, missing well-known aspects, and coming up with trivial products or repeating others' mistakes, researchers should take advantage of the pre-existing body of related literature to see further”.

[Appendix H](#) has the a priori grouping for the semi structured interview question highlighted with yellow.

Inductive/Structural Coding

Inductive or structural coding is the next step after the data has been grouped with a priori coding. This coding is also called “substantive” coding because it is “descriptive, stays close to the data”, and can be used to group data that don’t fit in the a priori grouping (Maxwell 2005 p. 97; Maxwell & Chmiel, 2014 p. 25). The dissertation coding used the actual terms expressed by the interviewees. The type of inductive coding used in this research was “structural coding” (Soldaña, 2013 p. 84-87) because it is useful for semi structured interviews, creates broad groups of data for further comparison and contrast analysis using a Grounded Theory approach, and can be used in quantitative analysis such as frequency tables. Urquhart et al. (2010 p. 369) note that word and sentence level coding, such as used in “the grounded theory method” (and in this research), provides a tight “chain of evidence” to the data.

This coding is suited to the technical shared understanding and “know how” of the philosophical hermeneutic tradition (Trede & Higgs, 2009, p. 22 Table 2.3 Topic 1) and the Grounded Theory analytic approach of code hierarchies from a priori groups , to inductive and to more abstract codes or themes.

[Appendix H](#) has the first round of inductive coding applied to the transcript marked as “THEME” followed by a summary of interviewee one’s suggested intent(s) in the response. These themes formed the base set of the inductive codes in the MAXQDA 12 software used in the analysis; these codes were changed as needed as the documents were coded and reviewed later in the analysis phase.

More Abstract Codes or / Themes

This level of coding or theming is the “researcher’s” concepts or understanding of the data, what it means, the “outcome of coding” and what are the data relationships (Maxwell, 2005 p. 98; Soldaña, 2013 p. 175).

These three levels of coding creates a *code system* that (Bazeley, 2013, p. 179) that:

- “Creates order”.
- “Provides conceptual clarity to the project”.
- “Codes additional aspects of data”-content and context or other additional subgroups.
- “Identifies patterns and relationships”.
- “Branch in a system are similar as they represent the same kind of thing”.

The researcher developed the code system through close reading of the interview data as outlined in the following section. This code system became the meat of the Chapter Five analysis.

4.3.6 Analysis Next Steps

[Appendix H](#) has the analysis next steps in more detail; the following is a summary to show the iterative process working with the interview data between the software data in MAXQDA 12³⁵ and the word documents organized either by a priori groups for each interview question in Parts II to VI or by inductive/subjective code.

Additional questions or comments arising out of the conversation with the interviewee were highlighted and coded or used as memos in MAXQDA 12 and the MS Word documents. As more codes and themes emerged from the analysis the researcher moved back and forth within the MAXQDA 12 data set and the MS word documents.

When the MAXQDA 12 descriptive statistics showed an equal number of clinical (nurses, physicians and pharmacist) and non-clinical interviewees, the parts of the Part II question three

³⁵ For more information on MAXQDA 12 please see section 4.8.4 (Software)

sample transcripts accepted for further analysis were grouped under the clinical and non-clinical headings respectively. Each quote was reviewed several times and further codes were highlighted with comments once they were grouped under the headings. MAXQDA 12 word finding was used to put these other inductive/structural codes such as “transcription” or “data entry”, for example, into new code groupings with theme summary statements at the beginning of each group of quotes.

Once the groupings were finished the quotes were further organized under the person (patient, user, staff), information and information system triad. These steps made the volume of interview data easier to manage and analyze. The codes and themes were then grouped in a word document by interviewee type³⁶, clinical or non-clinical, and grouped in the Chapter Five format. The Chapter Five findings were finally grouped as a series of tables (Tables 18 to 24) to summarize findings and aid the Chapter Six discussion of key points in Chapter Five.

4.3.7 Is there a Theory?

The coding, pattern coding and identification of themes fits well in Miles’ and Huberman’s Ladder of Analytical Abstraction which is an structured way for organizing the data analysis for this research (Miles & Huberman, 1992 p. 92 Figure 5.1). In the full Grounded Theory approach a theory should emerges from the data, ideally, if there has been full theoretical sampling to saturation.

Borycki et al. (2012 p. 97) provide the definition of theory: “a theory can be defined as an idea or system of ideas that can be used to explain behaviours”. “A theory consists of: 1) a set of concepts and 2) a set of propositions” (Borycki et al., 2012 p. 97). “In order for a theory to exist, it must state a relationship between the concepts in the form of propositions” that are “tested”, for example, against the data (Borycki et al., 2012 p. 97)³⁷. The Grounded Theory analytic approach of this research was designed to analyze interview data but *not* to develop a new theory tested with member checking because developing a theory would have required full application of the complete Grounded Theory methodology. This research did not use the full

³⁶ Note: the informants are labelled as RESP for each quote for the MAXQDA 12 software.

³⁷ If this research were to develop an IT theory de novo it would need to consider the seven step process developed and suggested by Gray and Sockolow (2016 p. 3-5).

Grounded Theory, only the analytic approach of comparison and contrast.

Types of Information System Theories or Models-Analytic Theory Type fits Best

Gregor (2006 p. 614) provides some practical approaches to theory that have a broad definition useful for this research including “what might be termed elsewhere conjectures, models, *frameworks*, or body of knowledge”. The term “framework³⁸” fits for the discussion and will be used to organize the semi structured interview results in the Chapter Six discussion.

Gregor (2006 p. 614) provides five types of information system theory to answer the question “what is the theory for?” Four of these theories (two to five) involve prediction or causation. The first theory, theory or framework for analysing, describes phenomena of interest without prediction or causation intent, as is the case for this research as highlighted with the grey row in Table 5.

Table 5³⁹ lists Gregor’s five theories.

³⁸ The term framework has been used in this dissertation as a more neutral term than model or theory development that was not the intent of this research. The term theory is used here to keep Gregor’s terminology.

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Table 5: Taxonomy of Theory Types

Taxonomy of the five Theory Types in Information Systems Research	
Theory type	Distinguishing Attributes
1. Analysis	Says what is. The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made. Basis for the other theories.
2. Explanation	Says what is, how, why, when, and where. The theory provides explanations but does not aim to predict with any precision. There are no testable propositions.
3. Prediction	Says what is and what will be. The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations
4. Explanation and Prediction	Says what is, how, why, when, where, and what will be. Provides predictions and has both testable propositions and causal explanations.
5. Design and Action	Says how to do something. The theory gives explicit prescriptions {e.g., methods, techniques, principles of form and function) for constructing an artifact.

Note: from Gregor (2006), Table 2.

Gregor (2006 p. 615) notes that there needs to be theory criteria for each theory type. Gregor’s basic Structural Theory components are listed in Table 6⁴⁰. Table 6 will be used again in [Appendix I](#) when discussing framework adoption in more detail.

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Table 6: Structural Components of Theory

Structural Components of Theory	
Theory Component (Components Common to All Five Theory Types)	Definition
Means of representation	The theory must be represented physically in some way: in words, mathematical terms, symbolic logic, diagrams, tables or graphically. Additional aids for representation could include pictures, models, or prototype systems.
Constructs	These refer to the phenomena of interest in the theory (Dubin's "units"). All of the primary constructs in the theory should be well defined. Many different types of constructs are possible: for example, observational (real) terms, theoretical (nominal) terms and collective terms.*
Statements of relationship	These show relationships among the constructs. Again, these may be of many types: associative, compositional, unidirectional, bidirectional, conditional, or causal. The nature of the relationship specified depends on the purpose of the theory. Very simple relationships can be specified: for example, "x is a member of class A."
Scope	The scope is specified by the degree of generality of the statements of relationships (signified by modal qualifiers such as "some," "many," "all," and "never") and statements of boundaries showing the limits of generalizations.
Causal explanations	The theory gives statements of relationships among phenomena that show causal reasoning (not covering law or probabilistic reasoning alone).
Testable propositions	Statements of relationships between constructs are stated in such a form that they can be tested empirically.
Prescriptive statements	Statements in the theory specify how people can accomplish something in practice (e.g., construct an artifact or develop a strategy).

Note: from Gregor (2006), Table 3.

4.4 Analytic Method: Memos, Reflexivity, Member Checking, Validity & Reliability

This section describes practices common to most qualitative research explaining the involvement of the researcher in the data collection and analysis with memos and reflexivity. It ends with a discussion of reliability and validity in qualitative research and an assessment of this research project validity.

4.4.1 Memos

Memos are researcher-based text, tables or diagrams created by the researcher's ideas or thoughts about the textual data or themes and are referenced to the text or theme (Charmaz & Belgrave, 2012 p. 357, 358). There are memos for: "open data exploration, developing the dimensions concepts/categories and properties, making comparisons and asking questions, identify gaps for theoretical sampling, elaborating the paradigm between conditions, actions, interactions, and consequences, developing the story line" (Corbin & Strauss, 2008 p. 118). They allow the researcher to get control of the data early so the data is not "overwhelming" (Charmaz & Belgrave, 2012 p. 357).

The researcher used memos to organize work or make short comments on text data comments but not develop theory. Please see [Appendix E](#) for some memo examples.

4.4.2 Reflexivity

The researcher has several roles in qualitative research including:

- Making assumptions "a priori" about data collection (Murphy et al., 1998 p. 188).
- Interpreting data (Stake, 1995 p. 41) as filtered through the researcher's "subjective judgement", training and bias (Tong et al., 2007 p. 351).

Walsham (1995 p. 77) notes that the outside observer has some advantages: "the researcher does not have a "personal stake" in the research results with the expectation that interviewees may be more "frank" in the interview provided there is trust in the interview but the "disadvantage" is that the researcher may not have access to "confidential" documents". This is not an issue in this research because organization documents will not be used.

The researcher was actively involved in the research process: it is the awareness and description

of that involvement in the processes of developing “methodological coherence”, choosing an “appropriate sample”, “collecting and analysing the data concurrently” and “thinking theoretically” or reconfiguring data as “new ideas” that helps ensure validity and reliability⁴¹ (Morse et al., 2002 p. 18).

The researcher’s medical background meant that the interviewees did not need to provide lengthy explanation of technicalities. The reflexivity examples in the [Appendix D](#) show how a mutual knowledge base between the researcher and interviewees created rapport in the interview.

4.4.3 Member Checking

Member checking is a form of triangulation where study participants are asked to review rough drafts or conclusions where their information or quotes are used to ensure that the researcher has interpreted the interview data as the participant intended, that is, the researcher used the same meaning to create the theme the interviewee intended (Bernard & Ryan, 2010 p. 72; Stake, 1996 p. 115). This improves “validity” and trust between the interviewee and the researcher (Kaiser, 2012 p. 463).

The risk of member checking is that the study participants may change their minds. One solution (if this happens) is to present and discuss the changes and have the reader decide: these changes or negative findings are more important for understanding the case than improving “validity” (Maxwell, 2005 p. 111; Murphy et al., 1998 p. 182). Another risk is that the study participants may not “recognize” their own data to check it once their text has been coded and analysed especially if the researcher has derived new themes (Morse et al., 2002 p. 16; Ryan & Bernard, 2003 p. 104). A potential risk to the researcher is that the researcher is giving control of the data to the study subject if the study subject wishes to strengthen confidentiality (Kaiser, 2012 p. 461). Mason (2002 p. 193 194) makes the important point that member checking is not a “quick-fix to the problem of interpretive validity” unless both the researcher and the interviewees are proven to have “epistemological privilege”. This privilege is assumed with the collection of the interviewees’ demographic data but not verified or examined further.

⁴¹ Morse et al. (2002 p. 18).also mention “theory development” as a strategy but theory development was not the purpose of the Grounded Theory analytic approach in this dissertation so has been added as a process step.

All of the interviewees agreed to be contacted after the interview for member checking but none was contacted for clarification as the transcripts were clear. This research did use member checking to confirm the researcher's understanding of the research findings based on the interview analysis but not to develop a theory.

4.4.4 Validity and Reliability

It is just as important to have valid and reliable results for a qualitative study as it is for a quantitative study. Reliability means that the “researcher’s approach result is consistent” and reproducible while validity means the result is accurate, “the truth” (Creswell, 2009 p. 190). Reliability and validity are most assured when: there is “coherence” among the conceptual framework, “research question”, “data and analysis”; the study participants are knowledgeable about the subject including the “negative” aspects; “data collection” and analysis happen concurrently; “thinking theoretically” or reconfiguring data as “new ideas” and, finally, developing “theory” from the data, (if there is theory development) (Morse et al, 2002 p. 18).

Grounded Theory Terms may be Different

Corbin and Strauss confirm Creswell’s description of qualitative validity and reliability but go further in saying that these terms do not fit Grounded Theory because other theories can be derived from the (same) data (Corbin & Strauss, 2008 p. 301, 302). Corbin and Strauss prefer terms such as “credible” (which is increased if there is more than one comparison group as there is in this research), believable, and trustworthy. Credibility can be increased by an awareness of the Grounded Theory process as noted in the four “tests” below (Bazeley, 2013 p. 405-409):

- “Validating the findings with member checking” as described above in 4.4.3 (Member Checking). This research did do member checking (see section 6.4.1).
- “Having a clear description of the Grounded Theory method”. This research has Chapter Four with a description of the method in section 4.3 (Analytic Method) (and [Appendix C, D, E, H](#)) and Chapter Five, the results from that method.
- “Contrary information and variation are part of the analysis”. This research has Chapter Five interview analysis with contrary and different interview opinions.

- “The relationship of the concepts and theory “makes sense” and is logical”. This research has a coherent relationship of the ontology, epistemology and paradigm in section 4.2.2 (Qualitative Method) validating the use of the Grounded Theory method for analysis. This research then used the SEIPS Model (described in Chapter Six section 6.2.3)) as a good fit to provide context for the research results because it is based on similar health care settings.

Credibility is similar to construct validity that depends on the degree to which the interview captures concepts or how closely the interpretation of the study subjects matches the intent of the researcher or how believable the study subjects are (Meyer, 2001 p. 345; Runeson & Höst, 2009 p. 153).

Validity and Reliability

Validity and reliability are quality assurance tests applied to data and results under the assumption that if the research is internally sound then the results can be applied more widely to similar settings. Quantitative research does have criteria such as internal and external validity and reliability. This is not so clear for qualitative research.

Qualitative research does not have guidelines or evaluation criteria for validation that are generally accepted and/or widely used. The issue of validation in qualitative research is rather “ambiguous and contentious” (Venkatesh et al., 2013 p. 33), however, there is agreement that there needs to be some criteria for qualitative research. Venkatesh et al. (2013 p. 33 Table 4) provide a good overview and framework to follow for this research. Table 25 in section 6.4 (Limitations) show the completed research process meets the reliability and validity criteria as defined by Venkatesh et al. (2013 p. 33 Table 4).

Validity, in the context of a qualitative study, is defined as the extent to which “data are plausible, credible, and trustworthy, and thus can be defended when challenged” (Venkatesh et al., 2013 p. 34). Reliability is “consistency and dependability of data and analysis” (Venkatesh et al., 2013 p. 34). Reliability is a necessary step to establish validity (Venkatesh et al., 2013 p. 34).

Triangulation

This is a “validation” technique to support “interpretation” leading to research findings (Malterud, 2001 p. 399; Stake, 1995 p. 114). This research used the findings from the literature review in Chapter Six as a triangulation technique for some of the major themes. The semi structured interviews from the two units of analysis, clinical and non-clinical interviewees, in this research is an example of data triangulation because interviewing individuals with different roles in the organizations is also triangulation (Orlikowski, 1993 p. 315).

4.5 Data Collection Introduction

4.5.1 Types of Data Collection

There are several types of data collection tools for qualitative research: 1) primary or direct collection of data via s interview or observations, 2) secondary data using indirect collection via others or video and 3) tertiary collection using knowledge sources from the publicly-available literature and documents, as needed (Runeson & Höst, 2009 p. 144 145; Verschuren & Doorewaard, 2010 p. 220 section 7.3, 231). This research used primary direct collection of interview data because the intent of the research was to get the interviewees' "behavioural" understandings and interpretations of the problem (Verschuren & Doorewaard, 2010 p. 232) rather than using direct observation in an acute care setting. This approach would have narrowed the scope and restricted the validity and reliability to one site rather than the Canadian setting generally. . This research did use tertiary data in Chapter Six, Discussion and Conclusions to explore some of the key research findings.

4.5.2 Ethics Approval

The research received University of Victoria ethics certificate of approval number 13-524 on January 7, 2014: this approval was renewed twice. There was one request for modification because the original scope of interviewee and questioning was too restrictive with no interviewee recruitment at the beginning (please see Appendix C, Sample Recruitment). The approved Request for Modification broadened the selection criteria so that the final sample size reached twenty over a period of twelve months from the end of August 2014 to July 2015. All semi structured interviews were conducted within the ethics approval time period with informed consent. Table 7 summarizes the ethics certificate steps. The ethics approval form is in Appendix A.

Table 7: Table of Ethics Certificates

Certificate of Approval Number	Issue Date	Comment
13-524	January 6, 2014 to January 5, 2015	
13-524 Request for Modification	August 7, 2014	Rationale: original sampling criteria too restrictive Redo the invitation email and initial questions 1 and 2
13-524 Ethics renewal	January 5, 2015 to January 5, 2016	Renewed for another year until January 5, 2017 until dissertation complete Renewed until January 5, 2018

4.5.3 Consent

The evolving nature of the Grounded Theory analytic method data collection means that interview questions may not be the same because of the “vagueness and ambiguity” of qualitative research (Marzano, 2012 p. 446), however, the scope as bound by the time, place, and person criteria will not change because the interviews were a “snapshot” in time and place Flick (2014 ch. 9 p. 126). This was the case for this research.

Please see [Appendix F](#) for a copy of the consent form and its list of questions sent to each interviewee before the interview.

4.5.4 Confidentiality

The small sample size in each of the interview groups means that there is a likelihood that either the individuals or their occupational groups might be recognized in publications (Kaiser, 2012 p. 458). All identifiers were removed at the transcription phase.

4.6 Participant Recruitment & Data Collection

This section provides details about participant recruitment and data collection.

4.6.1 Participant Recruitment

Multiple participants are important because they can validate findings, and provide “multiple perspectives from people in different roles” of the research question to improve “internal” and “external” “validity” (Ash & Guappone, 2007 p. S 37; Bygstad & Munkvold, 2011 p. 41; Wagner et al., 2010 p. 611). This was the case for this research’s interviewees as will be seen in the analysis in Chapter Five.

Sampling Method

This research used purposive sampling of interviewees to get the best understanding possible about the five key research areas. The individuals being interviewed, the interviewees, were considered key informants because they were selected on the basis of their expertise (provided they were willing to be interviewed) (Wagner et al., 2010 p. 585). It is important to sample “outliers” or individuals who are critical or sceptical of the process (Ash & Guappone, 2007 p. S 37). This research did not actively recruit contrary interviewees because they were not easily identifiable in the sample selection. Contrary opinions of interviewees were detected in the analysis.

Snowball sampling was used to initially recruit interviewees to ensure sufficient data for analysis. Participant recruitment is described in detail in Appendix C.

Sample Criteria

Research needs to be bound by time, place, and person to focus the data gathering and analysis (Creswell, 2009 p. 178; Crowe et al., 2011 p. 5).

- Time. Ideally, the acute care information system experience for the interviewees should have been about systems implemented within the last 10 years so that the data collection is about recent systems.
- Place. The interviews were limited to interviewees with Canadian healthcare experience.

The interviews took place by phone using 2 Sony audio recorders recording from a speaker phone. The audio recording from one recorder was downloaded into Sony Sound Organizer on a password-protected laptop. The other recorder was a backup and one interview replaced the one before it on this recorder. All data were collected, analysed and stored in Victoria BC Canada.

- People. Twenty individuals were interviewed.

Inclusion Criteria

- experience with information systems and/or patient safety as broadly defined
- are (or have) worked on a regional, provincial or federal health-related project that has implemented information systems.
- English speaking

Data Saturation

At some point there would be sufficient data to end data collection because new data does not add new insight and all available leads have been followed up. This is called data saturation (Eisenhardt, 1989 p. 545; Runeson & Höst, 2009 p. 147). However, given the “small” sample size of many research studies, the point of saturation is rarely reached (Pan & Tan, 2011 p. 169). This may be the case with this research with its sample of 20 interviewees. As explained above in the Participant Recruitment section 4.6.1 it was very difficult to get a sample of 20 given the sensitive topic that people would be discussing about for their own organizations. This research came very close to full saturation but there was one new code late in the interviews (interviewee 16) so it could not be guaranteed that full saturation was reached (please see section 6.4.1).

4.6.2 Primary Data Collection: Phone Interview

The phone interview was the data collection method central to this research because it was a good way to understand “real world” experience and “interpretation” about information quality directly from the interviewees who were dispersed over different time zones (Murphy et al., 1998 p. 200; Walsham, 1995 p. 78).

Sturges and Hanrahan (2004 p. 108) explain that there is no “significant” transcript difference between telephone and face-to-face interviews. Both Musselwhite et al. (2007 p. 1065) and Smith (2005 p. 32, 33) outline the benefits of phone interviews. They are economical, reduce response bias associated with a face-to-face interviews, anonymous, save time, improve data

collection with less intrusive recording, and allow one to interview individuals from different regions and time zones. This research used telephone interviews instead of face-to-face interviews because the interviewees were across Canada in four provinces and four time zones. Using face-to-face interviews for some interviewees and not others would have biased the interview data because data collection would not have been standardized for the entire sample.

This research followed guidelines to improve telephone data collection (Musselwhite et al. (2007 p. 1069 Table 1). According to Smith (2005 p. 35, 36) this includes: booking an interview time in advance; using a landline with a speaker phone in a private place for improved recording and security; checking that time is convenient for interviewee; reviewing the interview scope; advising that the interview is being recorded; and, asking about the potential to review findings with interviewees (this took place using member checking) .

Pilot Study

The interview questions were piloted with two health informatics professionals and a mock interview test recording was done with the supervisor to ensure the interview was clear for the transcriptionist. This test interview was sent to the transcriptionist by Dropbox™, the tool the transcriptionist uses to retrieve interviews. The supervisor also checked the initial descriptive coding for part of one interview to ensure consistency.

4.7 Interviews

This section of the dissertation provides the semi structured interview questions that the twenty interviewees were asked. These questions, based on the literature review in Chapter Two and the research questions in Chapter Three, were designed to get insight from participants about what they think about information quality in acute care in the context of information systems, risk and patient safety without ascribing causation.

The next section provides a complete list of the semi structured interview questions. Qualitative research permits flexibility in how the interview questions are used in the analysis provided: the scope as bound by time, place and person does not change (this was the case in this research because the interviews were a “snapshot” in time and place (Flick (2014 ch. 9 p. 126)).

The material content of the semi structured interview did not change, however, the questions did change to fit a more conversational format and flow with the interviewees. Additional questions arising during the interview were highlighted in a different colour than the interview question that was highlighted in yellow in the transcript. This is shown in Appendix H.

4.7.1 Semi Structured Interview Question Script

The following is the semi structured interview question script with an introductory section, Part I background information about the interviewees, and semi-structured interview question for the five key areas (Parts II to VI):

Is this a good time for you for an interview?

Is it OK if I record this conversation?

As this interview has semi-structured questions it could take anywhere from 30 minutes to an hour, how much of your time do we have available?

Do you have any questions before we begin?

Interview Questions - semi-structured interview format:

- PART I - Background information

1. You are being asked to participate in this study because you have experience with health information systems and/or patient safety and you are (or have) worked on a regional, provincial or federal health-related project that has implemented health information systems.
2. Which best describes your experience⁴²?
3. How many years' experience do you have with health information systems, risk management in health care or patient safety?
4. How would you describe your day to day work? Can you please provide a short description of what you do so I have an understanding?
5. Was it in the public sector or private sector or both? If both approximately how many years in each?
6. Do you work with information systems on a routine basis?
 - PART II - Information quality as a glue in the system
8. How would you describe information quality?
9. Are there specific terms that you would use to define good information quality? Or examples?
10. Are there specific terms that you would use to define poor information quality? Or examples?

For the purpose of this study information quality can be considered a measure of the value of health information in terms of: its accuracy, usefulness, timeliness, reliability, and certainty.

- PART III - Acute care is the context
11. How would you describe the acute care setting?
 12. Does the quality of information differ between acute care and other situations?
- PART IV - Health information system is the vehicle
13. Do you have some specific examples of how information systems have increased information quality in your organization?
 14. Do you have any examples of how information systems might have inadvertently decreased information quality in your organization?

⁴² This refers back to the statements in question 1

15. Are there any potential issues for you and your organization regarding information quality when implementing health information systems?
16. Technology-induced errors can be defined as being inadvertent errors that arise in the deployment of new health information technologies. They may arise from different points in the design of health information systems but typically don't manifest themselves until the system is in place and being used.
 1. Have you (or your organization) considered risk of technology-induced errors when implementing systems?
 2. Have you seen such errors? (if so please describe)
 3. Does your organization have strategies for mitigating the risk of such error (in order to ensure the quality of information and safety of patients when implementing healthcare systems)?

▪ PART V - Risk to describe information quality

17. Can you please explain how poor information quality could be a risk factor⁴³ for an adverse event⁴⁴?
18. Do you have direct experience with or know or have ideas about poor information quality as a risk factor for an adverse event?
19. How would you describe information quality's role? How was the risk mitigated? Or speculate if you don't have direct experience.
20. Does your organization have a strategy for ensuring the quality of information when implementing health information systems? (if so, please describe)

▪ PART VI - Patient safety provides models for information quality

21. How do you see health information systems affecting patient safety? Will health information systems improve patient safety and information quality? Please discuss.
22. Can poor information quality be a risk factor to patient safety?
23. Is it worth examining further? If so, how would you do this?

▪ PART VII - Member checking

24. Would you be agreeable to being contacted further for in case I need clarification at the data analysis stage and/or confirm findings?
25. If so, what would be the best way to contact you? Email? Telephone?

⁴³ This assumes the interviewee has an understanding of risk factor because of their experience in health care

⁴⁴ This assumes the interviewee has an understanding of and adverse event because of their experience in health care

▪ PART VIII – Closing

24. Do you have something further to add about information quality?

25. Is there someone you could recommend who might be interested in an interview for this research?

If so, could you please provide their Name, Organization, Position, E-Mail, Phone Number

4.7.2 Importance of the Interview Questions

Trede and Higgs (2009 p. 14-16) Flick (2014 p. 218, 219) explain how important these questions are and provide a good transition to the next Chapter, Chapter Five, Results, of the dissertation.

The interview questions provide a:

- Context of research topic: what has already been done on this topic. In this research: please see the Chapter Two literature review.
- Context for participants: questions are appropriate for the topic, but also sensitive to the participants, ethical and suit the purpose of the inquiry. In this research: the questions are appropriate for the interviewees because they are being asked about areas they have expertise in and this expertise is necessary for this research.
- Personal frame of reference: researchers should be aware of where they are coming from what they know and what assumptions shape their perspectives. In this research: the researcher is aware of reflexivity and its impact on the interview process as documented in [Appendix D](#).
- Theoretical framework sets the scope of the project, the current understanding and sets useful boundaries. In this research: Chapter One sets out the rationale for the research question and in Chapter Two, some of the concepts and theories in the literature review act as a prelude to the interview questions.
- Philosophical framework research paradigm and the type of knowledge that will be generated (please see section 4.2.2 (Qualitative Method) for the ontology, epistemology and paradigms). Defining what is accepted as knowledge is a core research activity; knowledge can provide a deeper understanding, cultural beliefs or insights. In this research: the interpretivist approach relying on social intent and the pragmatic hermeneutic tradition permits capturing the “common meanings and shared background practices of groups of people” (Trede & Higgs, 2009 p. 19). Defining knowledge will be

shown in the interviewees' interview analysis using a Grounded Theory analytic approach and summarised Chapter Six section 6.3.

- Value for research. In this research: we have seen this in the Chapter Two literature review section that each of the five key areas have knowledge gaps primarily because the literature review did not show real world experience in a Canadian setting⁴⁵. Therefore, they are worthy of a detailed qualitative analysis examining information quality in a Canadian setting.
- Breadth of questions: questions should be phrased in a way to enhance their appropriateness to chosen research goals, design strategy, and productiveness within the philosophical framework. Precise questions may have assumptions unknowingly imposed within them. In this research: although the interview questions were generated from the literature review and formed the basis of the a priori groups as broad “organizational categories” (Maxwell, 2005 p. 97), the a priori groups of these broad categories *did not* limit the analysis.

Now that there is a justification for the semi structured interview questions, the next section, 4.8, will describe how the interviewee's interview data were handled using data management before moving to Chapter Five, Results.

⁴⁵ Please see sections 2.3.2 (Information Quality), 2.4.3 (Summary), . 2.5.3 (Information System Elements and Characteristics for Safety), 2.6.2 (Assessing Risk), 2.6.4 (Classification of Adverse Events), 2.7.2 (Technology Induced Errors), 2.7.4 (Patient Safety Concepts and Frameworks).

4.8 Data Management

It is important to ensure the integrity of the research data so that it remains intact from the point of collection to the end of analysis. This includes all changes and manipulations to the data. Data collection includes the time and place for data collection including data security while data manipulation includes transcribing the data into a usable format for analysis.

4.8.1 Time

The semi structured interviews took place from August 28, 2014 to July 20, 2015 after ethics review and approval.

4.8.2 Place

. Contact was often over many months as both the researcher and the interviewees were working full time and it was often difficult to be at home on the one day every two weeks that were available for the researcher to interview. Several interviewees were in different time zones, and added to the complexity. After receiving an email from the interviewee that they wished to participate, the researcher sent each interviewee the consent form (please see Appendix F) and the semi structured interview questions as an email attachment so they could review the questions before the interview (if they wished).

All the semi structured interviews were recorded from the telephone dial-in to the conclusion at the researcher's personal residence using two Sony recorders [Sony IC Recorder MP3-.3.1.2] picking up the interviews from a land line speaker phone to the interviewee. At least one interviewee was on a cell phone, but many seemed to be in an office on a land line.

The researcher's computer was backed up nightly using Cobian⁴⁶ to an external storage device at the researcher's home: no cloud storage was used for this research. A thumb drive was used as an extra storage back up.

Each semi structured interview was noted on an Microsoft® Excel® "crosswalk" file with the interview identifier (RESP01), name, date, transcription checked, entered onto the Microsoft®

⁴⁶ For information on Cobian, please see the following link: <http://www.cobiansoft.com/cobianbackup.htm>

Excel® sheet for data entry, any referred names (other individuals referred as part of the snowball sample), initial coding.

4.8.3 Transcription

A University of Victoria colleague provided the name of a transcriptionist who has extensive transcription experience in academic settings. The transcriptionist signed the University of Victoria Confidentiality Agreement Undertaking prior to the transcribing. The transcriptionist agreed to provide what she called standard academic transcription that is word for word but not verbatim. The transcriptions included “ums”, and “ahs”, and repeated words. The transcriptionist checked for correct spelling and added time stamps when voices could not be understood. Please see [Appendix G](#) for a copy of the transcriptionist confidentiality undertaking form. [Appendix H](#) has an example of the initial transcript for one question.

The recording was downloaded from the Sony recorder to Sony Sound Organizer with a folder and date for each interviewee immediately after the semi structured interview. The recording was then dropped into the Dropbox™ software tool that the transcriptionist had set up in advance for this research. The transcriptionist had no difficulty collecting or hearing the recordings.

The transcriptionist sent back the transcript as an MS Word document as an email attachment with only a number (no names or identifiers were on the email or the attachment). The transcription was then checked and changed as needed using track changes against the recording and placed in its own folder with: the recording, the original transcription, the checked transcription with track changes and the checked transcription with initial coding entered as “THEMES.” Each semi structured interview was coded and themed as they were returned from the transcriptionist. All interviewee identifiers such as name were removed from the transcripts before analysis. As noted in sections 4.4.3 and 6.4.1 (Member Checking), the transcriptions were not member checked with the interviewee.

4.8.4 Software

Computer software has been developed that makes data management much easier with word counts, key word in context (KWIC), automated coding, memoing, coding of audio, audit log,

interviews, documents and literature. This research used MAXQDA 12⁴⁷ student version as it has all these features for a reasonable price⁴⁸. MAXQDA 12 has the advantage of not having an external server “internal database system” (Lewins & Silver, 2007 Appendix 3) for increased security. Computer software also provides a research audit trail (Corbin & Strauss, 2008 p. xi). Although MAXQDA 12 can be used for automatic coding, that was not the case here. Each transcript was coded manually so the researcher remained immersed in the interview data. [Appendix H](#) shows some MAXQDA 12 screenshots used in the analysis.

The MAXQDA 12 software required that the semi structured interview questions be entered onto a separate Microsoft® Excel® spread sheet with a row for each interviewee who were entered as (INF 01 etc.) and a column for each attribute or semi structured interview question. This provided a further check against the transcription and with the recording as needed. The transcripts were checked against the Microsoft® Excel® entries twice to ensure that the responses were complete for all the interviewees so this would not bias the data analysis between the early and late interviewees.

MAXQDA 12 generated the descriptive statistics tables of the interviewee variables or attributes such as years’ experience or work experience (please see section 5.2.1 (Demographic Characteristics)). The descriptive statistic tables are also provided at the beginning of some of the semi structured interviews in Chapter Five as “descriptive statistics”. Please see section 5.3.4 (Information Quality) for an example.

4.8.5 Data Retention and Destruction

All electronic and paper research data are being kept at a secure site at the researcher’s personal residence and will be destroyed securely at the end of the research period (5 years).

4.9 Summary

This chapter explains how the research questions are going to be used as a basis for the semi

⁴⁷ For more information on MAXQDA please see this link:
<http://www.surrey.ac.uk/sociology/research/researchcentres/caqdas/files/MAXQDA%2011-Distinguishing-Features.pdf>.

⁴⁸ The researcher took a 2-day course to learn the MAXQDA 12 software basics.

structured interview questions. The interviewees' responses to the semi structured interview question were analysed with a Grounded Theory analytic approach.

However, before this next step happened the research needed to have the following key points documented as was done in this Chapter:

- A rationale and justification for this method provided by the philosophical stance of the interpretivist approach to get an understanding of information quality and the hermeneutic philosophical tradition to get an understanding of the interviewee's understandings and interpretations about information quality.
- A Grounded Theory analytic approach is appropriate because elements of Grounded Theory will be used: a priori grouping based on the literature review five key areas of the semi structured interview questions and inductive/structural coding for analysis in Chapter Five.
- A clear description of the ethics approval process, recruitment and the interview process and how the resulting data is managed.

The next chapter, Chapter Five, Results, will be presented in the analysis of the interviewees' semi structured interview data. This will be done by presenting first, the interviewees' variables and characteristics as a series of tables, then, the qualitative analysis and interpretation of the interviewees' understandings and interpretations about the acute care sector, information quality (good and bad), information systems, adverse events and the wider health care setting (local and external).

Where possible, the semi structured interview data will be further organized by the triad of person (patient or information system user), the information, and the information system to organize the findings for analysis and discussion in the final chapter, Chapter Six.

Chapter 5: Results

5.1 Introduction

This chapter of the dissertation looks at the semi structured interview data provided by the twenty interviewees. The semi structured interview data is examined both quantitatively and qualitatively using a Grounded Theory analytic approach. There are two aspects of data analysis, first, a descriptive section about the interviewees and their interview (since not all interviewees answered every question), and then, an analysis of the interview content using a Grounded Theory analytic approach.

The semi-structured interview questions had two major sections:

- Part I that asked for background information about the interviewees such as experience and work environment. The MAXQDA 12 software used the Part I semi structured interview information to generate summary descriptive statistics on the interviewee demographics in section 5.3.12 (Tables 8 to 12), and the descriptions for each interviewee quote in the qualitative analysis in the rest of Chapter Five in section 5.3; and,
- Parts II (Information Quality), III (Acute Care), IV (Health Information System), V (Risk), and VI (Patient Safety) that were designed to tease out the interviewees' thoughts on each of the five key areas. The researcher's coding and analysis of these thoughts form the summary of coded questions in section 5.2, Descriptive Statistics (Table 13), and analysis in the rest of Chapter Five in section 5.3 (Qualitative Analysis).

5.2 Descriptive Statistics

The descriptive statistics tells us about the sample in order to assess if they possessed the characteristics to provide the depth of knowledge and experience to guide our understanding on the key topic areas each of which is each complex with their own knowledge gaps, and has a common thread or glue, i.e., information. The quantitative data is presented as a series of tables of frequency counts showing that the interviewees can provide key insights based on their years of experience in the health sector. The MAXQDA 12 software generated these tables.

5.2.1 Demographic Characteristics of Interviewees

The background set of semi structured interview questions, Part I questions two to six, was the source of the demographic and other variable information⁴⁹ that show the value and the credibility of the interviewees for this research. This research was interested not in the interviewees age and gender but only in their understandings and interpretations about the five key areas. In addition, information about age and gender could have made re-identification possible given the small sample size in a Canadian setting. This is an important privacy consideration.

Sector

This variable is about the sector, public or private, the interviewee currently works in. The private sector interviewees were either consultants to the public sector or are former public sector individuals who currently work in a non-publicly-funded health care field. Seventeen of twenty worked in the public sector, which is the sector of prime interest in Canadian acute care. Table 8 has the summary statistics for this variable.

Table 8: Interviewee Variable: Sector

Name	Frequency [# interviewees]	%
Public	17	85.00
Public & Private	3	15.00
Missing	0	0.00
Total	20	100.00

Work Environment

The public sector can be further divided into the federal, or provincial sectors. The provincial sectors can be either a provincial health authority or equivalent that provides patient care or a ministry with a funding or governance role. There were two federal interviewees and the rest were provincial with most of these in a health authority either providing direct care or close to care such as a supervisor / manager. Table 9 has the summary statistics for this variable.

⁴⁹ These variables are called attributes in MAXQDA 12.

Table 9: Interviewee Variable: Work Environment

Environment	Frequency [# interviewees]	%
Federal	2	10.00
Health authority	9	45.00
Ministry	6	30.00
Private	3	15.00
Missing	0	0.00
Total	20	100.00

Years' Work Experience

The group of interviewees is very experienced with 17/20 of them having more than ten years' work experience in the field. This implies a key depth of knowledge and insight needed for this research. Table 10 has the summary statistics for this variable.

Table 10: Interviewee Variable: Years' Work Experience

Years	Frequency [# interviewees]	%
<10	3	15.00
10-20	11	55.00
21-30	5	25.00
>30	1	5.00
Missing	0	0.00
Total	20	100.00

Experience

Although the interviewees were not asked specifically about their education, they were asked about their experience that could be considered a proxy for their education. "Clinical" means they have education and training in nursing, pharmacy or medical practice. If the clinical individuals are added up they make a total of ten which is the same as the non-clinical individuals. This provides a useful focus for comparison and contrast for analysis of each question in the next section of the dissertation. The "non-clinical" interviewees have experience and training in information systems. The MAXQDA 12 software can sort the coded interview data based on these two variables, clinical and non-clinical.

Table 11 has the summary statistics for this variable.

Table 11: Interviewee Variable: Experience-Clinical or Non-clinical

Work Experience	Frequency [# interviewees]	%
Clinical-nursing	6	30.00
Clinical-pharmacist	1	5.00
Clinical-physician	3	15.00
Non-clinical	10	50.00
Missing	0	0.00
Total	20	100.00

Work with Information Systems Routinely?

The interviewees were asked if they worked with information systems routinely to assess their current use of systems. Although eleven individuals did not routinely work with systems now, they did have a wealth of experience in the health care sector and they captured this experience.

Although many interviewees spoke of their current work situations, they also spoke of their past experiences with systems. The interviewees were not asked specifically about the age of the systems they worked with or were speaking about. This is not a serious issue for this research because the focus was on capturing the interviewee's understandings and interpretations about information quality in general within the Canadian acute health care context. Table 12 has the summary statistics for this variable.

Table 12: Interviewee Variable: Work with Systems Routinely?

Work with Systems?	Frequency [# interviewees]	%
No	11	55.00
Yes	9	45.00
Missing	0	0.00
Total	20	100.00

5.2.2 Interview Question Response Frequencies for Coded Questions

This section of the data analysis provides data about response frequencies for the non-variable/attribute questions i.e. the remaining questions that were coded (Parts II to VII). More specifically, it provides information about which questions were used for coding the interviewee answers and which ones were not. This will help inform later steps in the analysis. The researcher coded segments that were answered by more than five interviewees, an arbitrary volume of text data (where the coded segment descriptive statistics for the code segments showed this). This research is about what the interviewees thought about information quality generally so the opinions of most interviewees were used as a starting point, the comparison and contrast analysis revealed the nuances in the data. Chi (1997 p. 273) used this approach called “verbal analysis”.

As noted in the methodology chapter, Chapter Four, the five lenses or contexts formed the basis of the semi structured interview questions that in turn became the a priori groups listed in the Table 13 headings of information quality, acute care, information systems, risk and patient safety. These a priori groups created the initial organizing framework for the interview responses, for example: II Information Quality, III Acute Care, IV Information System, V Risk, VI Patient Safety. There were a total of 1336 interview text segments coded in the analysis.

The table of interviewee question response frequencies for all questions is on the next page on Table 13.

The following points clarify the layout of Table 13:

The respective Column numbers are noted in bold at the bottom of the table.

Column 1:

- INF 01 means the first person interviewed up to INF 20. Each Interviewee is on a separate row.
- Question # INT/Q is the number of people who answered a question (Q), for example 20/20 answered question 1, 4/20 answered question 2 , 18/20, question 3 and so on for number of people who answered the question shown in the row.

- # INT/ Q provides data on how many questions were answered (or not) by all the interviewees (looking at the columns for a given question) and consequently how much interview data was available for coding and analysis (Chi, 1997).

Column 2:

- This is the total time for each interview as measured on the tape recorder. The mean time for all the interviews is shown in the bottom row of the table.

Columns 3 to 19:

- The original set of semi structured interview questions had 24 questions spread over Parts I to VII. Table 13 counts the interview question sequentially starting with Part II (Information Quality) to Part VI (Patient Safety) and Q 17 (More to add?) because Part I contained the attributes/variables (used to generate the Descriptive Statistics in section 5.2) and was not coded.
- Not all interviewees answered all questions, for example, Interviewees 11 or 20. There are more unanswered questions towards the end of the interview (the later columns). The unanswered questions earlier could be because the question was not asked (question 11) or was merged in the conversation, for example question 1 and 2. This is discussed further in the limitations section at the end of the dissertation .
- Note: the “more to add” question codes were incorporated in the codes under the other questions as the topic fit within a given that question and its set of codes. The “more to add” was an open question at the end of the interview question sequence.

Column 20:

- This is the number of questions a given interviewee answered, for example, Interviewee 1 (INT 1) answered 12/17 questions, Interviewee 2 (INT 2), 13/17, Interviewee 3 (INT 3), 10/17 and so on for the number of people who answered a question (or not). It is shown as # Q / INT.
- This gives data about how many questions a given interviewee answered (or not) (looking across the row for an interviewee) and consequently how much interview data was available for coding (Chi, 1997 p. 273).

Table 13: Interviewee Question Response Frequencies for Coded Questions

Interviewee	time h:m	II. Information Quality			III. Acute Care		IV. Information System				V. Risk				VI. Patient Safety			More to add?	# Q/INT
		Q.01	Q.02	Q.03	Q.04	Q.05	Q.06	Q.07	Q.08	Q.09	Q.10	Q.11	Q.12	Q.13	Q.14	Q.15	Q.16	Q.17	
INT 01	1:39:43	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	12
INT 02	1:09:17	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	0	1	13
INT 03	0:50:21	1	0	1	1	1	1	0	1	1	1	0	0	0	1	0	0	1	10
INT 04	1:09:44	1	0	1	1	1	1	0	1	1	1	0	1	0	1	0	0	1	11
INT 05	1:12:46	1	0	1	1	0	1	1	1	0	1	0	0	1	1	0	0	0	9
INT 06	0:36:23	1	0	1	1	1	1	0	1	0	1	0	0	0	1	0	0	0	8
INT 07	1:14:54	1	0	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	10
INT 08	0:57:22	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	8
INT 09	0:36:09	1	1	1	1	1	1	0	0	0	1	0	0	1	1	0	0	0	9
INT 10	0:54:11	1	1	1	1	1	1	0	1	0	1	0	0	0	1	0	0	0	9
INT 11	0:59:29	1	0	0	1	0	1	0	1	1	1	0	0	1	0	0	0	0	7
INT 12	0:58:53 0:50:18	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	10
INT 13	0:32:18	1	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	7
INT 14	0:52:17	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	10
INT 15	0:34:19	1	0	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	11
INT 16	1:01:32	1	0	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	11
INT 17	1:03:33	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	10
INT 18	0:39:01	1	0	1	1	0	1	1	1	1	1	0	0	0	1	0	0	0	9
INT 19	1:18:37	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	10
INT 20	1:07	1	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	7
# INT/Q		20	4	18	20	14	20	14	17	14	20	0	4	6	5	0	1	4	
Column: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total interview time=15.6636 h/20 interviewees=0.78318 minutes mean interview time per interviewee																			

Some comments on Table 13 above:

interviewee

Interview time (from the audio recording time) (Column 2)

- One interviewee, 12, was interviewed over two sessions because of running out of time about half way through the interview and the interviewee wished to continue.
- The average time for each interview was seventy-eight minutes.

Interview Question Response Rate (Column 20):

- Looking across the rows: fifteen interviewees answered more than 50% of the questions⁵⁰. The lowest percentage of question responses were interviewees 11 and 20 [7/17 questions each].
- High question response rate [11/17 questions] for interviewee and a short time [0:34 minutes] such as Inf 15 suggests not much of a detailed response for each question.
- Lower question response rate [7/17 questions] for an interviewee and a longer than average time [1.07 h] suggests more detail per question e.g. Inf 20.
- High response rate [12/17 questions] and lengthy time [1 h 39 minutes] suggests more detail for more questions e.g. Inf 01.

⁵⁰ These were interviewees 01, 02, 03, 04, 05, 07, 09, 10, 12, 14, 15, 16, 17, 18, 19. There were two clinical [06 and 20] and three non-clinical [09, 11, 13] interviewees with lower response rates. This did not affect the analysis because every interviewee's interview data was analyzed.

Interview Questions: What did the Interviewees Say?

Code Frequencies

As noted earlier in the literature review, five key areas were used as a priori groups for the semi structured interview questions: Table 13 on the previous page has summary information about which questions were answered by which interviewees. Questions one and three generated many descriptive sub codes from the separate terms the interviewees used. Separate code frequencies were created for these structural descriptive sub codes. Questions one and three will be analyzed in some detail to show how key concepts from the interviewees formed the basis of the rest of the analysis. Other inductive codes were added as the semi structured interviews were analyzed; these codes were also used for analysis.

5.3 Qualitative Analysis

5.3.1 Introduction

The a priori groups and the inductive descriptive codes from the interviewees' semi structured interviews provide a wealth of material for examining information quality and information systems in more detail. The interviewees demonstrated through the use of their coded terms that the acute care setting is complex and changing; information quality may be poor because of unstable missing or unstructured data and information systems may also be unstable because they are a hybrid blend of different systems. The frontline staff in acute care, (i.e. the users), are also a factor for this destabilization because the front line staff are autonomous individuals. There are also external factors such as local entities such as health authorities, vendors and ministries influencing information and the information system.

The analysis in this Chapter will be summarized in a series of tables (Tables 17 to 23) at the end of this Chapter. These Tables will then be applied to a framework, followed by further discussion about how the findings from the interviewees relate to the five key areas in the literature review in the following chapter, (i.e. Chapter Six).

The Chapter Five qualitative analysis will be organized under these seven headings as follows:

- The acute care setting as the context⁵¹. This sets out the triad of the people (the patient and staff users), the information and the information system.
- Information quality. This key question sets out the information purpose (to make a care decision) and the ideal information qualities of accuracy and completeness.
- Information instability and some remedies.
- Information system instability and some remedies.
- Unstable information system effects in pharmacy, laboratory and radiology-imaging.
- The users, physicians and nurses.
- External factors, local entity such as a health authority, vendors and ministry.

The interviewees' quantitative and qualitative data within each of the seven headings will be

⁵¹ Acute Care Setting is Part III in the semi structured interview script but is presented in the Chapter Five qualitative analysis earlier because it is the setting for the decision making process.

organized for analysis in this Chapter in the following way:

- The quantitative component, the Descriptive Statistics, will be presented after the introduction to a section. The Descriptive Statistics give a picture of how many interviewees answered a question or provided a descriptive code or terms within a question and if there were any patterns such as one interviewee providing most of the responses or a group such as mostly nurses or mostly non-clinical or a balance of clinical and non-clinical interviewees responding. The Descriptive Statistics gives an idea of the breadth and volume of data for analysis. The MAXQDA 12 creates these summary statistics.
- The qualitative component, called the “Qualitative Understanding from the Interviewees”, organize and analyze the interview terms or codes used by the interviewees.
- The basic structure for the analysis of the interviewee’s understandings and interpretations was grouped under the major organizing *headings* (used as needed depending on the responses) with underlined italics shown as follows: *Person* (this could be a *Patient*, *Staff* or information system *User*), *Information*, and *Information System*. The purpose of these headings was to organize the responses into manageable chunks for further analysis both within and across the clinical and non-clinical groups of interviewees and not to establish a hierarchy. Tables 17 to 23 show how the data was grouped under the respective headings to simplify analysis.
- It should be noted that the organizing heading, *Information System*, does not refer to any particular system such as an electronic health record or a pharmacy system etc. but any system the user interacts with for patient care in the acute care setting. The system could be paper or electronic. If an interviewee mentioned a particular system then the particular term was kept for the analysis.
- The interviewees’ relevant variables such as their profession and years’ of experience and interview data are shown with indented quotes at the beginning of each quote and the paragraph number from the MAXQDA 12 software copy of the transcript at the end of each quote in square brackets. The interviewee’s relevant variables and quotes let the interviewee’s personality and knowledge show through.

- Themes were then grouped and discussed under each of the *headings* and labelled as “Theme:”. The code terms were underlined at the first instance in each interviewee statement.
- There is a short summary section. Each section e.g. 5.3.2 etc. begins on a new page.

To begin with, there needs to be clarification about the use of the terms “data” or “information”.

5.3.2 Information versus Data

A number of the participants raised the issue of what constitutes information versus data.

Descriptive Statistics

The terms “information” and/or “data” were coded thirty-six times for 11/20 interviewees : 2/6 nurses, 7/10 non-clinical, 2/3 physicians showing that the non-clinical interviewees used this term more often than the clinical, although a physician, interviewee sixteen, used the terms often. Interviewee sixteen used these terms eleven times, interviewee twelve, seven times, interviewee twenty, four times, interviewees eight and thirteen, three times and the rest once or twice.

Qualitative Understanding from the Interviewees

It is common in the information systems literature to make a distinction, in order of increasing abstraction, from data to information to knowledge. Interviewee twelve makes this distinction and goes on to state that data is needed at the right time and that it reflects the right flow of information as illustrated in the quote below:

Int 12 non-clinical 10-20 years' experience health authority: We all know data, information, knowledge. When we have the raw data and the information, we want to make sure that it's put in at the right time and that it's a reflection of the flow or the information being captured at the time, it's in the right field so that after that it can be used to make decision from each of the spectrum, for patient care and for improving the patient care, kind of like the end of it. That's what it means to me right now [para. 3]

Data might be raw numbers, but if a care provider makes a decision based on those raw numbers then those numbers are useful and become information. This idea regarding the usefulness of data is reflected in the two quotes below:

Int 02 non-clinical 21-30 years' experience public & private: Being available is important and it has to be readable and it has to be information and not just raw data. So it has to be useful [para. 1]

Int 09 non-clinical 10-20 years' experience public and private: I think

another big thing was information quality opposed to data quality. I've had this debate a lot of implementations, data quality versus implementation quality. Data is making sure that you've got the right kind of data in there; the drop down, the content is correct of drop down lists or whatever. Whereas information is more, can the user interpret all of this data, and is it useful to a user? [para. 2]

Accuracy of raw data also arose as a point of discussion. The raw data must be an accurate reflection of the patient's state. The physician can use the data to make a decision because the data is trustworthy. The implication is that any information arising out of that data is also trustworthy. This is reflected in the quotes below:

Int 16 physician 10-20 years' experience health authority: When I said the data needs to be viewable, it means that I should be able to look at a patient's chart, electronic or paper, and be able to see what I need to see quickly and efficiently. That data ... I need to know that that data is accurate, that it reflects the patient system [para. 6]

Int 16 physician 10-20 years' experience health authority: Yeah, so the information has to be available. It has to be useful. It has to be rapidly accessible and accurate. We have to know that the data, that we can trust [para. 1]

Summary

As can be seen from the quotes, physicians and non-clinical interviewees mentioned data, information and knowledge categories with useful data becoming information. The qualitative analysis will not make a distinction between data and information because of the decision-making purpose, *the use*, of both the data and information by the interviewees was essentially the same. Bryant (2002 p. 37) provides the convincing rationale for this interpretation in section 2.3.2 (Information Quality).

5.3.3 The Acute Care Context

Introduction

Question four captures the day to day work setting of most of the interviewees, both clinical and non-clinical, since we have seen earlier in the descriptive statistics that they work either in the public sector or private sector as consultants to the public sector. The acute care sector has high information demands because of the patient's clinical state (acuity) and the many specialized staff providing care to the patient and family. Acute care include the terms "acute care", "emergency (ER)", "ICU", "critical care", "hospital" .

Question four is asking about the interviewees understanding of acute care and what it means to them. This question will be discussed in some detail because it highlights some of the information and information system concepts that will appear later in the analysis.

Descriptive Statistics

This question was answered by all twenty interviewees , so there is sufficient interview data to examine. The term acute care was coded twenty times and both the clinical and non-clinical interviewees shared their extensive understanding of acute care as can be seen in the qualitative understanding below.

Qualitative Understanding from the Interviewees

This question sets out the health care triad mentioned above in section 5.3.1 bullets for organizing the results:

- People, the patient and staff-there may be information gaps because the patient is not able to provide the information.
- Patient information-high demands and the need for a stable patient identity.
- The information system-information must be available quickly.

The discussion of this question will follow the patient journey beginning with the admission and emergency.

Patient

Theme: There may be missing information at first

The patient may not be able to provide the information on admission so it is missing for this reason:

Int 12 non-clinical 10-20 years' experience health authority: our patients in principle are coming to us sicker, many not being able to give us the information. The information may be gathered from a family member, someone who brings the individual with us, like for example in the ER we'll have some John Doe, right? [para. 38]

Theme: The patient state is complex and changing with changing information

The information volume and flux increases the chance of error because the patient's clinical state is constantly changing at first. Patients may have several co morbidities each of which is examined and reviewed so creating more patient information from the specific diagnostic information for each body system involved:

Int 20 physician 10-20 years' experience health authority: The typical people presenting with acute care nowadays come with a high burden of disease. It's rare to come with a single health problem. You usually have a major health problem and 30 other health issues that influence the acute problem [para. 6]

Int 07 non-clinical 10-20 years' experience ministry: I think of the acute care setting as probably fairly dynamic so you know usually in acute care encounter begins as an emergent event um, you know which eventually stabilizes so the information is in constant flux during that time [para. 20]

Information

Theme: There are high information demands in acute care

Both the clinical and non-clinical interviewees mention that the acute care setting is an information-rich environment during emergencies where the patient is admitted and there are a large volume of patients:

Int 05 nurse 21-30 years' experience health authority: then volume

as well, especially where I work we have huge amounts of volume and we are in a constant flux to um, sort of balance efficiency and thoroughness right [para. 6]

Theme: There is a need for a stable patient identity

Ideally, the patient identifier information that is used to establish patient identity and create the patient profile for the admission is stable while other patient data such as monitoring or investigation data changes, but identifier stability may not always be the case and this could create problems downstream:

Int 07 non-clinical 10-20 years' experience ministry: ideally the patient identity information wouldn't change but the um, you know there is a lot of information coming from multiple sources you know you have nursing documentation and physician assistant documentation and allied health and diagnostic areas and it is really dynamic batch of information and I would say probably the high number of interaction between patient and care giver [para. 20]

Theme: There are many high demands on information quality at admission when there may be many unknowns and the patient is unstable:

Int 19 pharmacist 10-20 years' experience health authority: I think information quality is probably that much more important given they're in a potentially more delicate situation. Patients coming in to an emergency department in a trauma situation, it would be really important to have as much information quality as reasonable in that setting [para. 16]

Theme: Information overload, for example, elsewhere in the hospital such as an ICU that generates such large volumes of information that there could be information overload:

Int 18 physician 10-20 years' experience ministry: when we think about the volume of the information within a hospital, it's quite substantial, from critical care where you're capturing vital signs by the second, basically, to large pharmacy and large lab and the complexity is quite substantial within the acute setting para. 18]

Information System

There are information system demands in acute care that may be caused by a hybrid paper-electronic chart system working in parallel.

Paper Chart Hybrid System

Theme: The patient's information may be missing i.e. not available or readily accessible because it is in a paper chart in a hybrid system of paper and electronic records-this could affect care as these two quotes show:

Int 20 physician 10-20 years' experience health authority: the greater utility of electronic sources of health information on paper and archived. There's a delay to get that, to make quite a difference in the care that the patients receive, number one [para. 8]

Int 09 non-clinical 10-20 years' experience public and private: While they may be all sending information to a central point, like your health records, or health information management group, it's sent by paper, it's sent at different times, and it's not easily shared or accessible to other departments within the hospital. The challenge today, within maybe one way I describe the acute care setting, is it's hybrid. We are in a hybrid world today. We are in half of the clinicians use paper, half of them use a computer. Some information is registration and med orders, ... maybe those orders, electronic, but most of the documentation which follows the patient is done on paper. That complexity of that hybrid chart in a hybrid world makes it difficult, a tricky place for us to be in [para. 7-8]

Electronic Information System

Theme: Information volume for the complex patient who may have many monitoring devices attached, each generating its own volume of information about each monitored body system as shown in the following quote:

Int 16 physician 10-20 years' experience health authority: critical care is an environment where generally the sickest patients in the hospital reside. They usually require life support, both either mechanical life support, so breathing machines, dialysis machines, but also pharmacological support, with medications for their blood

pressure, for treating infections, for fluid management, and usually have a number of different invasive lines, such as measuring their blood pressure through a catheter in their artery, measuring pressures in their heart through a catheter that goes through one of the large veins in their neck or their collarbone [para. 14]

Staff Users

Theme: Multiple users accessing the system and adding their own data about the patient to the record as these two quotes show:

Int 20 physician 10-20 years' experience health authority: The health information needs health acute care generates a lot of health information. Just the particular acuity of disease, it takes collecting a lot of information. More providers tend to see people ... Within provider groups, it's not uncommon going from emergency to ward to ICU room, 20 different physicians and 60 different nurses, and 4 different respiratory therapists involved in your care [para. 7]

Int 12 non-clinical 10-20 years' experience health authority: It means you have to gather a large amount of information fairly quickly and hope that the accuracy of the information is security and the time like the quality of the data is high in a very, very short amount of time. Perhaps sometime information overload, which information do I use to make my decisions? Think of ICU for example. Think of an ICU perspective, so large amount of data that every day physician have to have and take in order to make decision in a very quick, timely manner. That's what it means to me [para. 39]

Theme: Patient's information is not available quickly so care providers order new tests and get more information adding to the information volume:

Int 02 non-clinical 21-30 years' experience public & private: in the emergency situation they need information that is um, reliable and it needs to be fast. And if they can't get it quickly they will just do their job without it regardless, they won't let it stop them. If they can't get the results ...they just run another one because it is faster than tracking down the previous results. There is a lot of um, of duplicates, and the duplicate tests if they can't get the results quickly [para. 12-3]

Theme: User demands: pressure and constraint in acute care. Many care providers with different expertise often working together under pressure and staff shortage (lack of capacity) constraint trying to access the patient information on systems at the same time to provide care. The interviewees mention there are limited resources of all types working under tight time constraints in emergency situations so they do not have the time to process information:

Int 05 nurse 21-30 years' experience health authority: I work in the emergency department it is very busy um, it is complex, there is a lot of inter – variables these different with regards to staff mix, physician mix, patient mix, so it is very complex um, and at the same time I think that it is also very constrained. I would say that there is a lot of constraints in the acute care system um, there is um, time there is never enough time to do what you need to do and there is always a lack of resources and funding and money. Um, there is a lack of staff seems to be ongoing problems and frontline staff in any area in acute care. Always trying to juggle frontline staff and the people who burden that are the frontline nurses and they are very much, the work doesn't stop and just because you don't have the staff the work doesn't change [para. 6]

Int 06 nurse >30 years' experience health authority: it is complex that is for sure because it is so multi-dimensional right it is um, it um, it is a constant hub of activity and every patient is critically ill um you are accessing data on that patient frequently and every computer at every bedside is open um, so you are constantly looking at medical imaging results and you are looking at lab results and you are maybe um, accessing information about an unusual illness that the patient may have or some complexity related to that illness so you know you are using um, that up-to-date and that information system that relate to education um, you are um, there are a number of individuals accessing the data, so there are physicians and there are pharmacists and there are nutritionists and there are social workers there are nurses there are physiotherapists um, there are respiratory therapists so there are a lot of people using the information systems at the same time [para. 21]

Here are a couple more quotes on the same theme of stressed staff not paying attention (there is a lack of staff capacity):

Int 20 physician 10-20 years' experience health authority: I think throughout Canada, there's an imbalance between demand and capacity to provide it. There's very little reserve and ability to provide that [para. 7]

Int 11 non-clinical <10 years' experience health authority: It needs to be truly accessed and it needs to be accurate and there's obviously going to be room for human error when using an information system. There are times where it's really busy and they just don't have the time to read through everything or there's a mistake in their reading or somebody input information incorrectly [para. 15]

Summary

There are several important themes that emerge from these quotes from the clinical and non-clinical interviewees:

- Acute care is complex with a large volume of information generated as the patient's state changes and as the patient is more intensively monitored.
- The patient's own information may be missing because the patient is unable to provide the information, some of it is buried in a paper chart or the patient identifier that is the starting point for the patient's record may be changed.
- There are heavy demands on the information system from data volume from monitoring devices, user test ordering and access.
- Many users working under pressure and stress are accessing the system maybe at the same time.
- All interviewees answered this questions so there was an equal balance of responses.

Now that the information setting is described, the next section will show how the interviewees describe information quality overall and then the information purpose of making a care decision and the information ideal state of accuracy and completeness.

5.3.4 Information Quality Overview

Introduction

Question one asks interviewees about how they describe information quality. There is a description of the overall statistics about how many times the interviewees used specific terms for the inductive subcodes. Some terms were used by more interviewees and these more common terms were used for further analysis.

Descriptive Statistics

This question was answered by all twenty interviewees, so there is sufficient interview data to examine.

The interviewees used many terms to describe information quality as seen in Table 14. As explained earlier in section 5.2.2 (Interview Question Response Frequencies), the descriptive statistics are not for content analysis but to estimate how much interview data was available for analysis (Chi, 1997). Therefore, the researcher focussed on the interview data volume from more than five interviewees:

Table 14: Frequency of Inductive Subcodes or Terms for Information Quality

Inductive Subcode Name	Frequency [# Interviewees]	Percentage
hand writing free text	17	85.00
standardized	15	75.00
accuracy	15	75.00
hybrid paper	12	60.00
make decision with it	10	50.00
timely	9	45.00
ease of access	8	40.00
complete	7	35.00
fit for use useful	7	35.00
PHN identifier	7	35.00
trust source	6	30.00
privacy	5	25.00
available	4	20.00
clarity	3	15.00
reliable	3	15.00
easy	2	10.00
safe	2	10.00
logical order	2	10.00
relevant	1	5.00
information	1	5.00
readable	1	5.00
changes	1	5.00
accountable responsible	1	5.00
self-directive	1	5.00
predictable	1	5.00
robust	1	5.00
certain	1	5.00
required	1	5.00
not open to interpretation	1	5.00
appropriateness	1	5.00
Missing	0	0.00
Total	20	100.00

The terms highlighted in **bold** will be used for further analysis because they were used by more than five interviewees so as to get representative terms for analysis: “hybrid hand writing free text”, “standardized”, “accuracy”, “hybrid paper”, “make decision with it”, “timely”, “ease of access”, “complete”, “fit for use/useful” and, “PHN identifier”.

The juxtaposition of “handwriting free text” or “standardization” as the two top-ranked terms

stood out as key organizing concepts with support from the other terms as will be seen below in section 5.3.7.

The table below, (see Table 15) takes question one codes and subcodes and analyzes them by clinical and non-clinical interviewees to see how the most frequent subcodes or terms are used by the two different groups at a high level.

Table 15: Q 01 Code and most frequent Subcodes of the Clinical and Non-Clinical Interviewees⁵²

Inductive Subcode Name	experience = clinical-nursing	experience = clinical-physician	experience = clinical-pharmacist	experience = non clinical-IT
Q.01. Glue description	100.00	100.00	100.00	100.00
hybrid hand writing free text	83.33	100.00	100.00	80.00
standardized	83.33	66.67	100.00	70.00
accuracy	50.00	100.00	100.00	80.00
hybrid paper	66.67	100.00	100.00	40.00
make decision with it	16.67	66.67	0.00	70.00
timely	16.7	66.67	100.00	50.0
ease of access	33.33	33.33	0.00	50.00
complete	33.33	66.67	100.00	20.00
fit for use useful	16.7	33.33	100.00	40.00
PHN identifier	50.00	0.00	0.00	40.00
N (Documents)	100.00	100.00	100.00	100.00

There are some interesting features of this Table:

- In discussing information quality, all groups mentioned “handwriting”, “free text” or “unstructured data” and “standardization”. As mentioned earlier, these two terms will be examined further below in section 5.3.7 (Information Instability Overview). Although handwriting was used as an information quality coding term, the intent of this term was to capture information in the form of free text that is written or typed and not selected in a drop down box.
- The term “accuracy” was coded more often for a physician than a non-clinical group.
- The terms “hybrid” or “paper chart” were mentioned more often by the nursing and physician groups possibly because nurses and physicians create and work within the hybrid system more often than the non-clinical interviewees. Although the term hybrid

⁵² The column percentages were based on the MAXQDA 12 analysis of number of code documents.

or paper chart emerged through the question one coding process, this term (hybrid or paper chart) was moved and analyzed further below in section 5.3.8 under Information System Instability because the hybrid or paper chart is an information system format or vehicle.

- The term "making a decision" was coded more often for physicians, as would be expected as the main decision maker of the care team, and for non-clinical interviewees.
- The physicians also used the term "complete" more often as they needed the entire information set for decision making.
- The nursing and the non-clinical group used the term "PHN identifier" more than the physicians. The non-clinical group participants were more likely to use the identifier for data manipulation and linking as will be seen below in section 5.3.7, (Information Instability and Remedies). The identifier is a form of standardization and was included for analysis for this reason.

The next section will look in more detail at the interviewees' understanding of making a decision, a process that needs accurate and complete information to be present.

5.3.5 Information Purpose: Make a Decision

Introduction

Although the term “decision making” was not the most-used term in relation to information quality, it does underscore the main use or purpose of information in health care where patient care is about making the best decision for the patient, that is, making an informed decision and creating a treatment plan that provides the best outcome for the patient (improved patient safety with reduced potential for adverse events).

Descriptive Statistics

The term “make a decision” or “treatment plan” was coded seventeen times for 10/20 interviewees: 1/6 nurses, 7/10 non-clinical, 2/3 physicians showing that the non-clinical interviewees used this term more often than the clinical (7 vs 3). Interviewee one, a clinical interviewee, used this term four times, interviewee twelve, non-clinical interviewee, three times and the rest once or twice. It is important that two of the physicians used this term as they are the lead decision makers on the patient care team.

Qualitative Understanding from the Interviewees

The interviewees provide some good examples of what making a decision means to them for information and information system requirements.

Patient

Theme: The patient’s own information must be complete

The clinical and non-clinical interviewees stress that information must be the patient’s own information and not someone else’s information. The patient’s own information must be accurate and on time i.e. not be missing as stressed by these interviewees, both clinical and non-clinical:

Int 18 physician 10-20 years’ experience ministry: if the wrong data is attached to a patient, then you’re making decisions on wrong information [para. 41]

Int 20 physician 10-20 years’ experience health authority: Obviously at the patient level you depend on accurate complete timely data to

make a decision [para. 48]

Int 03 non-clinical < 10 years' experience public: if we receive um, whether it be a lab result or a image that is not the correct image for the correct patient and a clinician is using that information on the basis to formulate a treatment plan that can have absolutely anything from minor to really major impacts [para. 20]

Int 09 non-clinical 10-20 years' experience public and private: Incorrect information, you're not going to make the right decision [para. 17]

Obviously, there are going to be times when health care providers will need to make care decisions when the patient's information may be missing; for example, when the patient is unresponsive and cannot provide their own information:

Int 07 non-clinical 10-20 years' experience ministry: Right, and you know if you have an unconscious or unresponsive patient it is not going to be able to confirm that and just to have the quality and complete information...a clinician is looking and assuming that they have all of the information that they need at hand and they factor it in and you are going to base your decision on that right?[para. 58-9]

Information

Theme: Type of decision determines level of accuracy

There are different decisions that can be made using the data collected during monitoring, planning and evaluation. The degree of accuracy of the data can vary: patient care decisions require the highest degree of accuracy, both clinical and non-clinical interviewees make this point:

Int 20 physician 10-20 years' experience health authority: Yeah, information quality is I think really important. I kind of divide it into two, there's the sort of point of time caring for the patient right at the bedside. Then there's the downstream use of that data to understand health systems on a unit level, a city level, a province level, et cetera. Both of those are important, I think they're equally important. Obviously at the patient level you depend on accurate complete timely data to make a decision [para. 48]

Int 15 non-clinical 10-20 years' experience public: I think that the

highest level of the accuracy in that context is required for the individual patient care decision. There may be information that is not of sufficient quality to be used for an individual patient care decision but that would be of sufficient quality to be able to be determined. For example, do you have a higher rate of obesity in Canada or in Australia? [para. 4-5]

Theme: A decision is only as good as the information available to the decision maker. Both clinical and non-clinical interviewees make this point, for example:

Int 01 nurse 21-30 years' experience public & private: really the decision making of a clinician is only as good as what you have in front of you, right? [para. 66]

Theme: There must be stable information

The information must be stable and precise; the clinical and non-clinical interviewees feel this may be more important than accuracy when not all the information is available:

Int 16 physician 10-20 years' experience health authority: That data is not accurate because it's not being collected properly. Information systems allow you to, even if that data is not necessarily accurate, its precision for change is better. An information system will allow you to at least see that. If I'm measuring a blood pressure continuously, even if the numbers are wrong, I can see that the trend of down or up tells me, gives me information about the patient. In an information system, it displays that kind of change over time. Allows the quality of the data to not necessarily be as important as long as it's being consistently collected [para. 19]

Int 12 non-clinical 10-20 years' experience health authority: Do we wish to use that information to make this type of a decision because sometime you'll be okay with unknown, you'll be okay with the information that maybe, even if it's 30% wrong, but then you'll say, okay, it's consistently wrong. Then you'll be comfortable with that, 30% of data quality issue [para. 8]

Information System

Theme: The information system must present the information to the decision maker. This means that the decision maker needs to have all the information before them; this may be difficult when

there is a hybrid paper-electronic chart. This creates information instability because information is missing:

Int 01 nurse 21-30 years' experience public & private: We are living in a hybrid world where we have paper and electronic charts and so now you have got um, the client coming in for the visit and the chart was not properly prepared so if I only have half the information that I can only make, I can make the best decision that I can but I have only dealing with half a deck and that is not good enough right? [para. 12]

Theme: The electronic record may be more complete, provided the data fields are filled out correctly using the drop down boxes so the information is accessible in the relevant modules in the system:

Int 01 nurse 21-30 years' experience public & private: you have a common dropdown tables and so forth and there are modules, there would be an OR module and an emerg module and so forth um, so if it is on a common system like say for example Vendor XXX and you can pull up the lab and you can pull up the medications, now the clinician you have enough information to make the more informed decision [para. 35]

Int 12 non-clinical 10-20 years' experience health authority: it's in the right field so that after that it can be used to make decision from each of the spectrum, for patient care and for improving the patient care, kind of like the end of it [para. 3]

Summary

The context of the decision will be for patient care, although the interviewees note that information can be used for monitoring, evaluation and planning. Patient care decisions require the highest degree of accuracy. The clinical and non-clinical interviewees agree on the importance of the close link of the information to the patient, that it is the patient's *own* information, otherwise a decision could result in an adverse event for the patient. If a care decision is made using another person's information, the assumption is that the patient's own information is missing.

Although all interviewees answered question one so there was an equal balance of responses, the

nurses were under-represented compared to the physicians and the non-clinical group for many of the information quality terms that arose within this question.

The decision maker must have a complete set of data necessary to make the decision. The information must be precise so that changes in the information reflect true changes in the patient state and not random changes. The next section will examine information accuracy and completeness as key characteristics of information quality.

5.3.6 The Ideal Information State: Accurate and Complete Information

Accuracy: True Reflection of Patient Identity and State

Introduction

Accuracy was identified as an important information characteristic for making a good care decision.

Descriptive Statistics

The term “accuracy” or “accurate” was coded thirty-two times for 15/20 interviewees: 3/6 nurses, 8/10 non-clinical, 3/3 physicians and the pharmacist showing that the clinical and non-clinical interviewees used this term almost equally. Interviewee one, clinical, used the term seven times, interviewee two, non-clinical, four times, interviewee seven, non-clinical, three times and the rest once or twice.

Qualitative Understanding from the Interviewees

Patient

Theme: Patient identity information is key

Although patient identity is discussed further in section 5.3.7 below it is an key element for accuracy because it is the anchor for all the rest of the patient’s information. We saw earlier that establishing patient identity begins at admission.

Information

Theme: Patient identity as source of truth.

The patient identity is a source of truth is especially important when making a decision at the bedside about that person. Interviewee sixteen makes the important observation that the information must reflect the patient system and state:

Int 16 physician 10-20 years’ experience health authority: I mean it’s the information quality at the bedside has to be accurate, and has to be available [para. 1]

Int 16 physician 10-20 years' experience health authority: That data ...
I need to know that that data is accurate, that it reflects the patient system [para. 6]

Information System

Theme: Patient identity is directly linked to the person

Both clinical and non-clinical interviewees see the importance of having identifiers that are directly linked to an individual so all of the individual's linked records are together. This creates a trustworthy source of truth about that individual from all the data sources (this assumes the devices registering the information are calibrated and working correctly. Please note-this is out of scope for this research):

Int 03 non-clinical < 10 years' experience public: the first thing that comes to my mind when um, that term is used is um, accuracy and so in my world because we are bringing together information from many different systems and trying to consolidate it into a single patient centric view um, the accuracy of the patient identity and ensuring that the right test results and reports etc. are um, on the correct patient and to be part of our worry and concern [para. 2]

Int 04 nurse 21-30 years' experience public: It really means that the data has some attributes that I am looking for, that it is accurate that I can um, trust the source and how it was collected um, that there is comparability and that I am if we are looking at a field label that it means the same thing for all of us [para. 1]

Summary

Most of the clinical and non-clinical interviewees use accuracy as an important descriptor of information quality because accurate information about an individual both identifies and reflects the true state of the individual. There was a good use of this term (15/20) with clinical and non-clinical interviewees using this term almost equally.

The next important information quality term is complete. Here, one asks the question: is all of the patient's own information available?

Complete: all the Information is available

Introduction

The interviewees suggested that care decision makers must have all of the patient's own information before them when they make a decision.

Descriptive Statistics

The term "complete" or "completeness" was coded nine times for 7/20 interviewees: 2/6 nurses, 2/10 non-clinical, 2/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical. The interviewees used the terms once or twice.

Qualitative Understanding from the Interviewees

Information

Theme: Patient information must be recent and relevant

The complete record in acute care may not be as extensive as the longitudinal record in community care, but it must be recent and relevant:

Int 14 nurse 21-30 years' experience health authority: I need the most recent and relevant information about that patient when they present, as opposed to needing more of that longitudinal record when we're in the community and trying to manage a broad spectrum of health concerns [para. 10]

Theme: There must be no gaps or missing information that could affect the decision

The complete record in health care must have all the information that has been collected on the patient, if possible. It may not be complete at the beginning of a patient's admission but the information becomes more complete during the admission from the care giver's interaction with the patient, the patient's family and any investigations.

Int 18 physician 10-20 years' experience ministry: I think for me it's the accuracy of the information and completeness of the information [para. 1]...It's the quality, so the structure of it - is that interpretable? Is it meaningful? Is it accurate? And then, are we collecting everything or have we got major gaps? [para. 6]

Information System

Theme: Complete information means information is entered into the system

The interviewees suggest that information completeness is largely an information system issue. Both the clinical and non-clinical interviewees mention with a particular emphasis that information must be entered in the electronic system:

Int 17 nurse 10-20 years' experience health authority: The quality, it needs to be complete. Let me back up from that. It needs to be entered [para. 1]

Int 12 non-clinical 10-20 years' experience health authority: There's fourteen determinants of data quality that we apply, and most often people focus on obviously the completeness, if the information was put in or not [para. 5]

Summary

Interviewees 17 and 12 make the important point that completeness means that the information must be made available to others using the information system. There must be no gaps in the information and it must be relevant.

Care decision makers must have information that:

- is directly connected to the patient-the patient's own information
- is precise or stable enough to detect *true changes* in the patient state
- is without any gaps or missing information (complete)

Although this term was used less often than accuracy (7/20 vs 15/20) with under representation by non-clinical interviewees, 5/7 clinical interviewees responded with the majority of physicians, the decision makers.

The next section will provide the interviewees' thoughts on when this is not the case in acute care because the patient's own information is missing and how this creates information instability.

5.3.7 Information Instability Overview, Examples and Some Remedies

Overview Introduction

Information instability is related to poor information quality, Part II question three in the interview so there will be a brief overview of this question first. Information instability suggests patient information is either missing or has been corrupted in some way.

Descriptive Statistics

Question three was answered by 18/20 interviewees except for interviewees eleven, non-clinical, and nineteen, clinical.

Most interviewees (11/18) considered that the terms for poor information quality were the opposite of the terms for good information quality, for example, accurate-inaccurate or complete-incomplete. However, some interviewees added clarification with other terms useful for analysis. These terms were: “misdirection”, “misfile”, “merging”, “transcription”, “mismatch”, “no value”, and “alter / change information” as shown below in Table 16. These terms will be analyzed below under the relevant topics.

Table 16: Frequency of Subcodes for Poor Information Quality

Inductive subcode Name	Frequency [# interviewees]	Percentage
opposite antonym	11	55.00
misdirection misfile merging	8	40.00
transcription	6	30.00
mismatch	3	15.00
no value	1	5.00
alter change information	1	5.00
Missing	2	10.00
Total	20	100.00

Depending on the interviewee’s point of view, unstructured data could be an example of poor information quality. In the next section of this work unstructured data will be discussed first and then unstable information generally from poor data entry and data manipulation.

Question ten also speaks of poor information quality. This question was coded for 20/20 interviewees. There were twenty-nine codes for examples for 17/20 interviewees: clinical

interviewees four and nineteen had four examples and the rest, one or two. Question ten examples include: skewed information, technology not recording, decision support, imaging, vendor upgrades, medication dosing, order entry, interoperability, and alerts.

Although the examples arise in the context of this question, they were used on a as needed basis in the analysis.

As we shall see throughout this research, any instability in patient identity information is serious.

Information Instability: unstructured Data-Handwriting, Free Text

Introduction

The descriptive statistics in the information quality overview showed “handwriting, free text” and “standardization” as the two top-ranked terms. The juxtaposition of these two terms becomes a key organizing concept in this research (i.e. information instability and stability respectively) in the analysis (with support from the other high-ranked terms).

The interviewees provided valuable understandings and interpretations on these two terms starting with handwriting free text as the first example of instability. The term unstructured data will be used to include handwriting, writing, free text, rewrite, narrative or unstructured data and includes the patient’s “story” that suggests a narrative form.

Descriptive Statistics

The terms handwriting, free text, or unstructured data appeared thirty-seven times in the interviews by 17/20 interviewees: 5/6 nurses, 3/3 physicians, 1/1 pharmacist and 8/10 non-clinical suggesting an almost equal balance (9 vs 8). Interviewees twelve, non-clinical, and twenty, clinical, used these terms four times, interviewees eight, nine, eleven and seventeen, three times and the rest, once or twice. Forty seven percent of the terms appeared in the non-clinical interviewees suggesting that this aspect of information quality was as important to them as it was for the clinical interviewees, but for different reasons.

Qualitative Understanding from the Interviewees

The interviewees provided many points of view on this topic ranging from full support to criticism.

Information

Theme: Unstructured data is a source of rich data

The clinical interviewees see hand writing, free text, or unstructured⁵³ data as a source of information density and richness because it tells the patient’s story or narrative as can be seen

⁵³ For further information on unstructured data that does not fit into data models please see http://www.webopedia.com/TERM/S/structured_data.html

from the following quote:

Int 16 physician 10-20 years' experience health authority: While you want to maintain some data integrity, the data that a physician provides is not really data in the usual sense. It's interpretation of the data. It's usually narrative. It's usually much better ... To meet the need of data quality that I listed earlier, availability and usable, it has to be written out in a way I can read it so that I can actually understand what's going on [para. 31]

Theme: Unstructured data lets staff tell the patient's story. Clinicians *want* to tell the patient's story as two nurses and a non-clinician note with the non-clinician feeling that much of this information is ignored –and maybe useless?:

Int 04 nurse 21-30 years' experience public: Um, for others it goes on to the extent of templating where it is almost a fill in the blank and that drives people crazy because they can't write their own narrative [para. 68]

Int 17 nurse 10-20 years' experience health authority: One of the things that we always hear about, and it's not just once a unit goes live with the electronic system from paper, but it's an ongoing thing. If they feel they've lost a bit of the patient's story.... Just that little story, they all feel, and I agree to a degree, they all feel they've lost that [para. 89-93]

Int 02 non-clinical 21-30 years' experience public & private: Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text but that is a lot of reading and people aren't going to read through it. Just free text like long documents and clinician will typically only read one page [para. 6-7]

The interviewees had much more to say about *the problems* associated with free text is illustrated in comments:

Theme: Unstructured data is there but hard to read

The clinicians and non-clinicians also noted problems with handwriting, free text or unstructured data. These include illegible orders or unreadable PDF scanned summaries that could be a source of wrong information for that patient's next admission:

Int 05 nurse 21-30 years' experience health authority: I struggle on this a bit is that most of our um, orders are communicated by physicians and um, you as a physicians would appreciate this and you still write, we still go by hand-written orders [para. 33]

Int 02 non-clinical 21-30 years' experience public & private: So emergency discharge summaries are often hand written by the physician and then they are scanned and they are shared up in the true system and a lot of times you can't read it [para. 2]

Theme: Unstructured data may be missing because of chart structure or charting style

The clinicians, although generally positive about free text, say that it can be a cause of a patient's missing data that could affect care decisions:

This data could be missing because of chart structure:

Int 01 nurse 21-30 years' experience public & private: when you have an exception and you put it into "other" or comments or right now it becomes text and if you are doing any kind of an analysis as you know the text boxes of whatever that is missed the data. So say ya, you could in fact be missing some fairly significant or important data because it doesn't fit into one of the boxes [para. 46]

Or because of different individual's charting styles:

Int 17 nurse 10-20 years' experience health authority: Whereas on a paper form, they may ... If it's just a free text, they may forget to make the notation, even though they know at the back of their head they're supposed to chart that particular item [para. 12]

Int 20 physician 10-20 years' experience health authority: Unstructured things are very limited because it's all individualized, right? There's one nurse that's very chatty and they'll pages of stuff, that's great but the next nurse that's not like that writes nothing all night. You could make the wrong interpretation that nothing happened overnight [para. 32]

Theme: Unstructured data can drift away from accuracy

The clinicians and non-clinicians comment also on a drift away from accuracy and completeness as the information passes through different care providers because this information passing

leads to unstable and missing information, almost like a virus!:

Int 19 pharmacist 10-20 years' experience health authority: I compared the physicians order, the prescriber order to what we had in pharmacy to what was in the MAR⁵⁴ and looked for differences between those three and there was tons....I think what we found was the further away it got from the physicians order, the MAR, the last step was where we were finding the most differences. There's all kinds of reasons why it was happening. Orders were being written on the chart and weren't being pulled, and so they weren't being flagged and then sent down to pharmacy [para. 48, 50]

Int 12 non-clinical 10-20 years' experience health authority: Then the clinician goes in, write it on a piece of paper. Then that piece of paper is taken by a clerical. They also kind of put their own perception or what this information means, put it into a computer system. Then that computer system goes through certain HL7⁵⁵ or batch interface or it goes from one or two or three different system... Then it's like that game, the telephone game. There's the information that was said at the beginning, and when it's spit out at the end of that telephone game, is it really the same thing [para. 12]

Further, Interviewee twelve has observed up to seven people handle the data and that if more than two people touch the data with data entry the information becomes unstable with poor quality. The first step is the paper chart:

Int 12 non-clinical 10-20 years' experience health authority: when we found that where the information was, the physician, for example, took some information from them and then it was input into the chart. Then there was read and then transcribed by our clerical. I found that if it involved more than two people or two individual, then the data or the quality of the data may be in question [para. 15, 22]

Theme: Unstructured data is difficult to standardize

⁵⁴ MAR is the patient's Medication Administration Record maintained during the admission.

⁵⁵ HL 7 and its members provide a framework (and related standards) for the exchange, integration, sharing, and retrieval of electronic health information. These standards define how information is packaged and communicated from one party to another, setting the language, structure and data types required for seamless integration between systems. Please see the link: <http://www.hl7.org/implement/standards/index.cfm?ref=nav>
HL 7 is mentioned further below in Legacy System Integration

The non-clinical group favours standardized information or codified information, as interviewee eight says, so data is not useful to others though it is to the clinician who wants to get ahead of the queue!:

Int 08 non-clinical 10-20 years' experience ministry Poor would be put in whatever you want.... When you lack that and you just say it's a five point scale without any criteria attached to them, well it's always a one or two if you're the ordering physician because you want to get it through faster. If you don't have criteria there, then that's very poor quality [para. 18-20]

And the endless variation creates difficulties for local terminologies as described in this quote below:

Int 11 non-clinical <10 years' experience health authority: If I'm pulling data from two different Excel files with 13,000 line items and I'm looking for NNN Hospital [name]. They've been using free text to enter this data. There's still many different ways to try and identify this hospital. There's the full spelling, and then you can spell it without the apostrophe if they did it wrong, or with the apostrophe. Without hospital it could be just be a short form or it could be initials . There's so many different ways [para. 5]

Information System

The interviewees describe some information system issues with unstructured data. The very richness of unstructured data limits it to other uses.

Theme: Unstructured data with redundant information may be a source for error

Clinicians also want to explain what might be clearly captured in an image for example in wound care in an electronic system so adding to workload and possibly discrepant information that could contribute to error:

Int 04 nurse 21-30 years' experience public: so they may have done a complete wound assessment by the check box which is great but then they feel the need to rewrite that so you have to um, that takes ongoing education to say you know that is great but you don't need to repeat yourself, you very clearly indicated the wound status in the flow sheet or you very clearly indicated whatever um, using the flow

sheet so you don't need to repeat you are only identifying information that is by exception or could not be documented in a flow sheet. Or that you felt that there was insufficient detail that flow sheet about the wound let's say [para. 72]

Theme: Non clinicians feel unstructured data is useless for analytics

The non-clinicians feel that the very flexibility and richness of free text makes the information useless for analytics and retrieval as these quote show:

Int 02 non-clinical 21-30 years' experience public & private: Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text ... [para. 6-7]

Int 07 non-clinical 10-20 years' experience ministry: to me is the biggest um, boon to health information as they exist today um, I think you know the electronic charting as opposed to paper charting is an improvement as especially I should say only if there are picks and drop down lists as opposed to free documentation free text is scary and it also doesn't give us the capability to retrieve information it is not um, you know terminology isn't consistent and that sort of thing [para. 66]

Theme: Unstructured data is difficult to manipulate or link

One interviewee noted that free text can be lost in data merging such that important patient information was missing and could have caused an adverse event:

Int 09 non-clinical 10-20 years' experience public and private: Another example was that comments would come across, which are often really helpful but they're often done in a free text field, right? ... and they would be cut off halfway through. There was actually one situation where it had been flagged that a patient had cancer, and that was missed, because it was one key information like that, putting it in the comment field is not good. Not good practice. But when they don't have anywhere else to put it, it gets put in there, and then it's cut off and the information's lost [para 5-6]

Summary

Forty seven percent of the terms appeared in the non-clinical group suggesting that this aspect of

information quality was as important to them as it was for the clinical interviewees but for different reasons as shown in section 5.3.10. The clinical interviewees noted the desire to “tell the story” but at the cost of information instability for the clinical and non-clinical interviewees including redundant data, missing data and technical issues with data manipulation. The non-clinical interviewees did not see any benefit to unstructured data. This disagreement was striking when compared to the general agreement in the other interview questions. This discrepancy leads to the higher concepts of information and system stability and instability arising out of the initial coding, with instability providing potential for error because the patient’s own information is missing. This is explored further in the next question, poor information quality for structured data.

Information Instability: Structured Data

Introduction

The interviewees spoke of several causes for poor information quality that could be human or system caused for structured data that is not handwriting or free text. Information instability suggests either missing or corrupt patient information. The patient information terms most commonly used are “identifier”, “data entry” (this suggests structured data), “transcription”, “putting the wrong information in the file”, “data manipulation”, “merging” or “migration” that suggests working with structured data. Content for this section came from a variety of questions in keeping with the Grounded Theory Approach Methodology as shown in Figure 7 grouped inductive /structural codes.

Qualitative understanding from the interviewees

Information

Data entry is a common step where the patient’s information can become corrupted and unstable. This is especially critical when patient identity is involved.

Theme: Inaccurate patient identity transcription or data entry changes source of truth

Inaccurate transcription of the patient identifier that is part of the source of truth for the patient profile can create problems establishing patient identity:

Int 05 nurse 21-30 years’ experience health authority: I do know of you know several situations for whatever reason people were um, entered into the system wrong and didn’t have proper identifiers that having those keyed in and making sure that that person there is, because lot of look-alike names the wrong look at the names a lot of similar birthdates and how do we make sure that we are unequivocally make sure that we are entering the right patient. Because now you are building a profile on that patient [para. 74]

Theme: Transcription or data entry in general can corrupt structured data

A human cause for poor information quality was transcription or data entry mistakes as

commented on by mainly clinicians, possibly because they have direct experience with the effects of wrong information in a patient record. This impacts accuracy. Four interviewees commented on this of which the following is a sample:

Int 06 nurse >30 years' experience health authority: I have never gone looking for patient information and gotten the wrong patient. Um, there is never there doesn't seem to be, as long as the person is entering the data is entering the right data the system doesn't make a mistake it is the person entering the data that makes the mistake... There is one thing that I want to stress is that the information is only as good as the person entering it [para. 6, 42]

Int 18 physician 10-20 years' experience ministry: the information that's actually getting transcribed is not accurate because we're still getting things ... getting systems working well, then we've got the clinicians not entering things properly [para. 11]

Interviewee thirteen provides a real example that created an inaccurate patient record:

Int 13 non-clinical <10 years' experience ministry: As well as, inaccuracies, like inconsistencies. For example, I mean this was a mistake that was in the database, but what happened is that this guy had a urine drug screen and he was positive April 21st. Then, the next time they took a urine drug screen on April 22nd, he wasn't positive. What had happened is that that nurse had put the wrong ... information on the file [para. 8]

Information System

Theme: Unskilled data merging corrupts structured data by changing accuracy and/or completeness

Poor information quality can also result from unskilled data manipulation or data merging in the electronic system. This manipulation can be a manual or automated process:

Int 07 non-clinical 10-20 years' experience ministry: I think one of the things that can result in poor quality information is um, is it manipulated? so whether that be you know by manual intervention

or whether it be through some interface or integration where information is filtered in some way or um, you know altered in some way [para. 7]

Manipulation can affect the accuracy and completeness of the patient's own information because the information has been dropped or linked to another person's information. This makes it difficult to identify the source of truth for the individual as the following examples illustrate:

Int 01 nurse 21-30 years' experience public & private: it is how do you merge or unmerge right. So that is all the accuracy because if you have duplicate records and you have to merge them how do you keep the source the truth? [para. 6]

Int 04 nurse 21-30 years' experience public: well it seems that most of it is um, the merging of records of people that don't have the skill to manage or merge records. So they are not matching on sufficient data elements that um, they will accept let's say names going in any format so a name could actually have a number in it or it is good enough to use nicknames not identified as nicknames um, those kinds of things that would if we are talking about a client registry situation where um, you know you can end up with some different ways to identify the same a certain person [para. 6]

Int 18 physician 10-20 years' experience ministry: Sometimes the information of how we're linking data with patient identity and so on, so sometimes the wrong information is attached to the wrong patient- Or the right information goes to the wrong patient [para. 8]

However, interviewee seven notes information loss can be minimized with careful planning and running systems in parallel:

Int 07 non-clinical 10-20 years' experience ministry: guess some other ones would be something like the data migration so if um, a health information system was being decommissioned and they wanted to move their data from one system to another and they didn't have guidance on proper you know record retention or validation processes to make sure that if all of the data was moved and I have seen lots of issues with data migration and they get others into another system and then realize that they should have brought more. Potentially systems if they run the systems parallel for a while and

normally when we decommission an old system and until you are comfortable with it [para. 45]

Theme: Effect of structured data instability-means poor decisions

The interviewees spoke of the effects of poor information quality: the care provider makes a poor decision.:

Theme: The missing or corrupt structured information does not reflect the true patient state

There is the obvious point that there is missing information or the information does not reflect the patient state. Seven clinical and non-clinical interviewees commented on this of which these quotes are a sample:

Int 01 nurse 21-30 years' experience public & private: You know that if you have information that is skewed or diluted or incorrect or vague that you know you don't have enough information to make the most intelligent decision and so you are going to as a clinician [para. 67]

Int 18 physician 10-20 years' experience ministry: if the wrong data is attached to a patient, then you're making decisions on wrong information [para. 41]

Int 09 non-clinical 10-20 years' experience public and private: Incorrect information, you're not going to make the right decision [para. 17]

Interviewee eighteen notes all sorts of results go astray!:

Int 18 physician 10-20 years' experience ministry: So I've got lab reports and diagnostic imaging reports and transcribed reports that often never get to where they're supposed to go, so sometimes it's not the information itself that actually doesn't get to the right hands, so I think that's a quality issue as well [para. 10]

Summary

Poor information quality undermines the accuracy and completeness of the information because the patient's own information, in particular the patient identifier, is not attached to the patient

either by data entry/transcription errors, unskilled lining of datasets, hybrid system or information system glitches. Poor information quality does not reflect the true patient state for the decision maker. This is a serious issue, however, the interviewees provide some remedies in the next section to improve information quality.

Information Instability: Remedies

Introduction

The interviewees provide several remedies to improve information quality by improving information stability, accuracy and completeness. These remedies reduce the variation in unstructured data either by standardization and identity identifiers imposed or mandated by the organization or regulators, by creating new structured data with templates or by staff validation checking the data. Each of these information-only remedies will be discussed in turn.

Remedy: Standardization

Introduction

Standardization in question one refers to standardizing data or information often through the use of external standards or in house standards and policies. Standardization is about the *information* part of the triad of person, information and information system. Standardization includes codified data and data that is the source of truth.

Descriptive Statistics

The terms “standardization”, “standards” were coded forty four times for 15/20 interviewees: 5/6 nurses, 7/10 non-clinical, 2/3 physicians and the pharmacist showing that the clinical interviewees used this term slightly more often than the non-clinical (8 vs 7). Interviewees eight, non-clinical, and fourteen, clinical, used this term seven times, respondent seventeen, clinical, six times, interviewees one, clinical, five times, non-clinical interviewees two and eleven, three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

The interviewees explain what they mean by standardization in the following quotes. The interviewees provide clarity on the types of information standards.

External standards

Theme: Standardized data enables information sharing

Although there are standards that are developed in house there are also external standards such as the International Standards Organization (ISO⁵⁶) that enable data sharing:

Int 14 nurse 21-30 years' experience health authority: We had specific dictionaries it was just on how we would use those dictionaries making sure that data point. If we had blood pressure we would make sure the OR group was using that same data collection point. We formatted all of the upper/lowercase, our mnemonic structure, that everyone was the same. We do look at the ISO standards, so making sure that our formats are conforming with that ... they're needing to share this information [para. 33]

There are also external Canadian standards established by funding bodies such as Canada Health Infoway:

Int 09 non-clinical 10-20 years' experience public and private: I think of the Infoway standard that most of our projects are measured against when we do our benefits realization; they define information quality as the ability for a system to correctly reflect the required information [para. 1]

Standardization benefits

Theme: Information standardization contributes to trustworthy data, especially for pharmacy data

Interviewee fourteen noted that knowing data is based on a standard provides confidence in the data that it is trustworthy.

Int 14 nurse 21-30 years' experience health authority: If I look at the source, I look to see how ... What were the requirements? How were ... Is it standardized work? How was it collected? If I don't know anything about the source, then I probably want to go find out about it a little bit more before I would trust the data [para. 3]

Three interviewees mentioned the pharmacy as a health care service that needs standardization- so there are known expectations about the data, likely because of the well-known risks of medication errors. Here is an example:.

Int 19 pharmacist 10-20 years' experience health authority: think as

⁵⁶ The International Standards Organization (ISO) was mentioned above in section 2.5.8.

a whole, when it comes to accuracy and completeness of information, I think standardization can help. Having a discussion interdisciplinary as far as when we say actual medication, we're talking about actual medication and we need the name of the drug generically, we need the dose, we need the route, we need the frequency and providing structure around the standard approach to documenting that kind of information so that we're all expecting and seeing the same thing [para. 90]

Theme: Standardized information is useful because it is accurate and complete for better analytics for care and other uses

The main benefits of information standardization are better information accuracy, completeness and better analytics for patient care, monitoring and data mining. Four interviewees mention this point of which the below are excerpts from the interviews :

Int 20 physician 10-20 years' experience health authority: documentation in the system would be the individual questions and some of the decisions support you move away towards standardizing how that information is collected. And hopefully makes the data more comparable not just on an individual provider and patient level but on a unit and provincial level. Certainly we're very interested in having comparative information between units to understand quality care and allow for feasible research to be done [para. 25]

Int 02 non-clinical 21-30 years' experience public & private: The structured when it comes to be codified and you can use it, and so it depends on the use of the information if you are doing it for analysis or if you are doing it for, if you are treating individuals or looking up populations, so if you are looking at data across multiple locations and you are doing any data mining you need to have information that is consistent and codified and structured [para. 8]

Theme: Standardized information can lead to process standardization downstream

Clinical and non-clinical interviewees note standardizing information can be a useful first step for standardizing other downstream processes in health care:

Int 14 nurse 21-30 years' experience health authority: we standardize with the system and then we have to make sure we have that

standardized care practices before we build [para. 32]

Int 07 non-clinical 10-20 years' experience ministry: The lab information system are trying to standardize it. they are all working towards that stuff and again just looking for consistency in standardization because that always brings accuracy and um, and so along with that of course they saw opportunities where they could improve their business processes as well and something that they can call their own [para. 86-7]

Theme: Information standardization is good vendor PR

As well as good PR for vendors meeting provincial standards:

Int 07 non-clinical 10-20 years' experience ministry: like I said both within and without the health services so it is kind of with stories like that go out it does become a badge of honour that hey, we are using these standards and the other thing is that when data sources come to um, the ministry and ask to be to have their clinical information allowed in the EHR if they are following these standards then there is a whole lot of questions that we don't have to ask them and a whole lot of rigor that we don't have to go through [para. 90-1]

Theme: Taxonomies may not be adopted because of mapping issues or third party software

There are also standard taxonomies such as LOINC⁵⁷ and SNOMED CT for patient data, however, the interviewees provided mixed messages on taxonomy implementation. One interviewee noted that these taxonomies are suited to drop down boxes, an information system data entry standardization as illustrated in the quote below:

Int 01 nurse 21-30 years' experience public & private: so there is now I think that we are improving through the accuracy of truth standardized taxonomy so we have for example like I said the LOINC SNOMED we have the taxonomy for nurses right that is coming and um, then when you have standardized departments you can do drop down tables and so your people at the front end just you know they drop down [para. 7]

⁵⁷ LOINC or Logical Observation Identifiers Names and Codes is a standardized terminology for laboratory test embedded in HL 7 messages. Please see the following link: <https://loinc.org/>. SNOMED CT is a clinical healthcare terminology. Please see the following link: <http://www.ihtsdo.org/snomed-ct>.

While another clinician observed that these taxonomies are not widely adopted:

Int 18 physician 10-20 years' experience ministry: We're not tremendously good at using our SNOMED CT structures or LOINC or those are standards around data itself, so all of our information is in different structures, different schemas, different formats, and when you try to bring it all together, there's a lot of stuff that has to be done and a lot of testing and a lot of ... in some cases, transformation ... that has to happen for that data to retain its quality, to retain its integrity, and its semantic interoperability [para. 33]

A reason for this may be the wariness of provincial staff to adopt a taxonomy that may rely on a third party mapping tool, a tool that could fail and introduce inaccurate or corrupt information:

Int 03 non-clinical < 10 years' experience public: We are not moving to SNOMED within the source systems they are putting a translation in place so the source systems will have to go through a translation service so I guess that I have reservations about the wisdom about that and implementing it at the source. It a mapping between local codes from all of the source systems to SNOMED code. And it is having to go back into the source system and saying ok then we are going to implement SNOMED... you wonder about cause as you say the opportunities for errors and that would be a good example for the SNOMED if you didn't have the um, if you were dealing with specific types of lab testing and diagnosis and you are doing a translator tool was wrong then you know there is an example right there where you know if they are not congruent in those two pieces of information it ends up on the patient record then that could be a source of error right there [para. 43-44 , 46]

Theme: Difficult to define source of truth for in-house information standardization

It is difficult to define the source of truth when there are no national or provincial standards such as would be the case in an in-house project:

Int 11 non-clinical <10 years' experience health authority: As long as you're going to one source of truth it shouldn't be too hard, but as for my job I had to go through three different spreadsheets and all from different parts of the organization. That's why it was difficult because everybody decided that they were going to name a different

thing. You're just looking at one location variable, but there's probably 50 columns on your Excel sheets and they probably have variables that are all different as well, right? [para. 12-13]

Theme: Persistent ancient information standardization that is no longer relevant or safe

Interviewee nineteen comments that an archaic standard term for dose interval qid (4 times a day or every 6 hours) in the paper chart led to an adverse event that likely would not have contributed to an error had there been electronic order entry (CPOE) with standardized medication ordering and ending up in the electronic medication record (eMAR). This points to keeping standards clear and current:

Int 19 pharmacist 10-20 years' experience health authority: We were giving the drug that we knew in pharmacy would never be given qid, the nursing staff didn't realize and so they were giving it qid. I mean that one was particularly daring because it was an approved abbreviation and it's one of those ones that's open to interpretation. That could happen with any drug, right? That a nurse could interpret it differently than pharmacy could interpret it as physician intended. When the systems don't talk ... At least if we had a common system like a CPOE that goes to pharmacy, that gets approved, that then generates either an eMAR or pharmacy generated MAR. You have some comfort that you're literally on the same page. [para. 53-4]

Summary

The terms standard or standardization was used almost equally by the clinical and non-clinical interviewees. Standardizing information has many benefits: accurate data collection of patient measures such as blood pressure [Interviewee fourteen], pharmacy [Interviewee nineteen], analytics [Interviewee two] and care provider practice [Interviewee fourteen, seventeen, nineteen] for the clinical interviewees. Standardization implies an agreement at some level in an organization that everyone will use the same term for the same thing, “the truth” i.e. to de individualize or de personalize the information but reaching agreement on this term may be difficult. One form of standardization is the patient identifier that creates a set of data such as a patient number and demographic information unique to an individual through provincial registries. The interviewees explain how important this piece of information is.

Remedy: Identifier Standards

Introduction

These are demographic or other information such as a personal health number that is mandated by the province to standardize data elements critical to identity such as name, birth date, gender, and unique identifier number, i.e. a provincial identity standard. It is thus a mixture of structured and unstructured data. Identifiers are stored in provincial registries and accessed by downstream users. Identifier standards also include the terms identity management, registry or registries, registration standards, and patient identification.

Descriptive Statistics

The terms “personal health number (PHN)” or “identifier” was coded eighteen times for 7/20 interviewees: 3/6 nurses, and 4/10 non-clinical, an almost equal balance. Interviewee one, clinical, used the term six times, interviewee eight, non-clinical, four times and the rest, once or twice.

Qualitative Understanding from the Interviewees

Information

Interviewees, mostly non-clinical, mentioned provincial standards for personal identifiers that are stored in provincial registries. These registries are very important sources for information quality because they are the source of truth for patient identity and for the patient’s own data (provided that data has been linked correctly to the patient in the first place).

The interviewees explain the great efforts the provinces go through to ensure each person has his/her own identifiers that may also be a unique number such as personal health number (PHN), and how important that identifier is to create and populate the patient profile during admission to acute care. This profile is the stable link to all other information attached to the patient during the stay.

Theme: Personal identifier is on a provincial identity card

Each resident carries a card that has their own unique identifiers. There are security procedures

in place to minimize fraudulent use of a person's card so another person's personal information is now attached to the card owner. This could add another person's information to the record so the persons own information was missing:

Int 01 nurse 21-30 years' experience public & private: And the reason being and it is kind of like it has a chip and pin in it kind of thing higher level of security and that is necessary because there was so many people so many people have issues and once more than there was people plus situations where um, you know one person would use another person's PHN and that would start a file that has your information and my information from a clinical perspective it is really inaccurate right [para. 2]

Theme: The personal identifier should be validated from other provincial data sets

The provinces have extensive validation process to ensure the accuracy and completeness of patient identity information. These can be system matching on identifiers and then staff checking discrepancies. These mismatches are resolved by looking at other data sources such as driver's licence records:

Int 03 non-clinical < 10 years' experience public: so we look at multiple data elements and um, we look for um, the obviously we will call it a here and it is essentially a PHN and we look at the gender and the date of birth and look to have a match on all three of those data elements when we are trying to marry data for multiple systems. If there is um, not a match then we um, flag the data as um, possible as a mismatch or a possible, I would say that they are matches but their date of birth or gender doesn't flag it and then there is a team that investigates or is responsible for doing investigation and determining whether there is remediation required or whether there is actually that is a correct match and you know maybe somebody in their source system has the data incorrectly? [para. 3]

Int 07 non-clinical 10-20 years' experience ministry: our job as the data integrity unit is to point those two records together and confirm they are the same person. Now for the most part the software um, has an algorithm that will compare the demographic of those two records and ideally link them together automatically but there does have to

be a threshold of which you know that is not feasible and um, so when that scoring algorithm takes place and the system can't say for certain that those two records belong to the same person that will trigger a flag for my team [para. 97]

Theme: The personal identifier can become corrupted with new information linked to it and no longer is the patient source of truth

New information gets special scrutiny because it could contaminate the existing information:

Int 07 non-clinical 10-20 years' experience ministry: So um, you know we do um, we do enforce a lot of validation um, you know before any new information is allowed into a system and most of that validation is done based on I guess that is my focus and that is person identity management you know that is where I am most involved [para. 51]

Int 07 non-clinical 10-20 years' experience ministry: we want to make sure that the person identity is correct and um, and the way that we validate that is by comparing it to these linkage sets and client registries. So you know we are looking for certain patient identifiers and so you know before we can even do that validation we have to do have something to validate so what we have said is that you we need to have you know this identifier and that identifier we can't have um, bogus identifiers and have blank ones because the business process doesn't necessarily accommodate and make sure that identifier is always there [para. 9]

Because contamination could create missing information and the information becomes untrustworthy which is a big problem when the information *is* the source of true patient identity:

Int 07 non-clinical 10-20 years' experience ministry: for us the clinical implications are that um, the document is in the registry um, and that it may be retrieved by someone looking for something else. Or it may be the record that they are looking for but they may also get this record which might contradict that. So maybe the question might be um, validity of the information, we don't want that because whenever and you probably know this um, you know if you don't trust the information you can't use it [para. 15-17]

Theme: Personal identifier can become corrupted with wrong data entry or transcription; this corruption can have a delayed effect on patient care

The identifier can become corrupted also when it is transcribed from the identity card to the information system admission screen and it is this screen entry that creates the patient profile for the admission where all the patient's own information is together for the decision maker.

Int 05 nurse 21-30 years' experience health authority: For a lot of different reasons from it starts at form registration perhaps and if somebody gets inadvertently entered wrongly into the system everything in those electronic databases are under the wrong patient. It is the huge, huge IT problem to rectify that . I am not trying to suggest that it is a registration problem that is one entry point that things can be entered wrongly. I do know of you know several situations for whatever reason people were um, entered into the system wrong and didn't have proper identifiers that having those keyed in and making sure that that person there is, because lot of look-alike names the wrong look at the names a lot of similar birthdates and how do we make sure that we are unequivocally make sure that we are entering the right patient. Because now you are building a profile on that patient. so if that profile is built under the wrong patient that is huge problem. And so anywhere that, anyway that we can make sure that front end that [para. 72-5]

This data corruption may become apparent either in subsequent admissions or when staff attempt to link data using these identifiers. This means that the data becomes suspect and untrustworthy because it does not represent the truth about that patient:

Int 04 nurse 21-30 years' experience public: many of the um, information systems, clinical information systems receive data from other sources so they are clinical system is dependent on their client registry system um, to pull up and identify a patient so when I am looking at those kinds of either interfaces or however it gets that data what are the safeguards in that client registry? Do they let them put in anything any way they want? So I can end up with two very different Mary Smiths but it is not obvious to me. you know I only need one factor and it is good to create a record versus a more traditional that you must have 3 data elements or um, something

along that line. Although I have more confidence that I am looking at the right patient that I am supposed to be looking at and that I am supposed to be doing something clinically for that patient so I have got at least a name, a date of birth, a healthcare number, a client registry number and something that gives me some sense that I am looking at someone specific [para. 3-5]

Information System

Theme: The personal identifier should remain stable whatever the system

In addition, interviewee seven makes the point that this identifier should be stable enough or system agnostic in any system so the information system cannot corrupt the identifier:

Int 14 nurse 21-30 years' experience health authority: I think we will certainly be aware when we have to conform and with the registry and the credential standards. Those are the external influences to the system that we have to conform with [para. 35]

Int 07 non-clinical 10-20 years' experience ministry: So you know making them kind of system agnostic so for example um, the health ministry and the services branch is where I work got together and prepared you know a provincial registration standards and practice manual that applies to everyone even community EMR's, and pharmacy and so on. Obviously we are all using different systems but if we can at least agree on some standards that improves information quality across spectrum the other thing is that there is a lot of focus right now on consolidation of systems so you know looking for less integration and less health information exchange [para. 30]

Theme: The personal identifier can be misread because of a poor screen data display

Even if the data is correct in the profile, the data display can make this information hard to read and be missed so there is wrong data entry on acute care admission so creating corrupt data downstream:

Int 04 nurse 21-30 years' experience public: So how do you now know that you have the right patient because one of the common errors with information systems is patient identification and it is fine if the patient is properly identified in the system but just the way the

headers are laid out patients discover they documented on the wrong patient. The demographic bar that often goes across the screen that says that I have Mary Smiths chart and she was born on such and such a date etc. and people have a tendency to not pay attention to that [para. 28-9]

Summary

The identifier is a key data element that is used to create the patient profile on admission to acute care and it is this profile that is assumed to be the source of truth for patient identity. This term was not commonly used but when it was there was an almost equal balance between clinical and non-clinical interviewees. It is important that the identifier not become corrupted and destabilized. The next section will provide the interviewee's ideas to stabilize unstructured data with information system templates, drop down boxes and forcing function.

Remedy: Stabilize Unstructured Data-Templates Control Free Text

Introduction

One way to stabilize unstructured or free text data is to use *Information System* templates or text fields. Interviewees four, clinical, fourteen, clinical, and fifteen, non-clinical, mention template use. Although these options are not commonly mentioned they do represent a method to provide structure to free text by providing mandatory fields or formats in the record. Other terms used include electronic format and check box.

Qualitative Understanding from the Interviewees

Information System

Theme: Template design is critical to show a benefit

Templates can be very helpful if they are well designed (especially those templates that come close to a drop down box style in an information system) but templates come at a cost of limiting care provider autonomy to enter free text as Interviewee four notes:

Int 04 nurse 21-30 years' experience public: it goes on to the extent of templating where it is almost a fill in the blank and that drives people crazy because they can't write their own narrative. You know so you get both sides of that argument but it does, when you go and look at it you see ok, sometimes you can have wonderful documentation in a template environment and they only have to fill in a field here and there and they only have to fill out the yes or no. Or a dropdown check box type of thing, you know, people will comply with that kind of thing [para. 68]

Theme: Template or text fields can ensure information is complete

Templates or text fields in an electronic format can be used to document care and to monitor care providers who may have had sloppy charting in the past:

Int 14 nurse 21-30 years' experience health authority: We moved to the electronic format, that gives an opportunity to read at a glance to see where we might have deficits in the collection of information and

address that. In terms of the quality, the improvement can occur using the system as a support tool. Some people may have gotten away with very limited documentation ...there can be a shift in practice [para. 11-12]

Theme: Specialized template with clinical criteria may be useful and provide complete information

Interviewee fifteen mentions a specialized template called structured synoptic reporting that embeds clinical criteria for decision makers:

Int 15 non-clinical 10-20 years' experience public: structured clinical synoptic reporting. Those kinds of additional tools that allow you to take it to another level as well. an absolutely horrible phrase, yeah, to describe a more structured way of doing clinical documentation. For example, for patients who have surgery, for their surgical report, for path report, for transfer reports from one setting to another, it's basically an evidence informed template for the information that should be captured about that type of care. If you think of cancer surgery, for example, you might report the surgical margins-To allow you to get to cancer staging [para. 16]

Theme: Template may not improve care and may add to work flow if too many input screens

Interviewee four is not entirely convinced templates are beneficial if all they do is create better notes or are so detailed that the documentation, although detailed, is too cumbersome to enter and could impede workflow:

Int 04 nurse 21-30 years' experience public: Um, often there are policies in place within an organization that has moved to electronic health records that talk about how frequently charting must occur. Not that they weren't there in the old days but there is more pressure that there actually be electronic documentation at a certain frequency, vital signs and it is legibility kind of thing um, and then you know there is always the organization that have decided that they will template notes so they are controlling the type of content now and I could argue that it is not necessarily an increase in quality of care your documentation is just better. Or more meeting standards so I am not quite prepared to say that documentation enhances care because it doesn't. You just have nicer notes [para. 19]

Int 04 nurse 21-30 years' experience public: I think it is a combination of templating and narrative. What I have seen with the templating format is that you can get some really nice um, detailed assessments and documentation but people are reluctant to use them because it requires them to go through 10 different screen to document that [para. 70]

Theme: Templates or text boxes too restrictive so possibly conflicting unstructured data added to the record

Interviewee four further adds that the urge to document or describe in a narrative add more unstructured data to the record increasing the workload and possibly adding conflicting information:

Int 04 nurse 21-30 years' experience public: so they may have done a complete wound assessment by the check box which is great but then they feel the need to rewrite that so you have to um, that takes ongoing education to say you know that is great but you don't need to repeat yourself, you very clearly indicated the wound status in the flow sheet or you very clearly indicated whatever um, using the flow sheet so you don't need to repeat you are only identifying information that is by exception or could not be documented in a flow sheet [para. 72]

Summary

The small number of interviewees who spoke on this topic have mixed thoughts. Templates can standardize and stabilize unstructured information in a patient's record, a good thing, but at the expense of increasing workload and erosion of care provider autonomy by scrutiny over charting which some may resent.

Remedy: Stabilize Data-Dropdown Boxes and Forcing Function

Introduction

Dropdown boxes and forcing function fields (data fields that the user must fill in otherwise the user cannot move to the next screen or field) in the information system can be used for structured or unstructured data to ensure the information is accurate and complete. It is a form of *Information System* standardization.

Descriptive Statistics

The term “drop down box(es)” was coded twenty-five times for 12/20 interviewees: 6/6 nurses, 4/10 non-clinical, 2/3 physicians showing that the clinical interviewees used this term more often than the non-clinical (8 vs 4). Interviewee seventeen, clinical, used this term five times, interviewees one, clinical, four, clinical, five, clinical, sixteen, clinical, three times and interviewee six, clinical, twice, the others used it once or twice. Other terms used in this section are documentation tools, and forcing function.

Qualitative Understanding from the Interviewees

Theme: Drop down box tips: when to use them

Interviewee seventeen has a lot of experience with drop down boxes and shares her tips on when and how drop down boxes can be used and the following quotes show.

The information must be commonly used:

Int 17 nurse 10-20 years' experience health authority: If everybody is supposed to chart item X when the patient's on dialysis, then we build a field. Generally ... We don't make a lot mandatory, but generally, if it's there, people will populate it [para. 11]

Int 17 nurse 10-20 years' experience health authority: We've tried to use the 80/20 rule. If it happens at least 80% of the time, we accommodate for it in a drop down, but if it was like, "We once seen a patient that had this." We're like, "Yeah, you can write that in the comment." [para. 18]

The information must make sense as shown in the example of a choice of planned patient self extubation which is *never* planned by the patient but by medical staff:

Int 17 nurse 10-20 years' experience health authority: We try to be very prescriptive, to say, "Okay, here's our drop down, would you ever pick more than one of these things?" If the answer is, "Yes," then we have to make it multi-select, right? But if the answer is, "No," we make it single select. We have created some that ... One of the ones we built, it's for if the patients self-extubates, for example, or the patient is extubated, let's just say that. If it was a planned extubation, where they're actually going to intubate this patient, then you would pick, "staff, planned." Now, what we've found, looking at some of the reports, staff aren't really reading, or I don't even know what they're doing, but some of them are picking, "patient initiated, planned." From a quality perspective, that was really bad [para. 25-27; 29-30]

Theme: Drop down boxes structure the record with mandatory fields such as patient scores etc. as a forcing function

Interviewee one explains that the role of the drop down is to structure the record with mandatory fields that ensure that the patient's own information is accurate and complete

Int 01 nurse 21-30 years' experience public & private: Um, so the other thing is around you know um, forcing people to use drop down boxes and mandatory fields and um, right and so all of those and you can do that in a digital world and you can then ensure that every time someone is entering in that screen that the mandatory fields are filled in [para. 45]

Interviewee twenty notes that drop down boxes can standardize patient information in clinical scores so patients are scored accurately and precisely. This is a forcing function:

Int 20 physician 10-20 years' experience health authority: Another example of electronic systems improving data quality would be being able to create documentation tools that make it harder for you to document the wrong thing. For instance in the ICUs and the system we have a way of documenting delirium [para. 22]

Theme: Drop down boxes are a convenient way to input data so patient information is more complete

In addition, people are likely to provide data on their patient because drop down boxes are convenient. This makes the patient information more complete:

Int 04 nurse 21-30 years' experience public: sometimes you can have wonderful documentation in a template environment and they only have to fill in a field here and there and they only have to fill out the yes or no. Or a dropdown check box type of thing, you know, people will comply with that kind of thing [para. 68]

Theme: Drop down boxes are more suited to quantitative information

Interviewee nine feels that drop down boxes are more suited to data as opposed to information, and interviewee sixteen says the same. This suggests that only certain types of information, such as quantitative information, can be structured in this way:

Int 09 non-clinical 10-20 years' experience public and private: Data is making sure that you've got the right kind of data in there; the drop down, the content is correct of drop down lists or whatever. Whereas information is more, can the user interpret all of this data, and is it useful to a user? So to me, information quality is more about interpreting the data that may be in the system [para. 2].

Int 16 physician 10-20 years' experience health authority: To meet the need of data quality that I listed earlier, availability and usable, it has to be written out in a way I can read it so that I can actually understand what's going on. If it's a bunch of drop-down check boxes, that doesn't help me. That doesn't help me make sense of what is going on. We're story-telling creatures. Tell me that story of what happened to the patient. Don't show a bunch of check boxes to me. That doesn't help me. It's a nightmare for trying to collect, to do analytics on physician documentation, but that unfortunate side effect is at least mitigated by the fact that the quality of the data from the user for understanding the patient is higher [para. 31]

Theme: Drop down boxes are a good forcing function for medication uses but still need human validation checks

Interviewees felt that drop down boxes or a forcing function using mandatory fields in a decision support environment are very valuable for medication order standardization that can decrease hospital mortality presumably from better prescribing:

Int 05 nurse 21-30 years' experience health authority: Right and so the ampules still look the same so then you have selected the 2 mg/ml full strength is this correct or no and then you choose yes and those types of problems on that kind of an information system. I think as much as you think I am back to wanting to force the function [para 56]

Drop down boxes are not error-proof because someone can pick the wrong medication selection that one hopes a pharmacist will catch and validate before a medication error happens. This suggests, as will be seen elsewhere, that human intervention is still needed with electronic charting:

Int 04 nurse 21-30 years' experience public: So we hope that we have a pharmacist in the middle now who looking at that order coming through and saying did you really mean that because it is great, you don't have to spell as well as we used to, we take a lot of things off of a dropdown list but you know we think that something is highlighted and something else was [para. 51]

Theme: Drop down medication errors are still less than unstructured data orders so drop down boxes are safer

However, the physician feels that drop down box medication errors contribute to medication errors less than handwritten medication orders:

Int 16 physician 10-20 years' experience health authority: so okay, occasionally the wrong drug will be ordered because it looks alike or they check the wrong drop-down menu accidentally, but those are less frequent events, and also improve the workflow for the pharmacist because they don't have to try and interpret somebody's scribbles [para. 41]

Theme: Critical patient information in an unstructured data text field may be missing if the care provider reviews only the drop down boxes and not the rest of the record that could have rich

important patient information for decision maker:

Int 01 nurse 21-30 years' experience public & private: increasing probably the richness of the information quality that you are collecting by having um, the standardized drop down boxes and so forth, you are automating it. So I mean that is good but then when you have, the other thing is when you have an exception and you put it into "other" or comments or right now it becomes text and it if you are doing any kind of an analysis as you know the text boxes of whatever that is missed the data. So say ya, you could in fact be missing some fairly significant or important data because it doesn't fit into one of the boxes [para. 46]

Interviewee seventeen agrees but expresses it differently by saying that the information will look complete if the text fields are filled in because people have the urge to write and use the text field instead of the drop down boxes:

Int 17 nurse 10-20 years' experience health authority: They've completed all of these forms, and all these drop downs on admission,We pushed back on adding something to give them a note area, because we actually want them to fill out the drop downs, because that's where we get our data for quality from. We're afraid if we give them an area to write free text, they'll put it all in the free text and it looks complete [para. 94-95]

Summary

The predominately clinical interviewees feel that drop down boxes are a useful tool for standardizing mandatory fields such as identifiers or acuity scores so the patient's own information remains accurate and complete. Drop down boxes allow users to select data elements but they do not convey the rich information that is in free text.

Mistakes can happen by making a wrong selection, for example a medication, so there is always a need for human checking in the electronic system as there was in the paper system. This is called validation and the interviewees have opinions to share about it too in the next section.

Remedy: Stabilize Data-User Validation Checks

Introduction

Validation means a care provider checking the information with the information source and making a decision about how that information should be handled. There is also a realization that human judgment will never be replaced. This is a *user* or *staff* remedy to stabilize data in the care process.

Descriptive Statistics

The term “validation” or “checking” was coded thirty times for 13/20 interviewees: 5/6 nurses, 6/10 non-clinical, 1/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical (7 vs 6). Interviewees five, clinical, and seven, non-clinical, used this term five times, interviewees one, four and sixteen, three times and the rest one or two times.

Qualitative Understanding from the Interviewees

The interviewees point out some of the different aspects of validation for information and for the information system, two parts of the triad.

Information

Theme: Staff validation checks maintain and preserve patient identity

We have seen that patient admission is a critical time for establishing correct patient identity and accurate and complete patient clinical information for the patient profile that becomes the core set of information for the rest of the admission. Interviewee comments on patient identity processes and validation has been discussed above in section 5.3.7. There is a need for validation to evaluate and correct the patient information because of poor history taking; this validation is important because it becomes part of the patient profile:

Int 19 pharmacist 10-20 years' experience health authority: a resident that's doing the interview with the patient in a emerg oftentimes or if

they're coming through pre-admission clinic it would likely be nursing staff or pharmacy staff that would be doing it. I will say that we have quality issues when it comes to getting a good medication history in emerg at 2:00 in the morning. We do have pharmacy technicians on each of our units here that will evaluate each of the histories that have been taken and repeat as necessary [para. 38]

Theme: Professional staff validation checks maintain and preserves other patient information

There is also a need for validation with a patient. In the below quote a pharmacist picked up a medical error a was the case here by validating information with a patient:

Int 19 pharmacist 10-20 years' experience health authority: I think it was the pharmacist on the unit and speaking to the patient, asking them about their furosemide dosing and they were like, "Well no, I was taking twice a day at home," and through that conversation after the admitting orders are written it came to light that the information was old [para. 46]

Theme: Professional staff validation checks counteracted system assumptions when patient clinical assessment and judgement were undertaken

The nurses cautioned that there was an over-reliance on a system that can replace clinical judgement or common sense, and, given the ubiquity of system access this could cause an adverse event as decision makers are acting on missing patient information as the following quotes illustrate:

Int 14 nurse 21-30 years' experience health authority: So we know in some of our ancillary areas that collect documentation and also do some assessments on theirs ... That would be patient care coordinator, a manager ... whoever the designate is ... can now much more easily review the care that's being provided. I think it's more improving care provision but I always caution and balance that with not removing the aspect of critical thinking. That still needs to occur even though we're using a new system to make sure the patient's being properly cared for [para. 19-20]

Int 17 nurse 10-20 years' experience health authority: So if you're not keeping your charting up to date, especially electronically, when

you have potentially people dealing with charts off unit and making decisions, perhaps, because it's four o'clock in the afternoon and they don't see any urine output since at seven AM. You know? I think then ... I would hope they would come up to the unit and evaluate the patient before they did anything. Do you know what I mean? It might alarm some people before they knew what was really going on. I guess that would impact patient care, if the quality of the information being answered wasn't entered [para. 136-137]

Theme: Professional staff validation checks, the human piece, are still needed to check that certain critical systems such as infusion devices provide accurate dosing decision support:

Int 05 nurse 21-30 years' experience health authority: This is what I got, I programmed heparin and they look at it and say yes correct you have the right drug that you programmed in. so it is um, it is good to a point but there is still a human piece that they have to I don't know that you can ever take it away completely. It is one area that of information systems that has improved um, with that um, human factor [para. 31-32]

Theme: Professional staff validation check workflows for a paper hybrid system needs to be replicated for the electronic information system; for example, double staff checks for medication orders

The nursing clinical staff mention the important point of validation as a check on patient orders and how the old manual nightly check safety net needs to be replicated for the electronic system checks:

Int 04 nurse 21-30 years' experience public: I mean so, the old days we used to check the charts at midnight and you don't have a paper record to do that now what is your mechanism and you don't need to looking for stop dates on drugs because it was done at the time of order. Um, so those kinds of things are picked up and how are you ensuring that you haven't missed anything, whose responsibility is that, and how do you build it in? [para. 59]

There are modern equivalents such as double checks for certain medication orders as described by one participant in the below quote:

Int 05 nurse 21-30 years' experience health authority: quite a few higher alert medications and there are some that really are mandated that you have an independent double check and that means two people would look at the medication and figure out the dose and come to the correct answer and compare and um, do their own independent double check. So things like that would commonly be influenced heparin, intravenous narcotic infusions, those are medications that have a high potential for significant harm [para. 30]

Theme: Staff validation check can also happen after a system check can be for other types of patient information too:

Int 12 non-clinical 10-20 years' experience health authority: Even though I would prefer a different decision making tool that would say hey, doc, you put x but your patient has y. Why did you put this number, kind of flag it. What we do is after the information has been put in, there's kind of a number of algorithm that's being built in the background, and then we have, we call them quality report that are being printed at the nursing unit for assigned individuals that kind of go back and go see the physician and say did you really mean to put that? [para. 25]

Information System

Validation with users and other experts is an important process to maintain the integrity of the data within the information system. The interviewees provide validation steps in the different parts of the information system life cycle as will be described in the statements below.

Theme: User and expert validation check should happen in information system life cycle design and use

Design

Validation during design could also forestall adverse events caused by merging data sets that cause missing fields in the patient's report:

Int 09 non-clinical 10-20 years' experience public and private: Really, making sure what we learned through that, is that during the

design phase of an implementation, you want the right people looking at the design to interpret it. What we needed to do was have both, for the lab situation, the end users that are reviewing the results, the physicians that interpret it, plus the lab person there too, so that together they were looking at how that lab data was coming across and being interpreted. Making sure you've got that ... you're taking into account all your clinical groups in your design is key to figuring out how you can really increase information quality within the system [para. 13]

Use

There is the nursing professional's validation of the clinical data produced by a device that is then considered accurate for the database

Int 16 physician 10-20 years' experience health authority: The bedside nurse will validate the data that they see. They are required to validate a certain number of values and a certain number of assessments per shift, based on not only frequency, but also on event. If a patient's completely stable, they don't have to select valid data points for that patient as frequently, but if a patient's rapidly changing, then they are frequently saying, "Yes, that blood pressure that was 60, that's abnormal but that's absolutely what it was," and say, "Yep, that was a valid number [para. 37]

Summary

Validation is primarily a clinical step used by staff and information system users. This is reflected in the predominant clinical use of this term by participants during the interview. Validation involves professional care providers checking the information to increase its approximation of truth by using their either knowledge and experience or verification with a patient. This process means that professional staff can correct any potential inaccuracies or gaps that could contribute to an adverse event. Validation can also be applied to system design and use. The information system cannot replace human clinical judgement or expertise. The next section of this dissertation will look at the information system and its effects on information quality as expressed by the interviewees.

5.3.8 Information System Instability and Some Remedies

Information System Instability affects Information

Introduction

Just as we have seen for information with its structured and unstructured data so there is an equivalent dichotomy with two systems, an unstructured paper chart and a structured electronic system, retaining information for the care providers.

The health care system is currently a hybrid of these two systems. Both the clinical and non-clinical interviewees comment on this and how systems can be stabilized so the information within those systems could also be stabilized.

Instability: Hybrid Paper Chart System

Descriptive Statistics

The terms “hybrid”, “paper”, “paper chart” or “chart” (assumed to be paper chart) was coded twenty-two times for 12/20 interviewees: 4/6 nurses, 4/10 non-clinical, 3/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical (8 vs 4) likely because they work with the paper chart routinely. Interviewee one, clinical, used this term five times and interviewees two, non-clinical, and fourteen, clinical, three times. and the rest one or two times.

Qualitative Understanding from the Interviewees

Most interviewees have issues with the hybrid paper chart as we shall see.

Information

Theme: Ideal state-patient information should be easy to find

The patient’s information should be easy to find and use even in a paper chart:

Int 16 physician 10-20 years’ experience health authority: When I said the data needs to be viewable, it means that I should be able to look at a patient's chart, electronic or paper, and be able to see

what I need to see quickly and efficiently [para. 6]

This is not often the case as we shall learn.

Theme: Unstable-information is missing because information is not accurate or complete or can't be found in the chart

The main concern expressed by the interviewees is the risk of missing information so the decision maker does not have all the patient's information available. The information may not be accurate and/or complete. The paper chart in the hybrid system can be disorganized so that, although the patient's own information is in the chart, the most relevant or recent information is missing for the decision maker:

Int 01 nurse 21-30 years' experience public & private: well poor information quality really is when you have either um, well if you have not the chart is not complete, right or if you have a situation where charts are mixed up [para. 17]

Theme: The information is missing because the chart is unavailable or parts of the chart are lost

The information may be missing because the paper chart is not available to the detriment of patient care:

Int 05 nurse 21-30 years' experience health authority: We have um, we have are definitely having difficulty with the demands on that paper chart still and so um, that is one way that the electronic record system would be very beneficial cause we are now a teaching facility and we have residents and they are all looking through that chart to review so there is still a heavy emphasis on that chart To review so there is still a heavy emphasis on the manual charts [para. 100]

Int 20 physician 10-20 years' experience health authority: Hence the greater utility of electronic sources of health information on paper and archived. There's a delay to get that, to make quite a difference in the care that the patients receive, number one [para. 8]

There are instances where information on in a paper file fell out of the chart in transit:

Int 13 non-clinical <10 years' experience ministry: I think more people are checking it, and more people are aware of it. For example, when you move to a hospital, you can lose information. That paper can be lost, or we don't know where that MRI requisition went, for example. On an electronic record, everything is on that electronic record, so when you move from center to center, you know where everything is [para. 13]

Theme: Information is missing because of poor charting

In some cases, the work culture fostered poor charting and staff decided they didn't need to provide that piece of information in the electronic system that they didn't provide in the paper chart:

Int 14 nurse 21-30 years' experience health authority: Bringing the system in, you don't need to spell that or put that particular form in there because we don't do it anyway. They were opting out of something that wasn't optional. Understanding that there was a big gap that exists in that particular area. You know how culture exists and someone come in and "you should be" and "oh no, we've never done that." [para. 60-62]

Theme: Missing information means a poor decision will result because of delayed transcription

Interviewee one noted that the decision will not be a good one because of missing information because it is not on time for the care giver:

Int 01 nurse 21-30 years' experience public & private: So I am a clinician and I am trying to make a decision on treatment for this client and if I don't know where to look. I am not aware of this consultation even I was thinking that ok maybe the consultation hasn't note hasn't arrived yet because I don't see it in the chart so it probably caught in transcription somewhere but it could be on the chart so ok, so now this is where it gets interesting if the consultation is there then it is presumed that I as the clinician has access to that information and that I am making my decision based on all of the information. If in fact the you know the way that information is filed is um, not allowing me to efficiently and timely have timely access then, you know and I make the mistake

and somebody health is compromised because of it [para. 22]

Theme: Information is complete, but is not useful because the health professional can't get a sense of the patient

The paper chart may have complete information in it but the information is not readily accessible so it is difficult to get a sense of what is going on with the patient:

Int 19 pharmacist 10-20 years' experience health authority: I think part of the reason is because in a paper chart it's really hard to have a sense of what the patient's actively on. We think what happened was it was a surgical floor, surgeon was asked for meds to treat pain, didn't look at the chart to see that they were already receiving other NSAID⁵⁸'s, prescribed yet another NSAID. It got missed in the pharmacy presumably because of our horrible alert firing and our sort of yet another alert ignored, override, override [para. 77]

Theme: Scanned PDF information inserts are not legible or in the wrong place in the chart so the information is unavailable

There is another kind of hybrid chart where paper records are scanned as PDFs into the electronic chart. This can also cause problems with missing data because the scanned document is not legible:

Int 02 non-clinical 21-30 years' experience public & private: a lot of systems take paper information and paper documents and they scan them and so they are sharing scanned copies. So emergency discharge summaries are often hand written by the physician and then they are scanned and they are shared up in the true system and a lot of times you can't read it [para. 2]

Or because the scanned documents are not coherently placed in the record so there is the same difficulty in getting a sense of the patient as interviewee one noted with the paper chart, just in a different format:

⁵⁸ NSAIDs are non-steroidal anti-inflammatory medications like Aspirin

Int 01 nurse 21-30 years' experience public & private: areas you are going to have a hybrid situation so there is going to be some paper and so what they are doing in the hospital and so forth is they are scanning it in. Those documents are they are not interactive at all they are just a pdf and they are just scanned in. And once they are scanned in then the process is to destroy the paper chart because now the scanned document becomes the original source, right. So there are some limitations and there are some good things with that because now you have the papers inside the electronic but the downside is that it is just an object right. And so you have to read all of these objects separately and try and piece it all together as opposed to the electronic system [para. 19]

Theme: Staff make personal notes on paper that may be entered into the electronic chart wrongly

There is also a common hybrid situation where staff write down information on paper then enter it later in the electronic record thus risking a potential data entry error on the electronic record:

Int 18 physician 10-20 years' experience ministry: then you got nurses capturing data on paper towels then trying to get to a computer to enter it and all that has a great deal to do with the quality of the information [para. 23]

Theme: Health care may never be completely paperless!

Despite the many failings of the hybrid paper-electronic system interviewee fourteen wonders if the patient's clinical records will ever be completely paperless because much of the health care system is still paper based:

Int 14 nurse 21-30 years' experience health authority: We will still be in a hybrid for a number of years until we get all the physicians on. I'm always curious at the end of the day, aside from actually scanning and if you have scanning on units during the patient's stay. I'm curious on some sites that are actually completely paperless. How to get away from without having all of the processes because there's still so much paper that comes in [para. 53-55]

Summary

The mostly clinical interviewees used terms such as missing data or inaccurate data entry resulting in poor decisions that are similar to those for unstructured data; this is not surprising given the paper system format holds unstructured data and that clinical staff work with the paper chart routinely. The interviewees have clearly described that there are several types of hybrid records such as the paper chart, notes on paper and scanned PDFs all of which can contribute to missing data and information instability for the decision maker making the information inaccurate and /or incomplete. Interviewee nineteen commented on a hybrid situation that factored into an adverse event. The loss of a paper system makes staff more accountable for record keeping because the more structured format of the electronic record makes it harder to not chart, as interviewee fourteen notes. The interviewees also talk about the electronic information system itself affecting information stability in the next section of this dissertation.

Instability: Electronic Information System

Introduction

Just as the paper system is unstable, so too is the electronic information system. Information system instability can lead to missing information from different causes as the interviewees will explain.

Descriptive Statistics

This section uses three sets of codes to document the interviewees' thoughts on how the information system can affect the information within it. There are the two a priori groups for questions eight (i.e. issues for implementation), fourteen (decreasing information quality) and the inductive or descriptive catch-all code for system.

Question eight was coded for 19/20 interviewees: 6/6 nurses, 9/10 non-clinical, 3/3 physicians and the pharmacist. There were forty eight codes: interviewees one, clinical, and two, non-clinical, used this term six times, interviewees four, clinical, seventeen, clinical, and twenty, clinical four times, and interviewees eleven, non-clinical, and sixteen, clinical, three times. and the rest one or two times.

Question fourteen was coded for 16/20 interviewees: 4/6 nurses, 8/10 non-clinical, 3/3 physicians and the pharmacist, an equal match. There were seventeen codes for examples for 15/20 interviewees: all the interviewees had one or two examples.

The term "system", a catch-all term used for instances anywhere where system was mentioned, including outside of a specific interview question on the system, such as questions six to nine and fourteen.

This term was coded ninety-five times for 19/20 interviewees: 6/6 nurses, 9/10 non-clinical, 3/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical (11 vs 9). Interviewees sixteen, clinical, used the term eleven times, interviewee four, clinical, ten times, interviewees one, clinical, and eighteen, clinical, eight times, and interviewee twelve, non-clinical, seven times and the rest, twice. The segments coded

under system were used throughout the analysis in this chapter as needed to provide interviewee insight on different aspects of system as relevant in a given section.

This section provides some examples that point to information system instability. It would be reasonable to assume that almost all of the examples provided by the interviewees relate to software programming errors.

The system-related terms used in this section include: “programmers”, “programming”, “automation”, “formula”, “technical intervention”, “system induced errors”, “product upgrade”, “technology induced errors”, “developers”, “building”, “modified”, “technical issues” and “upgrade”.

Qualitative Understanding from the Interviewees

The interviewee’s comments are organized to show examples of *Information System* instability throughout the system life cycle starting with design.

Design

Theme: Missing information resulting from poor design may not be immediately obvious but show up later when that bit of information is needed

The system design needs to be carefully thought out before automation to minimize problems later, (i.e. problems that may not have a direct connection to the design):

Int 02 non-clinical 21-30 years’ experience public & private: when you go to automate you have to really understand what your current processes before you can ever redesign them or automate them. And um, often they are not the right skills or the number or resources or time spent on that. Um, so that is one area where you can have the technology reduced errors or issues, right, maybe not errors right but you could have issues down the line .It could be an error or a new inefficiency or it could be maybe it was a department that was collecting data off a piece of paper that you got rid of and you weren’t aware of it [para. 38]

Theme: Programming modifications for Canadian system may create unknown risks

System instability can start at the beginning when the system is purchased and modified for the Canadian setting. This requires programming for this setting that can create unknown risks:

Int 01 nurse 21-30 years' experience public & private: So these systems are built on American models and they have to be because there is ten times the population in the US than in Canada so we buy these things but generally they are made in America for Americans right. So when we bring them here to Canada there is some things that are different here in Canada so then you get um, the modifications done and so that means there are programmers going in and breaking code and changing code and whatever. Ok, so that is a risk and the reason is that because you know how do you test everything because now if you link up with something how do you know that you haven't effected something else [para. 27]

Theme: Programming, a coding formula, can cause a disconnect between data entry and output so there is an information error if there are programming errors:

Int 12 non-clinical 10-20 years' experience health authority: Then sometime even in the formula. That's when technology-induced error in the sense that the physician put in number two, or when the mathematical formula gets in and it gets processed, it spills out a five. That would be an example where technology would induce less than satisfactory, obviously, data quality [para. 52]

Theme: Programming even drops the data entirely so it is missing or makes abnormal data look normal, a false negative result so that either a clinical decision is not made or is made based on missing information:

Int 01 nurse 21-30 years' experience public & private: So say for example somebody is in trouble but the technology doesn't record it, it records it as normal the nurse is just going to sit there and go well you know that one sat there looking fine there and I am going to put my attention to these people that need the help [para. 68-69]

Theme: Patient information may seem missing because it is delayed

Int 20 physician 10-20 years' experience health authority: So if the abnormal vital signs are coming in a delayed fashion, yeah you're

going to miss something if you're looking at some kind of trend or relying on some trend to make a decision [para. 49]

Theme: Accurate and complete information may compensate for missing information

The fact that the system has missing data may be mitigated if the accuracy and completeness of the rest of the data compensates for the missing data so the decision maker can put all of the data in context and make a decision:

Int 16 physician 10-20 years' experience health authority: While the chart is, well the electronic record is a continuous stream of data is the patient's record, it is understood that errors can occur in the recording of the numbers that are not reflective of the patient's actual state, and it's not necessary from a medical-legal perspective to have to make any changes to that record. You can accept the errors. You can flag them. You can say, "Yeah, I'm aware that this is probably erroneous," or the transducer was on the floor or what have you, but that's not entirely necessary because by collecting all of the data continuously, you can get that sense just by looking at the data [para. 9]

Patient Identifier Effects

Theme: Programming to simplify a system can cause problems if some of the system validation steps are lost. This would affect the patient identifier:

Int 04 nurse 21-30 years' experience public: so the minute you start focusing more on simplicity um, you are often compromising the safety components that you would build in, the checks and the double checks and the mandatory fields kind so things that you would see in the system [para. 12]

Theme: Programming could allow a dummy identifier in a field where a true one would be so the data set becomes corrupted:

Int 07 non-clinical 10-20 years' experience ministry: Um, and so what one of the systems does unbeknownst to us is if there is a blank there rather than sending it back to the source it um, it is putting in a default value. Yes it isn't the true value so it is passing the validation

because the value fits the format but it is not necessarily the correct value, so that sort of thing where you have technical intervention that hasn't been properly tested [para. 9-10]

Theme: Unannounced vendor upgrades that creates an patient identifier to data mismatch so that a decision could be made based on another patient's information:

Int 03 non-clinical < 10 years' experience public: we have certainly do see some front end errors where um, your patient identification has been incorrect due to data entry or what have you, but we have also seen um, system induced errors um, we have had one or two cases where a vendor has done a product upgrade and introduced a problem that has caused the wrong patient identity to be tagged to results that they are sending um, so that has happened and that is um, very serious issue [para. 22]

Other Data Effects

Theme: Programming to simplify can contribute to an adverse event because removing safety features such as medication alerts to minimize alert fatigue

Int 04 nurse 21-30 years' experience public: Or because someone is allergic to whatever they should not be on this type of drug or they are taking this type of meds you know they shouldn't be taking this kind as well, it is when you start removing those kinds of alerts because they don't want to see them. They remove the kinds of things that could saved them which basically now you just have a glorified type writer that you are working with because it is the same as when you used to work with paper [para. 47]

Theme: Poor system design cannot be made usable with training

Interviewee sixteen notes that no amount of training can remedy a poorly designed system that is unusable:

Int 16 physician 10-20 years' experience health authority: That's a frequent thing I hear when we talk about changing a system. They'll say, "Oh, that's just a training issue. We'll get them in training." No, if it's poorly designed, you can train all you want. In many respects, it doesn't make the problem go away [para. 44]

Theme: System does only what the programmers tell it to so this must be right

The interviewees stress the importance of design and programming the system because they feel that the system is a passive vehicle that does only what it is told to do

Int 12 non-clinical 10-20 years' experience health authority: Because often what happens with IT system is people think that, oh, buy a system and it'll fix it. Really the computer system is what you put in is what it's going to put out. If your process is not clear then you still won't have better data [para. 27]

Int 07 non-clinical 10-20 years' experience ministry: Well just the information systems are just that, they are computers and they only do what we program them to do right [para. 36]

Implementation

System implementation is another risky time that can threaten information quality as the following interviewees explain. These implementation incidents are often unanticipated in the design phase:

Theme: Rushed implementation can lead to programming errors and incorrect information:

Int 17 nurse 10-20 years' experience health authority: Then it got pushed to production and people started using it, and they needed to chart to one decimal. The order would be for 16.2, and they could only chart 16. The patient was receiving the proper amount, they just couldn't document it [para. 128-129]

Theme: Some poor information quality is inevitable after implementation because the test environment can never replicate reality so there is some malfunction

Interviewee twenty sees degraded information quality from unstable systems as an inevitable part of implementation that should be anticipated because the test environment can never perfectly replicate the production environment in the clinical setting:

Int 20 physician 10-20 years' experience health authority: So despite all of that on our early couple of go lives, yeah we actually found errors and they were technology-induced errors where something

like these five things would happen together and it would create erroneous data. We only discovered that after go-live. One of those ended up basically shutting our system down for a week until we could fix it and needing to get the vendor make some changes to the core coding of the product and releasing emergency hot fixes and all that kind of thing [para. 38]

Int 20 physician 10-20 years' experience health authority: Fortunately the number of technology-induced errors have been relatively small, certainly not none. I think the small ones that happened there reflect the fact that you can't exactly mimic the clinical environment in a testing environment. You can get close but you can't do it. I've just sort of resigned myself to saying I expect there to be problems. I wish there weren't but I know there will be and I should just be prepared for that. We just have to be prepared to detect them, to react to them, to have enough resources to be able to respond to them, et cetera [para. 41]

Interviewee one notes also despite careful design field testing can still cause the system to malfunction:

Int 01 nurse 21-30 years' experience public & private: honest to goodness we implemented it was a such poor quality but yet all of the scenarios that the developers could dream up were we presented scenarios and we tested them but when you got into the actual field it was awful, it was so, so awful [para. 57]

User Interface

When we get to the interface level with the user, there are information system issues that can affect information quality. This may not be because the information in the system is inaccurate or incomplete but because the user misinterprets the information he/she sees because of the ways the data is displayed or entered.

The information should be easy to see, whatever the medium:

Int 16 physician 10-20 years' experience health authority: When I said the data needs to be viewable, it means that I should be able to look at a patient's chart, electronic or paper, and be able to see

what I need to see quickly and efficiently [para. 6]

However, the interviewees have some examples where this is not the case.

Theme: The demographic information may be difficult to find in the data display

For example, users often miss the demographic information, ie the important patient identity information:

Int 04 nurse 21-30 years' experience public: So how do you now know that you have the right patient because one of the common errors with information systems is patient identification and it is fine if the patient is properly identified in the system but just the way the headers are laid out patients discover they documented on the wrong patient. The demographic bar that often goes across the screen that says that I have Mary Smiths chart and she was born on such and such a date etc. and people have a tendency to not pay attention to that [para. 28-29]

Theme: Other data may not be accurate or complete in data displays too

Interviewee four is also sceptical about the dashboard displays in a platform, for example, and asks how accurate or complete is the information presented on the different versions:

Int 04 nurse 21-30 years' experience public: I look at obviously the clinical data um, tombstone data because there is some impact from A co morbidity and that kind of things but then I am also looking at what am I getting documented. So if I was wanting to say you know do we want a XXX platform or a this platform or that platform? Um, what is it that gets documented? Um, and then look at they are typically not mandatory fields so what is the probability and if I look at diagnostic information and I am not seeing um, particularly significant clinical documentation why is that? If I would expect to see certain kinds of documentation for a diagnosis why am I not seeing it [para. 68]

Theme: The screen font and contrast may be poor making information difficult to find

Int 04 nurse 21-30 years' experience public: And depending on

the system design on how it does highlight it for you um, you know sometimes depending on the visual acuity even in the best light it is hard for them to see if the grey out is too much or they use white print on grey or you know where full black would be better [para. 52]

Int 16 physician 10-20 years' experience health authority: I will vociferously complain about the quality of the font size when that doesn't seem like a big deal. I will say, "No, no, no, that matters. In fact, stop what you are doing. Everything. This needs to be fixed now." I'd like to think that that eye for usability earlier mitigates some of the technology-induced errors, but I know they don't all go away [para. 35]

Theme: Different keyboards layouts can enable wrong data entry of numerical information because the system is not user friendly as the following quotes show

Int 12 non-clinical 10-20 years' experience health authority: Another example is of transcription orders, for example. Today, the orders are put in paper and then people are transcribing information using the system, but there's different computers. Some of them has the numbers at the top and some of them has the number on the side. We found that depending on the keyboard that people are used to, they may be entering the wrong information without knowing it [para. 51]

Int 18 physician 10-20 years' experience ministry: In general, when I read a lot of the literature on this, there's not as much about the inner workings of the systems are usually pretty good, it's usually a user interface-type issue, but that means that either physicians or clinicians can't find what they need or they're entering it in the wrong place, or that the context switching isn't working and they're entering data on the wrong patient, or that sort of thing versus the systems ... the technology itself [para. 31]

System Integration

Theme: Poor integration leads to truncation of important information is-as a result the system has no credibility and the information is considered untrustworthy:

Int 02 non-clinical 21-30 years' experience public & private: So the tests were ordered and they never received the results they didn't know that this was responsible problem. Um there was a few examples here where lab results were actually wrong patient, now they fixed that without any problems but it certainly I would say impacted the clinicians' confidence in the system, that was probably the biggest impact that it had. Those were mostly technical issues and the indexing numbers were truncated so they weren't attaching to the right person. what caused it but it was an interface problem [para. 27-29]

Theme: Poor system integration of system time clocks leads to inaccurate time for clinical event such as time of death

Interviewee twelve brings up the interesting example of seemingly unrelated systems contributing so erroneous information about a patient because the facility clocks were out of synch with the system clocks creating an accurate time of death:

Int 12 non-clinical 10-20 years' experience health authority: We found out the clocks were wrong. Depending on where you were in the department, you would write down the right time, but you can just see that. If you add 10 minutes every time, you can see how it can be affecting your overall wait time. What we did is we actually implemented electronic clocks. Every day, there's actually a thing that it gets reset that makes sure and that they're auditing being done on the clock After that, we found out that, well, okay, that wasn't just the clock in the wall, but that was the computers. The computers, depending what system they link it with, the clock wouldn't say the same times. This totally affected our data, and that's another technology-induced error [para. 56-60]

Theme: Integration is complex with several points of failure with points of failure increasing as complexity increases

Interviewee eighteen sums up the complexity and the potential points of failure when integrating multiple systems each with their interfaces:

Int 18 physician 10-20 years' experience ministry: Yeah, well, I think for whenever you're implementing something new, you're usually- Very few of us are living in a complete greenfield environment, so generally we're always ending up trying to migrate some data or to integrate data from other sources, and I think there is always challenges with that. We're not tremendously good at using our SNOMED CT structures or LOINC or those are standards around data itself, so all of our information is in different structures, different schemas, different formats, and when you try to bring it all together, there's a lot of stuff that has to be done and a lot of testing and a lot of ... in some cases, transformation ... that has to happen for that data to retain its quality, to retain its integrity, and its semantic interoperability, if you like, so in my world [para. 33]

In a similar vein, the same interviewee feels that the points of failure increase as the complexity increases:

Int 18 physician 10-20 years' experience ministry: It's when we kind of have to transfer and transition patients that sometimes, it's problematic inside the hospital as well, certainly moving outside the hospital walls and making sure that the quality of that information is sustained across multiple systems and multiple settings is a more complex problem than just within a hospital [para. 17]

Theme: Overall system needs constant tweaks and upgrades that can introduce further error

Overall, the information system needs constant maintenance and upgrades that can introduce errors of themselves as the interviewees have explained when there are programming errors.

Int 02 non-clinical 21-30 years' experience public & private: The constant maintenance of it, you always have to maintain it and you always upgrades are having to modify the system because there are always changes that you have to make right [para. 90]

Legacy System Integration

Theme: Integration of legacy systems working beyond their lifespan creates information

instability

Moving on from one system, there are information instability issues that can arise from the hybrid electronic system that is an amalgam of many legacy systems all trying to work together beyond their original design limits. These systems are being pushed beyond their limits with integration.

Int 01 nurse 21-30 years' experience public & private: what we have is a hybrid but not really a hybrid it is an environment where you have um, multiples of information systems and they have evolved over the years and they are patched and they are basically made to work over the years and they are they might be doing stuff that they never intended having them do and the people have been pushing and pushing and pushing and building and they say if we only have these data in there and whatever, so people have been modifying and changing them as well, right. So essentially you have no integrity of the system now because it has been adapted so much and modified so much and now it is adapted right [para. 29]

Theme: Legacy system integration and modifications can lead to information instability

There are so many modifications that the information is compromised:

Int 01 nurse 21-30 years' experience public & private: these systems a lot of them are old and out dated, modified to the nth degree right and so you have got to ask what is you know, what is the quality of the information going in and what is the you know, what is the accuracy and so forth, all of those issues. We have come to the fork and that is today's reality [para. 32]

Theme: Legacy system integration with registry system have potential to corrupt patient identifier

There are particular concerns when systems are linked to the registry systems that are the sources of truth for patient identity:

Int 04 nurse 21-30 years' experience public: now many of the um, information systems, clinical information systems receive data from other sources so they are clinical system is dependent on their client

registry system um, to pull up and identify a patient so when I am looking at those kinds of either interfaces or however it gets that data what are the safeguards in that client registry? Do they let them put in anything any way they want? [para. 3]

Theme: Legacy system integration is difficult because of different HL 7 messages

The non-clinical interviewees speak of the difficulty of reconciling the HL 7 messages of the different legacy systems as the following quotes show:

Int 03 non-clinical < 10 years' experience public: The other difficulty is that systems are all um, varied and different and even though they are all sending the same HL 7 message the report has distinct formatting etc. so the difficulty for every source system to try and pick out where do they have the patient identification and can we pick it off the report to do that type of matching and you are talking about hundreds of source systems sending data becomes unwieldy [para. 40]

Int 11 non-clinical <10 years' experience health authority: Integration in Canada right now, especially I know in our organization, it's so hard to integrate the system because they have to be using the same healthcare standards or HL 7 standards. Without that, it's really hard to integrate and it takes a team of people and they have to have so much experience. I know our team has people who have been working in IT for more than 20 years and it's a difficult one for them to connect all the dots because you need to know if we're implementing this healthcare system that is supposed to be integrated and having one system for the whole Health Authority [para 24]

Decommissioning Legacy Systems

Theme: Patient information can get lost and missing through poor data retention practices:

Int 07 non-clinical 10-20 years' experience ministry: something like the data migration so if um, a health information system was being decommissioned and they wanted to move their data from one system to another and they didn't have guidance on proper you know record retention or validation processes to make sure that if all of the data was moved [para. 45]

Summary

Almost all the interviewees have provided understandings and interpretations on how electronic system instability (from programming issues most likely) places demands on the information and the users accessing the system primarily through the phases of the system life cycle from design to decommissioning, system integration, user interface with an end result of a fragile system.

The interviewees also provide some remedies for some of these issues in the next section.

Information System Remedies: Increase Stability

Introduction

The interviewees provide information system remedies to reduce instability. Increased stability can mean in this research context that the information system is user friendly and reliable so care providers do not feel compelled to continue using a hybrid system or free text such as personal notes. Electronic information system remedies include: better data display, user friendly and intuitive interfaces, increased automation and integration. Stringent logging off procedures would reduce the likelihood of introducing another patient's information to a patient's chart.

Descriptive Statistics

This section uses three sets of codes to document the interviewees' thoughts on how the information system can affect the information within it. There are the two a priori groups for questions six (information system increase information quality), thirteen (ensure quality) and the inductive or descriptive catch-all code for system.

All twenty interviewees answered question six with nineteen providing examples: 6/6 nurses, 9/10 non-clinical, 3/3 physicians and the pharmacist. There were thirty-two codes for examples; interviewee fourteen, clinical had three examples and the rest, one or two. Question thirteen was coded for 6/20 interviewees: 2/6 nurses, 3/10 non-clinical, 1/3 physicians. Each interviewee had one example in this rarely used question.

The term "system", a catch-all term used for instances anywhere where system was mentioned, including outside of a specific interview questions on the system, such as questions six to nine and fourteen.

This term was coded ninety-five times for 19/20 interviewees: 6/6 nurses, 9/10 non-clinical, 3/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical (11 vs 9). Interviewees sixteen, clinical, used the term eleven times, interviewee four, clinical, ten times, interviewees one, clinical, and eighteen, clinical, eight times, and interviewee twelve, non-clinical, seven times and the rest, twice. The segments coded

under system were used throughout the analysis in this chapter as needed to provide interviewee insight on different aspects of system as relevant in a given section. This section provides some examples that point to *Information System* instability remedies.

The key system mitigation terms used in this section include: “monitor”, “accessible” and “more efficient”, “less noise”, “legibility”, “mandatory fields”, “complete”, “less able to document wrongly”, “pressure”, “gaps more visible”, “conformance”, “standards”, “reduce human factor element”, “self-directive”, “smart enough”, “automated”, “configuration”, “integration”, “technical enabler”, “reminders”, “prompts”, “data display”, “clinical advisory group”, “clinical design team”, “logging out” and “natural language processing”.

Qualitative Understanding from the Interviewees

The interviewees provide advice and recommendations for improving the information system’s handling of patient information.

Information

Theme: Electronic system provides faster access to patient information for improved care diagnosis and decision making

Interviewee nine has an excellent live example of how information systems can improve patient care and decision making in an acute care setting through faster access to patient information:

Int 09 non-clinical 10-20 years’ experience public and private: They had gone from completely paper-based to full electronic record. We had decided to do everything online, so from the point of intake, to orders, to clinical documentation, to the departure process, all of that was made electronic. That was really cool to see their transformation and now know that children who always are going in, they can easily find their information quicker, access it more, quicker, then have readily information about that patient depending on what clinician is seeing that patient. I think that there's definitely, if it's well planned out, you can make sure that you're creating these good stories [para. 14]

Interviewee six clarifies this further by saying improved access improves diagnosis and decision

making for care:

Int 06 nurse >30 years' experience health authority: I think that it is speed of access which improves diagnosis which subsequently improves patient care so I think that it is dramatically improved patient care. It is the speed of access of information to make a reliable definitive diagnosis which can only make a positive difference for the patient. So I mean I would never want to go back to the old way ever [para. 30]

Theme: Electronic information system provides data for health system analytics

Although the focus of this research is on acute care, interviewee ten explains the downstream operational benefits of accurate and complete data for other efficiencies such as tracking adverse events, procurement, staff scheduling etc.:

Int 10 non-clinical 10-20 years' experience ministry: First of all, I think the ability to be able to monitor the financial performance of individual institutions is an example of where information systems have suited very well the accounting, the procurement, that whole business process. I think it's also made strong contributions in terms of making services far more accessible and more efficient so that things like scheduling systems and the organization of operating room schedules and trying to develop an efficient production line within an institutional setting has also been complemented. In the case of pharmaceuticals it's been incredibly powerful in identifying opportunities for identifying drug adverse interactions [para. 25-26]

The interviewees have told us that the information needs to be accurate and complete for the decision maker. They now explain how an information system can improve accuracy and completeness of patient information.

Theme: Information is more accurate because there is less “noise” from unstructured data

The information is more accurate because there is less noise presumably from the reduced unstructured data in the record:

Int 01 nurse 21-30 years' experience public & private: we would

be able to do now is that we are going to be able to document um, in a more comprehensive way so that when we do analysis what you are getting out has increased accuracy right, less noise. We are going to be able to make more accurate predictions because the data would be more accurate. [para. 45]

Theme: Information is more accurate and legible for safer prescribing

Although a written prescription may be complete, the illegible writing can introduce transcription errors that are removed with electronic prescribing. This is an obvious and well known example:

Int 18 physician 10-20 years' experience ministry: high areas, high value areas like e-prescribing. People can actually read the prescription and get the right numbers and the right frequency versus all the illegible stuff in the past, so legibility has always been an issue [para. 26-27]

Theme: Information is more complete because of forcing function of drop down boxes and mandatory fields

Information systems can provide more complete information to the decision maker. Mostly, the nurses comment on the importance of improved charting either through the use of drop down boxes and mandatory fields the encourage data entry so there is less missing data:

Int 01 nurse 21-30 years' experience public & private: Um, so the other thing is around you know um, forcing people to use drop down boxes and mandatory fields and um, right and so all of those and you can do that in a digital world and you can then ensure that every time someone is entering in that screening that the mandatory fields are filled [para. 45]

Int 20 physician 10-20 years' experience health authority: Another example of electronic systems improving data quality would be being able to create documentation tools that make it harder for you to document the wrong thing. For instance in the ICUs and the system we have a way of documenting delirium [para. 22]

Theme: Information is more complete because there is mandated and legible charting frequency. There is less missing data because gaps in information are detected more easily through a quick scan through the screen as is having more legible notes:

Int 04 nurse 21-30 years' experience public: often there are policies in place within an organization that has moved to electronic health records that talk about how frequently charting must occur. Not that they weren't there in the old days but there is more pressure that there actually be electronic documentation at a certain frequency, vital signs and it is legibility kind of thing ..[para. 19]

Int 14 nurse 21-30 years' experience health authority: Having that in a system, when you've got the collection method there, just makes it more visible when it's not occurring [para. 14]

Theme: The information will become more complete over time as more information is added to the electronic information system to create an extensive and complete longitudinal record for the patient:

Int 02 non-clinical 21-30 years' experience public & private: So the information that is available through clinicians you have 11 years of historical data in there so all the lab results, imaging results, transcribed documents, some nurses are being added now [para. 24]

Information System

Important remedies to improve stability are via provincial conformance standards which are the system equivalent of provincial identity standards, and by improving system life cycle elements. Interviewee sixteen mentions a potential future improvement, natural language processing.

Theme: Ministry conformance standards provide information standards for vendors wanting to access provincial data

Information systems enable regulators such as ministries to impose information system standards that are usually called conformance standards or “computer consistency” mentioned by

interviewee seven that establish performance standards for systems. This helps to preserve the integrity of the patient information, including the standardized patient identity information, held in the system as the following quotes show:

Int 03 non-clinical < 10 years' experience public: we provide a nice set of standards that they need to speak to us in and um, that is part of their conformances that they are following that standard [para. 33]

Int 07 non-clinical 10-20 years' experience ministry: I was thinking of are where the organization would apply mandatory standards. So you know making them kind of system agnostic [para. 29]

Int 07 non-clinical 10-20 years' experience ministry: Well that is where you know I reference um, the standards and the computers consistency and so if everybody is using the same system in a different way then you are going to have six batches of different information if everybody is using a different system in a different way you are going to get six batches of different information so the way to bring things together and make it more consistent and thereby more better quality is to use it in the same way and to try to enforce some standardization where possible [para. 38]

Information System Life Cycle

Design

Theme: Ideally, remove the human input factor as much as possible so system is intuitive

The clinicians have provided some recommendations for system designers to make the systems easy to use and intuitive so the user does not have to struggle with the system to get at the information. According to some interviewees an almost automatic system would be best but at the expense of placing huge expectations on the system and its infrastructure! The following quotes illustrate this:

Int 05 nurse 21-30 years' experience health authority: And there was a lot of dose error reduction systems features to reduce that human factor element. Such as, it is not full proof but it is trying

to eliminate the possibilities so that streamline that intuitiveness as much as possible. So when you are putting in a medication we also we use um, standardized pharmacy concentrations [para. 27]

Int 06 nurse >30 years' experience health authority: So the system has to be relatively straightforward and simple and it can't be too cumbersome and there can't be a whole bunch of steps that access it um, the actions have to be recognizable and um, you know it should be almost um, self-directive um, I shouldn't have to take a whole day course or hours and hours and hours of training to be able to use the system it should to be user friendly [para. 2]

Int 17 nurse 10-20 years' experience health authority: I can improve quality in the way the system is designed. If we design it smart enough, then I can improve the quality of the documentation without them having to think too much about it [para. 36]

Int 16 physician 10-20 years' experience health authority: An information system should, in many respects, be largely automated. It should automatically collect data. It shouldn't have sort of human filters built in really in the integration of the data into the system [para. 2]

Design Integration

Theme: Information system will need customization for local users

Part of design is taking the ideals expressed by the clinical interviewees and turning the information system into one that fits in the workplace and work flow through customization and programming configuration:

Int 18 physician 10-20 years' experience ministry: So taking a system, taking it out of the box and plugging it in may not get you all the improvements that you're looking for. I think it is what else we do with those systems and how we configure them so people use them well. It's not the system itself, it's the system plus the change management and the training and the configuration and it's a package deal to get the quality and the health information quality that you're looking for [para. 53]

Theme: Information system design to reduce manual data entry and potential for errors

Part of this integration is reducing manual data entry and unstructured data as much as possible: this is for economic reasons and for reducing data entry errors that could contribute to an adverse event:

Int 20 physician 10-20 years' experience health authority: I mean one would be device integration. The old system of dealing with bed site devices and technology indeed is to have a individual piece of technology data, typically displays that data. And to have a human being, usually a nurse or a RT, manually translate that data onto either a piece of paper or onto an electronic health record. Obviously opening up. Well one, there's a workload associated with that and it's a workload that's always sensitive now to the time people need to devote to the patient, number one. Number two there's certainly opportunities for error, so I think the specific example is being able to electronically interface things after appropriate testing and like to one, save the time of the care provider and two to enhance its accuracy and take out the human error factor. So that would be one example. [para. 20-21]

Theme: Information system integration should allow for other clinical information modalities such as photos

Part of the information system integration is allowing other types of data such as photographs that are more accurate and complete information sources for the decision maker, for example in wound care:

Int 01 nurse 21-30 years' experience public & private: So in so if we look back at wound care say I am out 10 years or something then the nurse would say you know this is what I do and this is what I do. And they would say ok, with this new technology that is going to change your business process right because now you are going to take a picture of the wound and you are going to do these types of things know what I mean. So when you are doing business requirements you are really also challenging the new reality of a technical enabler so if we have this technical enabler how does that change your business process your purpose you are still meeting your outcomes,

right? [para 86]

Reminders

Theme: Information system reminders can improve information accuracy and completeness by ensuring tests are done on time

The information system can improve accuracy and completeness of information by automatic reminders for tests so the changing state of the patient is monitored and results available for the care providers:

Int 04 nurse 21-30 years' experience public: Some of the newer systems that are coming up have almost like um, a dashboard quality to them and they do include reminders so what nurses used to write on a scrap of paper or a paper towel used to go into our pocket is now popping up on some of these dashboard kind of systems so it will say that the order would be let's say vital signs Q 4, so it would come up with seeing whatever time range and it is all in the set up. Or reminders of blood work or prep for tests that kind of thing so it is really automating some of the things that used to get on that paper towel or that cardex, it is more of an automated cardex [para. 21-22]

Theme: The information system can provide prompts to assist staff with data entry:

Int 05 nurse 21-30 years' experience health authority: So I think any good health information system has to have enough of those prompts because like I said there is never enough staff and there is always staff that are not adequately oriented or staff orientation or don't use the system very often and the quality I think in the system is going to be able to medicate that if possible [para 51]

Theme: The information system can provide templates to assist staff with data entry but may increase workload compared to a checklist

Int 04 nurse 21-30 years' experience public: What I have seen with the templating format is that you can get some really nice um, detailed assessments and documentation but people are reluctant to use them because it requires them to go through 10 different screen to document that. It has increased the time and that combination with some core pieces of information that are most easily documented in

a checklist kind of way to go for it but still allow people the opportunity to make some kind of clinical note [para. 71-2]

Data Display

Theme: The information system must have a data display that captures changes in patient state in a usable and easy to read format

Interviewee sixteen has many ideas about data display possibly because he needs the information to be displayed so he can make the right decision based on what he sees in the system. He needs to be able to get a snapshot of the patient based on the date, and, more importantly, interpret an abnormal result in the context of the other data so that he can decide if this is a valid abnormality that reflects a true change in the patient state that he needs to act on:

Int 16 physician 10-20 years' experience health authority: it's also all of the other data around it. Not necessarily that it's normal or not abnormal, but that the data itself, all of the data that's on the screen that's available when you look at it, it should help you make sense of the patient. It should help you go, "I understand what's going on here. This number that's flagged. Well, that's clearly not congruent with the rest of the picture here, so I can ignore this," but the rest of the data helps form the picture of the patient [para. 8]

He goes on to explain further that the information system must be precise rather than accurate.

This was mentioned earlier as an information characteristic as well:

Int 16 physician 10-20 years' experience health authority: That data is not accurate because it's not being collected properly. Information systems allow you to, even if that data is not necessarily accurate, its precision for change is better. An information system will allow you to at least see that. If I'm measuring a blood pressure continuously, even if the numbers are wrong, I can see that the trend of down or up tells me, gives me information about the patient. In an information system, it displays that kind of change over time. Allows the quality of the data to not necessarily be as important as long as it's being consistently collected [para. 19]

This precision will then allow for detecting trends or changes in the patient's state over time this

is also useful for assessing how rapidly the patient state is changing:

Int 16 physician 10-20 years' experience health authority: Information systems allow you to, even if that data is not necessarily accurate, its precision for change is better. An information system will allow you to at least see that. If I'm measuring a blood pressure continuously, even if the numbers are wrong, I can see that the trend of down or up tells me, gives me information about the patient. In an information system, it displays that kind of change over time. Allows the quality of the data to not necessarily be as important as long as it's being consistently collected [para. 19]

Interviewee sixteen also has other ideas about data display such as the use of colour schemes or icons to heighten data contrast as shown with the following quotes:

Int 16 physician 10-20 years' experience health authority: If I'm looking at something that looks wildly abnormal, because it's easily viewable and I can easily tell that it's wildly abnormal because of the changes in the color scheme, of the icon, something like that, then I can make a judgment. There's a lot of other ... Then I can cross-check it with other data points to say, "Well, that seems odd that that number should be so abnormal, yet everything looks okay, and they quickly got better. This is probably an error. I can just ignore it. Move on to whatever other questions I was seeking to answer." [para. 6]

Int 16 physician 10-20 years' experience health authority: I also need to be able to see that it's clear. The data on the screen has to be structured in a way, displayed in a way that I can tell that it's abnormal because it's just an outlier or it's not reflective because of the way the rest of the screen looks, the way other things are on there that can give me feedback on, "Well, you know, this number is abnormal, but all these other things that are part of that display normally are clearly non-abnormal, well, then that number doesn't mean anything." It's how you structure your display that helps your data quality as well [para. 7]

Implementation

Theme: Information system implementation provides an opportunity to get expert clinical input at design and implementation

Information systems provide the opportunity for the organization to use clinical experts as part of the design and implementation so the system and information parameters are agreed to for relevancy and use in the short and long term. Three interviewees spoke about this, here is an example with these quotes:

Int 04 nurse 21-30 years' experience public: seeing when I been in organizations that are implementing systems and they have usually what they have called clinical advisory group which didn't exist before, so they had professional practice and all that kind of stuff but it is usually clinical advisory that is a forum where during the implementation there are discussions about should we do it this way or should we do it that way? Should we make this a mandatory field? What are the ramifications if do and what are the ramifications if we don't [para. 67]

Int 18 physician 10-20 years' experience ministry: they have a clinical design team and clinical decision support team and so when they're constantly revisiting their implementation, if you like, and improving the quality and so, adding new content or reconfiguring something, to do something better, so it's that you implement, and during implementation, you have the vast numbers of clinicians and configuring systems for surgery, for anesthesia, for pediatrics and so on, so tons and tons of people that are actually engaged, but it doesn't stop with the implementation. There's that ongoing optimization and quality improvement of the systems and that constant surveillance for things that aren't working well [para. 54]

Theme: Information system implementation with expert clinical input may reduce workarounds that impact information quality

Another benefit of design and implementation by consensus is that it might forestall workarounds that have a serious impact on information quality:

Int 02 non-clinical 21-30 years' experience public & private: well it is no single silver bullet, like I mentioned before it is everything from planning your system, designing and engaging your clinicians and looking at your business processes, how you build it, what you license, user training, QA testing and information quality it starts

from day one on what you chose to implement and what you chose to implement it and where you implement it and how is a big thing. You know and supporting your clinicians and making sure they don't develop all of these workarounds. And trying not to bite off too much at a time. well the organizations want to do everything and they want to get the most things for their bucks and they don't have a lot of patience right and it is really is baby steps [para. 82-83]

Theme: Information system logging off may not be automated so maintains a potential for error

Logging off may be something that may not be automated, despite the wishes of these two nursing interviewees, although interviewee six notes a one computer/patient may reduce the problem:

Int 06 nurse >30 years' experience health authority: But the way around that is that you know it is should become mandatory that if you are finished the information and you shut down and you log out so that it is not your profile, not your personal access that someone else was using that is number one, number two the best way which I have heard from other institutions is that one computer at a bedside is dedicated to the person in that bed. So if you need to access information on a patient then you have to go to that patient's bedside you can't use another computer. And then that I think that is a great way to do it because that is a safety feature that is now built in to the system right [para. 26-28]

Interviewee fourteen notes missed logging off can corrupt the data on two patients, mother and babe so there is missing information on two individuals the decision maker may be relying on:

Int 14 nurse 21-30 years' experience health authority: Some of our monitoring equipment, and I'm going to go back to perinatal, if we're using a system to collect fetal monitoring, heuristics we need to make sure that the practitioner is required to clear, from the last patient, any information that was collected before going onto the next patient. If that doesn't occur, you've got a corruption and poor data [para. 26-27]

Natural Language Processing

Theme: Natural language processing⁵⁹ may provide a structured format for analysis of unstructured data in the future:

Int 16 physician 10-20 years' experience health authority: I don't know, I tend to believe that natural language processing will solve all of our problems eventually. While you want to maintain some data integrity, the data that a physician provides is not really data in the usual sense. It's interpretation of the data. It's usually narrative. It's usually much better [para. 16]

Summary

The clinical and non-clinical interviewees' remedies explain that better design so that care providers can access and use information that is more structured and subject to less human interference. There is also improved monitoring of the health system as a whole [interviewee ten]. This may even happen for unstructured data once natural language processing is perfected and standardized. The next section has the intervieweesrespondents providing examples of adverse events from their experience when unstable information systems affected information quality and decision making.

⁵⁹ For more information about natural language processing in health care please see, as an example, the Open Health Natural Language Processing Consortium at the following link: http://www.ohnlp.org/index.php/Main_Page

5.3.9 Unstable Information System: Examples from Three Systems

Introduction

System instability can lead to patient adverse events at the patient provider interface. The rich experience of the interviewees have provided several examples of adverse events in the three major acute care systems outside of the care record itself. These are the pharmacy, laboratory and imaging-radiology systems. The pharmacy system was mentioned most often and will be examined first. Some pharmacy examples have been mentioned earlier under different inductive or descriptive codes to illustrate specific information or information system points.

Information System: Pharmacy

Descriptive Statistics

The terms “pharmacy”, “medication” or “drug” was coded fifty times for 11/20 interviewees: 4/6 nurses, 4/10 non-clinical, 2/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical (7 vs 4). Interviewee nineteen, the pharmacist, the term nineteen times as would be expected, interviewee four, clinical, nine times, clinical interviewees five and six, five times, interviewee eleven, four times, and interviewee two, non-clinical, three times and the rest, once

The terms “pharmacy”, “medication” or “drug” were mentioned most often because medication errors are a recognized events in health care. These errors can happen at any stage from admission onward and a patient’s medication information can become inaccurate or incomplete.

Qualitative Understanding from the Interviewees

Information

Admission History

Theme: patient medication information at history taking step is often missing and unstable-this early information can conflict with later information

Medication history about what a patient is taking is generally very poor in interviewee nineteen’s experience partly because the patient themselves may not know what they are taking:

Int 19 pharmacist 10-20 years’ experience health authority: I think everyone is struggling with trying to find a way to marry up what we have on record as what a patient is taking and what a patient is actually taking. We're not there yet for sure. I think they've been some effort at least, in my world, to try and impress upon patients and families the importance of them knowing exactly what they're doing and being able to communicate it readily [para. 11]

This can cause problems for the patient if more accurate information comes later after the

medication order is written and the patient started a medication they were not on in the first place:

Int 19 pharmacist 10-20 years' experience health authority: You know a patient comes in and we think they're on Metformin bid and we start jacking up their dose to get their blood glucose under control and low and behold they're not taking that, and then create the potential to cause side effects and harm because we are basing our decisions on poor quality information [para. 15]

Theme: Inaccurate patient's information validated with the patient's chart may be a source of error if the chart itself does not have accurate or complete information

If the patient does not have the accurate information then then the staff admitting the patient may check the chart which is another source of error if the information in the chart is not accurate or complete for the present admission; this can contribute to patient death as it did in this case:

Int 19 pharmacist 10-20 years' experience health authority: All the medications ... I don't think there was a single medication documented on admissions that was correct. Because of the poor quality of information, and I think it had to do in part with the way that we presented the information in the system. It wasn't obvious that it was old. It speaks to the sort of usability I think of our systems and how people understand and is sort of in your face of you're looking at so they can evaluate whether or not what they have is quality information [para. 43]

Theme: One remedy for the patient-chart discrepancy in patient information is to have specialized staff to take medication histories with an example

Int 19 pharmacist 10-20 years' experience health authority: Yeah and other sites in the province I know of, like just across the street on the adult side they have pharmacy technicians that actually are in the emergency department, I want to say almost 24 hours a day now 7 days a week, whose job is to do nothing more than to take medication histories from patients who are in emerg or who are in emerg awaiting admission to the floor [para. 40-42]

Interviewee nineteen has an excellent example illustrating information discrepancy about

medication concentration between the community and hospital formulation that caused an adverse event. The discrepancy was resolved by standardizing the concentration and centralizing the dose concentration within the pharmacy:

Int 19 pharmacist 10-20 years' experience health authority: Yeah so previously when I worked in the adult world, significant adverse events have stick out in my head I think that pertain to poor information quality. One of them was involving Methadone. There was a difference between the concentration that was supplied in the hospital versus the concentration the patient was receiving in the community. The medication order was written in mls, and so you can probably guess what happened. The concentration that was stocked in the hospital is ten times more potent than the concentration that was received in the community. Because the poor quality of information either accessible to the prescriber, i.e. the concentration of the product, and the poor quality of information received through the order itself lead to the a nursing staff administering ten time overdose of. Fortunately the patient was found with a resp rate of five and they were able to bring them back ...That could have gone terribly wrong [para. 74]

Ordering

Theme: Pediatric dosing requires accurate dosing based on weight so needs accurate weight information

The interviewees raised several issues with ordering. One is the problem with paediatric medications that are based on the child's weight so accuracy is key:

Int 18 physician 10-20 years' experience ministry: I know with some systems, particularly in pediatrics, where you're getting down very, very small amounts of the drug and so on, you have decimal points in the wrong place. sometimes that's, again, a user entry problem and sometimes the systems themselves have made a mistake around that. So I don't think about it largely and it's not fair, but all of them go back to medication management as being one of the places where we have to be so incredibly precise [para. 41]

Theme: Pediatric medications dose uses specific concentrations that vary from

manufacturer to manufacturer so can be a source of error if the drug concentration is ignored:

Int 19 pharmacist 10-20 years' experience health authority: something that happens often here I know in the pediatric side, because we have so many kids that are taking liquid medications, is that people leave out important information like concentrations. You know how many different kinds of Amoxicillin you can get and they just write Amoxicillin suspension, take 5 ml. and that could mean anything [para. 40-42]

Theme: The scientific basis for pediatric doses is weak so may be a source of error

With very little strong evidence for paediatric dosing in the first place:

Int 19 pharmacist 10-20 years' experience health authority: There is a lot of extrapolation that goes on when it comes to pediatric dosing. Very little actual studies done in kids. There's lots of off label prescribing that goes on in pediatrics too. A lot of the drugs we use are not even officially indicated for use in kids [para. 69]

People

Theme: After hours staffing with no pharmacists on site is an error risk because of missing validation checks

There are organizational issues around after hours pharmacy coverage. This was mentioned by several interviewees. This meant that the important validation checks for accuracy and completeness pharmacists perform was often missing:

Int 05 nurse 21-30 years' experience health authority: the problem is when those are all processed outside of pharmacy hours and someone will actually process those and handwrite them onto a medication administration record which is another whole source of error that we are constantly trying to struggle with [para. 40]

Theme: Medication orders placed off site can miss the staff validation check for accuracy and completeness

Another problem happens when the organization allows physicians to place orders from another site and the orders are missed on the information system because the validation nursing check did not happen or there was no system dashboard order alert:

Int 04 nurse 21-30 years' experience public: biggest issues are, typically in the acute care environment it is med orders that are problematic or missed orders where a physician has actually placed an order on a patient and nobody has realizes that the order is there. Um, in most instances we have caught that in the paper world because we typically made rounds with the physicians but now the physician can have been there and gone without us really even realizing it. The dashboard is the way that they are typically being picked up now. And in a lot of organizations the electronic record is still a little bit on the new side so on the up side is when physicians still need a little bit of help placing the orders and usually there is somebody around that knows that the physician has in fact just placed an order and we need to do something about it. They are the most resistant that is for sure [para. 54]

Theme: Patient medication information passages through many individuals as a source of error

There are many potential points of failure in after-hours ordering because of the number of individuals who handle the patient's medication information:

Int 06 nurse >30 years' experience health authority: the actual doctor's orders are all um, manually written and then they are faxed to the pharmacy and then the pharmacy enters them into the system online and then we have the computerized m, medication sheets, so that is a little bit more cumbersome than other sections of the system or other elements of the systems, pharmacy could tighten up a little bit [para. 17]

Theme: Low staffing levels may be from chronic underfunding

Int 06 nurse >30 years' experience health authority: It is still a bit cumbersome yes, it still takes too long, and that is because they don't employ enough staff, you know what I mean, the health authority has short changed pharmacy historically for the 30 odd years that I have been associated with them. Um, whatever long periods of time that I

have been over on this side pharmacy has always, always, always been under-funded [para. 34]

Information System

Instability-Hybrid Paper Chart

Theme: The paper chart can contain disorganized patient information leading to poor care decisions

The hybrid paper chart can make patient information disorganized so there is not a clear idea of the patient state. This was combined with alert fatigue in a pharmacy. This contributed to a fatal error:

Int 19 pharmacist 10-20 years' experience health authority: The patient was receiving these multiple NSAID's for unknown indications and it never got picked up. I think part of the reason is because in a paper chart it's really hard to have a sense of what the patient's actively on. We think what happened was it was a surgical floor, surgeon was asked for meds to treat pain, didn't look at the chart to see that they were already receiving other NSAID's, prescribed yet another NSAID. It got missed in the pharmacy presumably because of our horrible alert firing and our sort of yet another alert ignored, override, override [para. 74]

Electronic System

Design

The interviewees comment on some design issues in their experience that may have contributed to medication adverse events:

Alerts

Theme: Automatic alerts warn the prescriber if the patient is allergic to a medication or the medication is contraindicated for some reason.

Accurate allergy information begins at admission:

Int 06 nurse >30 years' experience health authority: Well the only thing that I think is crucial is allergy information so if people aren't collecting accurate allergy information and implementing that then I can see that um, experiencing the adverse event [para. 38]

Theme: Alert fatigue can lead to medication errors if users ignore critical alerts

In some cases, possibly for liability reasons, vendors would have too many alerts that prescribers would ignore and click through even though the alert may be a significant piece of patient information:

Int 04 nurse 21-30 years' experience public: the vendors were really keen on the we can error message you until you are blue in the face and it was always that fine line of um, thinking and trying to decide where the right amount of messaging would occur because you get um, error message fatigue and people just click through them, though even though it might be a very significant message they don't even know what it was they just know I click three times and then I am in the field that I want to be. Never mind that it was telling me that was dangerous dose or whatever, you often see it when you are implementing the pharmacy side of clinical systems [para. 34]

Theme: Data display design should have clearly visible alerts

It seems obvious that information system should be designed so the alert is readily visible so that it is acted on, or not, as the previous example shows. However this is not always the case were the allergy information is at the bottom of the page!:

Int 11 non-clinical <10 years' experience health authority: Unfortunately, the design of the application had all of the allergy information and all of the urgent notes at the very bottom of the page. If a physician is going to go in and look at this patient chart, they have to scroll down to the very bottom of the page after seeing all the notes and all the information. They have to scroll down to the very bottom in order to see this allergy information. That's something I think logically this physician has to see it right away [para. 39]

Theme: Users should have access to a no-blame incident system if ignore critical alerts

If staff are going to ignore the alerts because of alert fatigue then there should be a no-blame incident reporting system so staff can report the near misses and adverse events because they did not read and act upon critical patient information:

Int 04 nurse 21-30 years' experience public: alert fatigue, how do you think they could deal with that better? I don't know that anybody has necessarily found a really good way to deal with that, it is still the um, what you see most significant and it really depends on the organization. Some organizations have a very good history of incident reporting and it is not seen as a penalizing activity but rather we only want to see what kinds of things might be problematic for you, so sometimes if you are in organizations that have had that kind of QA program, um, you can see and track those kinds of things and integrate it into your training but most organizations what you see for incident reporting is typically for monumental events [para. 38]

Displays

Theme: Pharmacy information system programming should reflect the true drug dose patient information

Another design issue is programming displays that show only a whole number. This likely would not be an issue for adult patients but could be serious for children/infants. It also means that the device does not reflect what the patient is getting so the patient's information is not accurate:

Int 17 nurse 10-20 years' experience health authority: Every now and then, something gets past testing that's not correct. One I can remember was from a couple of years ago. We added a new fluid. I can't remember what medication, or what fluid it was now. But when we customized it, we made it to only document a whole number. Then it got pushed to production and people started using it, and they needed to chart to one decimal. The order would be for 16.2, and they could only chart 16. The patient was receiving the proper amount, they just couldn't document it [para. 124]

User Interface

Theme: Another device design issue is poor display and interface on infusion pumps so the

infusion rate could be changed in error. This pump has been replaced by a pump that has a display, decision support and interface for each channel.

Int 05 nurse 21-30 years' experience health authority: polly pumps they were calling it and they were um, triple channels and there was one pump and three channels and you could run three medications on this pump- the trouble with it was that it really only had a single interface panel .And it was a problem because if you happened to and each of the channels they weren't individually, they weren't clear on the individual labeling so if you happened to stop or change it to a rate on the wrong channel you could change the wrong medication. There was multiple medication errors from that. [para. 25-26]

Integration

Theme: Information system merging so information truncated and missing

The system may have been designed so there is inaccurate data merging of patient information so patient allergy information is missing and a wrong decision is made based on that information:

Int 07 non-clinical 10-20 years' experience ministry: both records were for the same person but when the merge was done the allergy information didn't consolidate. In fact what happened was that the allergy information on one record got left behind and the allergy information on the surviving record was downgraded from confirmed to um, unverified I believe. There was potential allergies but they had been unverified and they all of the allergies weren't listed and only the ones that were listed were verified and then a medication was given that was contra indicated [para. 57]

Possible Remedies But...

Theme: Bar coding is seen as a potential remedy for medication errors by synchronizing the patient's medication information, the medication and the patient's armband but there is nursing resistance to it:

Int 04 nurse 21-30 years' experience public: Exactly so you know and I realize that nursing is sort of resistant to the bar coding for

medication administration um, just because it is an extra tool and push a cart around to dispense medication and stuff like that, so there is still enough of us around to remember the medication trike and stuff, that was a quick and simple way to deliver meds but there were also a lot of med errors and some of them we didn't even know we made. You know putting things like bar-coding on and you do have to ensure that you have the right patient and the med that you took out of the drawer is in fact for that patient and it is the right one [para. 63]

Theme: Bubble pack workarounds cause medication error

As there is to bubble packs that were designed to remove ward stock a source of medical errors. There was nursing resistance and a workaround to this that caused a medication error because of patient misidentification:

Int 02 non-clinical 21-30 years' experience public & private: Well the nurses told them that they didn't like the bubble packs and they have decided it is too slow so they were taking the medications out of the bubble pack and putting it into paper cups and writing the patients initials on the paper cup. And they have two patients with the same initials and they gave the wrong medication to the wrong patient and they nearly killed somebody well these are where the clinical staff are trying to find, they are developing their own work around and they think that they are trying to find efficiency to save time but they are introducing that error [para. 46]

Pharmacy Decision Support

Theme: Pharmacy decision support may give a false sense of security

The interviewees had mixed thoughts on pharmacy decision support such as FDB. Interviewee nineteen, the pharmacist, feels that they give a false sense of security and should not replace clinical judgement:

Int 19 pharmacist 10-20 years' experience health authority: Ultimately here while we have it on and it does fire alerts, we sell it to the pharmacist as it's just there to help you, it doesn't replace your clinical judgments. Having said that, it's very, very easy, I can speak

from experience, to become over reliant on the system telling you what to do [para. 24]

Theme: Pharmacy decision support difficult to interpret because of an excessive number of risk probabilities. This may occur as the risk of a specific adverse event is automatically calculated by the decision support and presents all of the probabilities for an event, from the common to the excessively rare event.

While interviewee four feels that the probabilities for specific adverse drug interactions range from the common to the excessively rare, here again probably for liability reasons, so the information is difficult to interpret:

Int 04 nurse 21-30 years' experience public: if you put things like first data bank or any of those kinds of systems on the back end where you can get um, incompatibilities or interactions and those kinds of things. From the lowest possible there is a 0002% change of interaction versus 200% chance here. So what I am trying to say is that you know what we will talk about compatibilities and we will talk about the match um, allergies and those kinds of things so trying to be conscious of how many messages you give people [para. 34]

Theme: A poor system is still better than illegible handwriting!

Int 16 physician 10-20 years' experience health authority: don't forget, one of the primary causes of medication error in hospitals is handwriting. You have just taken that out of the equation, so okay, occasionally the wrong drug will be ordered because it looks alike or they check the wrong drop-down menu accidentally, but those are less frequent events, and also improve the workflow for the pharmacist because they don't have to try and interpret somebody's scribbles [para. 40]

Summary

Medication errors are a common and serious risk for patients. Pharmacy examples have appeared earlier in the analysis because they provide examples for information or system instability generally. This section has shown that medication errors can start at admission when the threats to information stability are highest. The predominately clinical interviewees provided good

examples of information paper and electronic system and user causes such as inaccurate validation, poor decision support and lack of ordering and dosing standards. They also offer remedies and the reminder that medication errors have been reduced greatly by improving legibility alone.

Information System: Laboratory

This is the second information system mentioned by the informantinterviewees. The few examples are information system based.

Descriptive Statistics

The terms “laboratory” or “lab” was coded sixteen times for 7/20 interviewees: 2/6 nurses, 4/10 non-clinical, 1/3 physicians showing that the clinical interviewees used this term more often than the non-clinical. Interviewees nine, non-clinical, and fourteen, clinical, used the term four times and interviewee three, non-clinical, three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

Information System

Theme: Interface creates missing information because information is truncated including unstructured data

The information system issues that corrupt information are interface issues such that patient information was truncated and missing. Both of these examples are provided by non-clinicians possibly because they are familiar with data manipulation:

Inf 02 non-clinical 21-30 years' experience public & private: few though that it was purely system, one that I can think of was where the lab results were not getting through to the ordering physicians and that came out in an inquiry after a patient had died. This was the lab results did not get back to the ordering physician and the ordering physician didn't have the system in place to know that they were missing the results. So the tests were ordered and they never received the results they didn't know that this was responsible problem. Those were mostly technical issues and the indexing numbers were truncated so they weren't attaching to the right person what caused it but it was an interface problem. Technology interface problem so I can't remember the exact problem but it was a technical issue I believe [para. 27]

Other examples involve truncated unstructured data so the patient's information was truncated including in one case, critical cancer information was missing. The information at the bedside was not useful or safe because of poor design as interviewee nine explains:

Int 09 non-clinical 10-20 years' experience public and private: I think of an example of a situation we had where we implemented results in a children's hospital. We integrated with lab, and lab had its own system, so we were interfacing the lab data over to the clinical information system Cerner at the time. The lab data was correct, but when it came over to Cerner, the data was correct, but it was displayed in a way that could not be interpreted, and so the information wasn't useful. We learned from that the importance of design in getting the information quality, having information quality there is not just about having the good data, it's about having it designed properly so that it can be interpreted. To me, the poor information quality, it can't be interpreted [para. 4]

Int 09 non-clinical 10-20 years' experience public and private: Another example was that comments would come across, which are often really helpful but they're often done in a free text field, right? ... and they would be cut off halfway through. There was actually one situation where it had been flagged that a patient had cancer, and that was missed, because it was one key information like that, putting it in the comment field is not good [para. 5]

Users

Theme: User workarounds to game access

There are also pseudo errors, a high number of urgent texts, that monitoring picks up, but are really workarounds so the clinical area can have the results available for ward rounds. This did not affect the information quality for those patients but it could have affected the information of other patients if the lab did not have the capacity to process all the urgent tests, including the true urgent requests:

Int 14 nurse 21-30 years' experience health authority: When we get reports ... the lab reporting, a certain error rate ... investigating that is really defining what we consider to be an error. We did find a lot of

them to be process related rather than system. What the system allowed an opportunity to do was to order all their labs. I think they were ordering them urgent because they would make sure the results were on the unit before the physician came into rounds They're inadvertently pushing the queue within the lab system. That was process related but it was using the system that allowed them to ... and then it was defined as an error, that they were ordering them incorrectly but it was leading to support a poor workflow in their department. We have the routine which is to see your next collection time, your urgents, and your STAT and they were putting it as urgent because it gave them a quicker turnaround time [para. 36-8]

Summary

The interviewees did not speak of up front lab test ordering but of technical behind the scenes data manipulation issues so that the data was missing and incomplete. This is probably because the interviewees were non-clinicians speaking from direct exposure to these issues.

Information System: Imaging-Radiology

Descriptive Statistics

The third system term “imaging”, “radiology” or “x-ray”, was coded fourteen times for 7/20 interviewees: 1/6 nurses, 4/10 non-clinical, 2/3 physicians showing that the non-clinical interviewees used this term more often than the non-clinical (4 vs 3). Interviewees six, clinical, seven, non-clinical, and eight, non-clinical, used the term three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

The radiology events were all information system related because of the way the images are presented to the radiologist who must toggle through the screens so the patient’s image is linked to the patient identity information.

Theme: There are many points of failure in radiology (diagnostic imaging (DI) and Health Information Management (HIM)) as interviewee eighteen notes:

Int 18 physician 10-20 years’ experience ministry: We’ve had three Kaisen events to actually address it. So one for Lab, one for DI, and one for HIM. Even in DI itself, we came up with eighty points of failure, if you like [para. 12-3]

The radiologist interprets multiple images on multiple patients at the same time:

Theme: There can be a faulty automated linkage of patient information to the patient’s image

The information system should link on the accession number for the patient:

Int 02 non-clinical 21-30 years’ experience public & private: When they dictate they have to select which exam they are dictating on. They will often read more than one exam and they might have three images in front of them and they will read them all at once and they need to link to all three. It isn’t a link, they just click on things on the screen and then when they are dictating on this and this, if it is for admission they can say you know patient blah, blah for the accession number and they just read the accession number in the system and it

is linked properly [para. 33-35]

Sometimes the system has a design flaw so the linkage does not happen: this could contribute to an adverse event for those patients whose information was corrupted and made unstable as noted by interviewees nine and seven (PACS is the archiving system and RIS is radiology information system):

Int 09 non-clinical 10-20 years' experience public and private: This was an implementation we did in radiology. In radiology, they have to toggle back and forth between their PACS packs and then their radiology information system. We were implementing the radiology information system. Typically there is like a ... I forget what they call the tool, but it's like a little translator which let's you toggle back and forth PACS packs and RIS on the same patient, and again, I think this one design problem was that it wasn't designed or configured properly. They were toggling back and forth, and they went onto the wrong patient, and started documenting information on a different patient in the wrong patient record. Yeah. That was less around information quality, that was more around a system quality issue. It results ... that could actually result in, of course, poor information quality, if that information's left in the wrong patient record [para. 17]

Int 07 non-clinical 10-20 years' experience ministry: I can't even really describe what their issues was because it was definitely technical beyond my understanding and what it resulted in was um, images of different patients appearing on one document [para. 42]

Theme: There can be a faulty manual linkage of patient information to the patient's image

The interviewees also note that this linking process may be manual so is subject to error:

Int 02 non-clinical 21-30 years' experience public & private: The radiologist is a good example too right where they weren't following the new process and linking the exams to the patients and they have all of these unreported radiology procedures, thousands of them. Well we had to go back and change the process and train the radiologist. Change is hard [para. 49]

Int 06 nurse >30 years' experience health authority: we do nine chest x-rays and the um, radiologist is um, evaluating nine x-rays and then entering that information on each patient and it is their um, if they pick up the patient's report and don't go into the next screen on that patient I could see that be making a mistake so it is when you are entering multiple pieces of information on a variety of patients that I could see information um, errors being made [para. 38]

Summary

The radiology examples, provided again mainly by non-clinical interviewees point to faulty linking of the patient to their own image so the patient information was inaccurate. Some of this linking is manual which leads us to the last section, and the last of the information, information system, and person triad, the users.

5.3.10 The Users

Introduction

There are two classes of users in the health care system: the front line health care providers, physicians and nurses, in acute care at the so called sharp end of the system where patient care decisions are made, and, the more distant behind-the-scenes users at the blunt end: the health authority, or ministry and other regulators. The users at the blunt end will be discussed in the next section, external factors. The third class of people in the triad of *People, Information and Information System*, the patients, are not considered users for this research because patients do not access the acute care information systems.

This section will highlight what the interviewees, both clinical and non-clinical, say about the front line users' behaviour, physicians and nurses, in acute care from the perspective of insiders (nurses, pharmacist and physicians about themselves) and observers (the non-clinical). The next section will highlight what the interviewees say about the users' assumptions or expectations of the information system. The user terms or codes appeared throughout the semi structured interview question responses.

Descriptive Statistics

The term "physician" or "doctor" was coded twenty-nine times for 15/20 interviewees: 5/6 nurses, 7/10 non-clinical, 2/3 physicians and the pharmacist showing that the clinical interviewees used this term slightly more often than the non-clinical as would be expected (8 vs 7). The non-clinical interviewees eight and fifteen used the term five times, interviewees two, non-clinical, and four, clinical, three times and the rest, once or twice.

The term "nursing" or "nurses" was a common term being coded sixty-five times fourteen times for 15/20 interviewees: 6/6 nurses, 6/10 non-clinical, 2/3 physicians and the pharmacist showing that the clinical interviewees used this term more often than the non-clinical as would be expected. Interviewee one, clinical, used the term eleven times, informant nineteen, clinical, nine times, interviewee seventeen, clinical, eight times, clinical interviewees four and five, six times, clinical interviewees fourteen, sixteen and twenty, five times, and the rest once or twice.

Qualitative Understanding from the Interviewees

Users

Physicians

Theme: Physicians have a dual role-data extractors and creators

Interviewee sixteen, a physician, notes that they are data extractors, however, they are also creators of data through their orders.

Int 16 physician 10-20 years' experience health authority: The physician will do nothing with it, because the way that our current system is built, we are not data entry. We are primarily data extractors [para. 9]

Theme: Physician power as decision makers and initiative opponents

Physicians have a lot of power because they are the decision makers for the care team.

Interviewee two, a non-clinical observer, has some good examples that do not put physicians in a good light as team players for information system projects but they can be tricked with different terminology!:

Int 02 non-clinical 21-30 years' experience public & private: physicians are all scared of the word pilot, they don't want to get involved in anything that could be shut down and they hear the word pilot and they are like we are going to do this for a while and then you are going to take this away from us? So they don't want to get involved, so they might do most of them think that this is limited term production roll-out. They roll it out with a few people and they will evaluate it and then roll it out further but we are not going to take it away from you. So it is really a matter of wording this, right [para. 64]

Physicians have the power to shut down information system projects unless they are handled gently and involved at the beginning. This makes sense as they are the consumers of patient information and in in the example, likely enter data in the pathology system:

Int 02 non-clinical 21-30 years' experience public & private: there was those that refused to get involved and implements with limited involvement and so they had no ownership over it and they refused to accept it. There was also some personnel issues going on there right and there was some HR issues and that types. the hardest part of it and implementing the systems with all of the political stuff. we pick this system and we don't want it and we want the other one and we didn't want this project and I saw one system that we are ready to start data the conversion and go live with the new software system and the pathologist a week before go live says we are not going to use it, we didn't order it and we are not going to use it. That project just got shut down. That is all part of the whole process involving them from the beginning and getting them to sign off and having them helping with it. Especially if they are involved in the beginning then they should be ok until the end. diplomacy, big part [para. 73]

Theme: Physician power-secrecy around physician adverse events

Physician-involved adverse events are veiled in secrecy so there seems to be less learning from these events as interviewee nineteen notes when comparing to the methadone event in the pharmacy adverse event section above in section 5.3.9 pharmacy that resulted in change of practice for pharmacy and nursing staff using standard methadone concentrations.

Int 19 pharmacist 10-20 years' experience health authority: As far as Heparin orders not a whole lot changed at least on the surface that I saw. There was a lot of shrouded secrecy because that actually lead to a death and so I don't ... There was a lot of closed door meetings that went on. I don't know ultimately what happened as far as the access to quality information about elevated PTT's and processes thereafter [para. 81]

Nurses

Theme: Nurse power-use workarounds to oppose new processes

The interviewees noted that nurses use workarounds if they were not happy with a new process, for example from a non-clinical observer:

Int 02 non-clinical 21-30 years' experience public & private: nursing

unit to nursing unit, in a hospital if they ever want to standardize on their process well even if you do put in a new process they are famous for finding workarounds. They get all of these workarounds because they want to save time or go back to doing things the old ways and those workarounds is often what causes the errors [para. 45]

Interviewee two provides an excellent example of a workaround that caused an adverse event through misidentification of a patient. The nursing staff bypassed standardized procedures designed to minimize medication errors:

Int 02 non-clinical 21-30 years' experience public & private: So the new system they implemented bubble pack so the medications are not on the wards they weren't doing ward stocks and they weren't having all the medication dispensed from the pharmacy for individual patients in bubble packs for clearly identified the patient name. so the idea that later in time when the next step they would go to scanning the patient arm band and scanning the bubble pack and make sure that you have the right patient and right medication and right time dose so everything is right. Well the nurses told them that they didn't like the bubble packs and they have decided it is too slow so they were taking the medications out of the bubble pack and putting it into paper cups and writing the patients initials on the paper cup. And they have two patients with the same initials and they gave the wrong medication to the wrong patient and they nearly killed somebody [para. 46]

Information

Theme: Physicians and nurses support unstructured data, although nurses have resentment and reservations

Physicians and nurses continue to work with unstructured data, especially physician order entry. This caused resentment for interviewee five when everyone else is compelled to submit information in the information system:

Int 05 nurse 21-30 years' experience health authority: just a little on that even more up front on that is that when you look at the computer system and I struggle on this a bit is that most of our um, orders are

communicated by physicians and um, you as a physicians would appreciate this and you still write, we still go by hand-written orders [para. 33]

Physicians seem almost passive aggressive about structured data entry it as illustrated by the following:

Int 18 physician 10-20 years' experience ministry: We've got physicians that, either don't enter structured data or use a lot of free text. Don't use the right boxes, you know all sorts of competency, if you like, and etiquette around the use of the systems that [para. 5-6]

Theme: Physicians and nurses want autonomy to tell the patient's story

Both physician and nurses resent the loss their ability and autonomy to tell the story about a patient because they must use templates or drop down boxes. They resent the information system constraint the organization places on them as the following quotes show and as interviewee two observes:

Int 02 non-clinical 21-30 years' experience public & private: Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text ... [para. 6-7]

Int 04 nurse 21-30 years' experience public: Um, for others it goes on to the extent of templating where it is almost a fill in the blank and that drives people crazy because they can't write their own narrative. [para. 68]

Int 17 nurse 10-20 years' experience health authority: The whole idea of a nurse's note, where you would say in paragraph form, he's arrived from here with this wrong, accompanied by that person, and pressure toward the lab, toward that, got them settled into bed, changed him over, family went to the cafeteria for a coffee, mom is the main contact. Just that little story, they all feel, and I agree to a degree, they all feel they've lost that [para. 91-2]

Int 16 physician 10-20 years' experience health authority: We're story-telling creatures. Tell me that story of what happened to the patient. Don't show a bunch of check boxes to me. That doesn't help

me. It's a nightmare for trying to collect, to do analytics on physician documentation, but that unfortunate side effect is at least mitigated by the fact that the quality of the data from the user for understanding the patient is higher [para. 31]

Summary

Although there are not many examples from the interviewees in this section, those who provided comment speak strongly about the importance of health care provider autonomy in a system that is increasingly restrained under the guise of information standardization. This need for autonomy can be at the expense of information quality [interviewee two]. The interviewees also provide opinion on assumptions users make about the information system itself in the next section.

User Assumptions about the Information System

Introduction

The interviewees provide interesting insights on what users think the information system is capable of. Even though users realize it is a system, they assume and expect that the system is a kind of validation.

Descriptive Statistics

The terms “assume”, “assumption”, “just work”, or “think about the system” was coded sixteen times for 9/20 interviewees: 4/6 nurses, 4/10 non-clinical and the pharmacist showing that the clinical interviewees used this term slightly more often (5 vs 4). Interviewee seven, non-clinical, used the term four times, interviewee four, clinical, three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

Theme: There is the critical assumption that the system will be there for the decision maker with the patients accurate and complete information readily available:

Int 07 non-clinical 10-20 years' experience ministry: Absolutely because as a clinician is looking and assuming that they have all of the information that they need at hand and they factor it in and you are going to base your decision on that right? [para. 59]

Theme: There is an assumption around the permanence of the information (and reliance on others without checking) when in fact this is not the case

Int 07 non-clinical 10-20 years' experience ministry: Ya in this case I think it was the clinical area that made an assumption that the value would always be there um, and so you know they are relying on another business area that knew better but wasn't as involved in the testing [para. 14]

Theme: Users assume that all systems are the same especially staff who have worked on different systems at different sites:

Int 04 nurse 21-30 years' experience public: what we are seeing now is people that have used different types of systems and they assume that they all do the same thing. So trying to say on one hand it is becoming easier to train those nurses if you will because hey, they worked XXX, they have worked YYY and they have worked ZZZ and they have worked a dozen different EMR's and they come into an environment so they assume you know based on the last system they had used maybe or any combination that every system does a combination of all these systems to me it is really a case of without making a big deal of it just try to say that the system isn't going to do some of these kinds of things for you but it will do these kinds of things [para. 35-37]

Theme: Users assume they know what the alerts and messages are without reading them. They get desensitized to the messages:

Int 04 nurse 21-30 years' experience public: I think that it is more um, they don't even know what some of the messages are and they assume that they know what it is and at that time you know typically it is a message about x that comes up at this point. So they haven't even really read it and if you said to them what was the second message that came up on the screen and they would look at you stupefied and then they might say oh it had something to do with whatever and it may have or not had [para. 45]

Theme: Users assume they can input missing data easily as a workaround

Int 17 nurse 10-20 years' experience health authority: A lot of ICU staff are very type A... We are very smart, and we know a lot of stuff, and one of the challenges ... With this specific piece of software, when you're documenting, your in-takes and output. Intake, specifically when you're documenting their fluids, it has an area in the text where you can start dopamine going at so many mgs an hour, and make so many milligrams in so many mls. The way the system works is that you can't really go back and ... I titrate at noon, and I titrate again at one, and I say, "Ooh, I titrated at eleven. I forgot the chart that." If you try to go back to eleven, you can titrate it for eleven, but then it gets rid of the twelve and one because it thinks you want to start again. We have work around that can help you fix it if you make this boo-boo, but it's a lot of work. I

agree with them, it shouldn't do that, right? It should time stamp everything, it should know when I've done it, and what if, anyway They think that they know better, and that it should just work, and so they go in and do whatever they want. Do it a few times. That is one of the issues, introducing the electronic documentation that we've had to deal with. In various ... That's what comes to mind, the big one, because it's still exacting, you have to make sure your fluids are right. But we have to make sure people do it the way we tell them, not the way that they think they can figure it out. Like, "Oh, look. It lets me do it. If I just right click, I can rate change right here. Why do I need to do anything else?" It's hard to get around to them that they can't do that [para. 97-106]

Theme: Users assume system will save them from errors

A key assumption several interviewees mention is that the system will save users from making a mistake when in fact it can't. This adds to information instability because the users assume the information system will flag any inaccurate or incomplete patient information:

Theme: Users assume system will warn them about allergies

Int 04 nurse 21-30 years' experience public: So what I am trying to say is that you know what we will talk about compatibilities and we will talk about the match um, allergies and those kinds of things so trying to be conscious of how many messages you give people, but the other side of that coin is that the assumption that people have is that if I am doing anything wrong the system will tell me. Whether or not it was ever said that it would do it people have some assumption that um, there is some kind of decision tree logic in the background that would prevent me from making an error and sometimes there is not. So trying, so it is the other side of that coin and there are some things here to help you but don't be looking for it to do this, this and this because it was never designed to do that [para. 34]

Theme: Users assume system will warn them about drug interactions

Int 02 non-clinical 21-30 years' experience public & private: And we were implementing the physicians were to enter all of their medication orders into EMR and they when they go to enter them

into the system they assume that the system does the error checking for them so there is that drug interaction right well the organization wouldn't pay for the licensing so that the knowledge base to provide that functionality and no matter how many times you told them that they had to use their brain they couldn't rely on the system forget it wasn't that. So it is not the system it is the assumption that they system is going to do it but it depends on how you implement the system, right. there is learning what the system does and doesn't do [para. 53-55]

Theme: Users assume system will alert them for almost everything so the user doesn't have to think or may not be aware!

Int 10 non-clinical 10-20 years' experience ministry: Some of them would be contributing to an information system and causing perhaps a degree of concern as to whether in fact people are going to now start taking shortcuts by assuming that because the machine is smart, it now will do everything but look after the patient. That's the concern I have is that you still have to make sure that you put the right medication into the IV pump. You still have to ensure that you're attaching it to the correct patient, and so there is this concern with becoming complacent as a result of information systems taking on more than what people can believe [para. 29-30]

Int 12 non-clinical 10-20 years' experience health authority: Because often what happens with IT system is people think that, oh, buy a system and it'll fix it. Really the computer system is what you put in is what it's going to put out. If your process is not clear then you still won't have better data. but sometime we think that the computer will fix the whole world, right? [para. 27-28]

Theme: Electronic system means a new way of thinking is needed when information is presented differently

Interviewees four and twenty comment that the move from unstructured information in a paper hybrid system to more structured data in an electronic system require users to think and pay attention in a new way:

Int 04 nurse 21-30 years' experience public: becomes a training thing and that is all you can do and it is right from the very beginning when

you start introducing the systems about reinforcing how do you ensure you add the right record and draw those parallels between it is not as easy as potential, it is not that it is hard you just need to pay more attention that you have the right record kind of thing [para. 30]

Int 20 physician 10-20 years' experience health authority: As we move towards putting more stuff in a structured or semi-structured form and less stuff in an unstructured form throws a bit of backlash. You need them from all levels, from nurses and RTs to kind of, look I'm used to writing stories and doctors who are used to reading that. Just sort of reading, I'm going to read this little text thing and now I can understand all of the blow by blow what happened overnight and with sort of more structured and semi-structured it's ... You can see that, but it's a little harder to see, it's a little different to see. You have to look at it in a different way [para. 31]

Summary

The clinical and non-clinical interviewees have provided examples that staff assume on the one hand that the system will protect them as a safety net because they may have unrealistic expectations about the information system, while on the other hand, they feel they can over-ride the system to replace missing data. Two clinical interviewees make the important point that users need to think about paying more attention while using the system.

The other group of users, those external to the front line, (at the local entity such as a health authority or ministry level) provide health system business practices and standards to reduce information and information system instability. The information system vendors may bridge the users, local entity and ministry.

5.3.11 External Factors: Local Entity, Vendor, Ministry

Introduction

The interviewees mention three external entities or factors that regulate the health care system of which acute care is a part. These are the local entity such as the health authority, the vendors and the ministry. These will be discussed in turn with the first being the local entity such as a health authority funding and overseeing health care at a regional level.

External Factor: Local Entity

Descriptive Statistics

Many of the local entity comments appear under the catch-all business practices term that was coded fifty-four times for 14/20 interviewees: 5/6 nurses, 6/10 non-clinical 2/3 physicians and the pharmacist showing that the clinical interviewees used this term more often. Interviewee two, non-clinical, used the term eleven times, interviewee four, clinical, ten times, interviewee fourteen, nine times, clinical interviewees one and five, four times, interviewees three, non-clinical, and nineteen, clinical, three times and the rest, once or twice.

The business practices term included the word “business,” “business practices” or process that means the work of health care. Other terms such as “organization”, “hospital” or “Authority” referred to legal entities: these terms were also used in this section. These terms were used throughout the interview questions and compiled under in this section.

Qualitative Understanding from the Interviewees

A selection of these terms that pertain to a local entity will illustrate some of the roles the local entity plays in information and information systems.

Information

Theme: Health authority standardize charting and data entry

Health authority policies and procedures standardize practice including information requirements

so there is accurate and complete charting on the patient:

Int 14 nurse 21-30 years' experience health authority: I think that we've got some care standard work that we did for all our disciplines across the Authority who took professional practice groups that conducted that work to make sure that we had a strong foundation before we put systems in [para. 21]

There can be standardized data entry so the patient information is complete for care and analysis on a weekly basis:

Int 16 physician 10-20 years' experience health authority: We also have to make sure that the nursing staff and the allied healthcare professionals who also enter data into the system through their assessments and their impressions is also representative of the patient's condition. That's actually part of our weekly review cycle of, this nurse has noted that they don't have the following parameters that they should chart on [para. 25]

Theme: Health authority or its funded hospitals may not have any standards or policies!

The health authority may also not have any policies as several non-clinical interviewees explain. This makes it very difficult to replicate care in the paper chart system setting in the electronic information system setting. This can lead to downstream problems later as these two interviewees show:

Int 02 non-clinical 21-30 years' experience public & private: often most organizations have no idea of what their processes are and they have had paper different processes for years and when you go to automate you have to really understand what your current processes before you can ever redesign them or automate them. And um, often they are not the right skills or the number or resources or time spent on that. Um, so that is one area where you can have the technology reduced errors or issues, right, maybe not errors right but you could have issues down the line. It could be an error or a new inefficiency or it could be maybe it was a department that was collecting data off a piece of paper that you got rid of and you weren't aware of it [para. 38]

Int 09 non-clinical 10-20 years' experience public and private: If there's no clear policy or process, which a lot of hospitals try and set up process and policies around managing within a hybrid world, most of them don't. Most of them actually don't get it done, so it's not clearly communicated what's on paper versus what they should find electronic, right? I think that, going back to some other principles of having it be accessible, if you don't know where to look, that's going to be difficult [para. 10]

Theme: Health authority as funding body sets the information and information system agenda

As a local funding body the health authority can drive the agenda in some cases over the better judgment of the users to the detriment of information and system stability:

Int 16 physician 10-20 years' experience health authority: The health authority decides that this is the next best thing since sliced bread, and about a year later, they lose focus and they go off and now the next thing is the next best thing, it's better since sliced bread. They took our information system, the old one, and they just said, "Well, it's in one site, so we will just leave it there. We're not going to do anything with it. We're not going to improve it. We're shutting down the project, but you can keep using it." After five years, because they thought, "Well, we'll just replace it with the new system," but that of course took five years. For that five years, is this antiquated system was the source of significant problems [par. 43]

Int 01 nurse 21-30 years' experience public & private: So then you say ok well, you know so the project teams they are putting in these um, software and they are adapting as you go to because you have programmers in there or you have the client who is the health authority or the doctors office or whatever saying you know it has to do this as well, and now you have people in there really bastardizing what the program is [para. 52]

Information system

Theme: Health authority standards can improve hybrid paper chart information accuracy and completeness

The health authority or profession can impose documentation standards and policies to improve information accuracy and completeness, something interviewee one sees is a gap

Int 01 nurse 21-30 years' experience public & private: so I am saying that documentation standards so what we have now is professional is we do have documentation standards but you own by our profession so how does it document to be timely and so forth. So we have had those forever but in the hybrid paper electronic world you need to be able to have a common understanding of how documents are put together and so it so there is that consult going on the paper chart or does it go on the electronic chart? [para. 21]

The implementation of an information system tightens up paper chart era sloppy charting:

Int 14 nurse 21-30 years' experience health authority: I think safety and patient care is often is it a break in process that occurs and, as you know when you implement systems, you highlight practices that may have compromised that patient's safety and may have been going on for quite some time and now the system highlights it. Some may attribute the systems creating that issue when it's been existing [para. 56]

Theme: Health authority is a source of legacy systems

In some cases, government created health authorities from smaller organizations each of which has their own systems that then were integrated into the hybrid legacy systems mentioned earlier. These systems are detrimental to information stability but still better than the paper chart:

Int 11 non-clinical <10 years' experience health authority: There's many different applications in our Health Authority like BB and AAA and all the older information systems and our new one coming in, which you're going to be able to pull the information so much faster than if you were to pull it from a paper healthcare record and have to read the chicken scratch correct [para. 22]

Summary

Policies and procedures, if known, can standardize care and the information needed to document that care so it is more accurate and complete for the decision maker, and the correct patient the

decision is about if logging off procedures are followed. However, the organization or health authority can also be a destabilizing factor through unclear direction including information system acquisition as the clinical and non-clinical interviewees have explained . The other external factor, usually the health ministry, has a prime role in encouraging standardization to reduce instability. The third factor, the vendor, is the next external factor as it is often implemented in the local entity and funded by the ministry.

External Factor: Vendors

Introduction

Information system vendors are another external factor that work with the buyers to design and implement information systems so they are an important influence on information and information system stability.

Descriptive Statistics

The terms “vendor” or Vendor XXX or Vendor YYY (note that the transcripts have been anonymized to remove vendor names with letters used to replace vendor names mentioned in the transcripts) or other system name was coded thirty times for 12/20 interviewees: 4/6 nurses, 4/10 non-clinical, 3/3 physicians and the pharmacist showing that the clinical interviewees used this term more often (8 vs 4), possibly because they work with the systems routinely for patient care. Interviewees one, clinical, and three, non-clinical, used a term five times, interviewees seven, non-clinical, and nineteen, clinical, four times, interviewee four, clinical, three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

The interviewees did not provide positive thoughts on vendors. They are seen as adversaries and poor service providers to the health care system. They can impact information system stability in several ways.

New System

Theme: Vendors are unwilling to customize new systems extensively for the Canadian setting

Int 04 nurse 21-30 years' experience public: Yes there is more and more vendors that that is their claim to fame they have decided that the marketplace is fairly saturated with your clinical systems with your Vendor YYYs and your Vendor XXXs and your um, those guys. They can't compete with them so um, let's go look at some of the other things that other people aren't looking for, so it is the dashboard kinds of things and it is the way that data is being

presented that kind of stuff. More and more it is the big firms less and less willing to customize [para. 62]

Theme: Vendors force social engineering on users

Interviewees four and twelve note that this unwillingness to accommodate to Canadian health care leads to a form of social engineering imposed on the users. This could cause information instability if the system is not user friendly and information is not entered or accessed easily:

Int 04 nurse 21-30 years' experience public: And it increases the possibility of error and it requires more resources on their end and so they in trying to do that they price themselves out of the market, so they have done, so somebody like Vendor YYY because that is the vendor that I have been working with. They basically are moving to the market position that we don't customize period. And that they will do a little customization but it is limited to American terminology versus Canadian terminology other than that you don't like that field label name that is really unfortunate, get used to it [para. 25]

Int 12 non-clinical 10-20 years' experience health authority: We have to have a system that is there to meet the clinical need and not have a system off the shelf, and try to have the clinician mold themselves to the actual IT system. It has to be the opposite, but still, every day, I'm seeing it. We all ... We go buy a phone and then the phone is already pre-setup for us, and we change. It's a really interesting social engineering piece that Apple was doing. We all have modeled ourselves to work with what Apple wants us to do and wants us to act [para. 87-88]

Theme: Vendors seem quick to blame their client's requirements when implementations go sideways:

Int 08 non-clinical 10-20 years' experience ministry: Any of the systems that we've worked on at the ministry at least for medical imaging is always the vendors initially seem to understand what the problem is or what you're trying to get to but when they finally roll it out there's gaps. IMIT people would always say, "Well you can write your business rules better," and perhaps you can, but from an

end user perspective you can't always anticipate things. You have the big picture of what you want [para. 52-54]

Theme: Poor alert design example

The vendors can have different alert levels for the same drug interactions. This could cause issues for the decision maker who is used to a different vendor interpretation. This is also why the pharmacist has advised above in the pharmacy adverse event section 5.3.9 that these alerts do not replace clinical judgement:

Int 19 pharmacist 10-20 years' experience health authority: There's a lot of problems with the decision support provided by those third party vendors. The evidence that drives what will fire an alert and not fire an alert is ambiguous and conflicting between systems at times. For example one vendor will say that, "That's a moderate interaction that requires no intervention," and others will say, "That's a severe alert that requires immediate intervention." There's a lot of mixed messages [para 22-24]

Theme: Unannounced vendor upgrades impact information quality

Once a system is in place, vendors can do upgrades without telling their client who then notices there is a problem. This can have serious consequences if the information is patient identity:

Int 02 non-clinical 21-30 years' experience public & private: but we have also seen um, system induced errors um, we have had one or two cases where a vendor has done a product upgrade and introduced a problem that has caused the wrong patient identity to be tagged to results that they are sending um, so that has happened and that is um, very serious issue [para. 22]

Int 03 non-clinical < 10 years' experience public: we typically engage the vendor as soon as we see something that um, looks like you know we have many patients, multiple patients then we will immediately engage the vendor and say that something happened, did something change? He might say, oh ya, we did an upgrade two days ago ok, sure enough we start looking back at all of our data and we can see a pattern where ya, ok, prior to that data everything it is good after that date we have problems [para. 24]

Theme: Vendor YYY has poor design

Interviewee four mentions the Vendor YYY platform. Interviewees seven and nineteen have particular examples of this vendor contributing to information system errors as the following quotes show:

One error was truncated allergy information in a data merge

Int 07 non-clinical 10-20 years' experience ministry: one adverse event that we had um, because there was missing information it was missing um, allergy information so um, when we are I don't know if you are familiar with Vendor YYY the software and this speaks to a technical issue as well that was resolved but one of the things that can happen when we are merging two records together within that system is that their um, their lifelong clinical information like allergy, that is not life-long necessarily but their immunization information is um, allergy information ideally um, it is my understanding that that would be confirmed at each encounter and in this particular case a merge was done of two to patient records um, both records were for the same person but when the merge was done the allergy information didn't consolidate. In fact what happened was that the allergy information on one record got left behind and the allergy information on the surviving record was downgraded from confirmed to um, unverified I believe. There was potential allergies but they had been unverified and they all of the allergies weren't listed and only the ones that were listed were verified and then a medication was given that was contra indicated. The patient was quite ill but it wasn't a tragic event there was a lot of investigation because that was a technical issue but it was also you know maybe due diligence wasn't done in the patient interview or history I don't know [para. 52-57]

Another was changing demographic information for an inpatient that did not carry through to another linked information system:

Int 07 non-clinical 10-20 years' experience ministry: creates a problem when those two care settings are sharing a demographic database. it has really been an issue with the Vendor YYY um, implementations because they do like all of the applications and all

of the modules around the EMR hub share the same demographic database and um, for example if a homecare client is in hospital um, the hospital may update their address information to be you know something that is more current and then when the patient goes home, or say the patient has been living with a son or a daughter um, you know they have a temporary address and then they go home and a homecare nurse who has never been involved in that patients care before goes to the wrong address...It is so um, and then you try to solve some of those things technically so you know we try to say ok this is the record has a homecare um, encounter this piece of information shouldn't be able to be updated and that is where I start to have concerns about information quality when you are putting exceptions on things. [para. 24-27]

Interviewee nineteen singles out Vendor YYY for having very poor analytics for medication usage that are displayed in the YYY board, a dashboard display:

Int 19 pharmacist 10-20 years' experience health authority: You'd have to do it all manually. There's so much potential with the data that's in the systems, but it's not being presented to the clinicians in a fashion that is usable. Vendor YYY ? Well it's good by Vendor YYY's standards, but Vendor YYY's not good. I mean definitely with respect to my position where I have to sort of keep an eye on drug costs and looking at what's driving our drug costs in the organization to try and get that information into the system right now. It's almost a manual process. It doesn't really sort of blow up data easily for me and say, "OK, on the medical unit these are the top five drugs." Likewise, as far as adverse event reporting system, "On this unit, what are the top five drugs that have been involved with incident reports." It's not presenting the information in a usable fashion, it's very cumbersome to figure out trends and visualize data [para. 94-98]

Interviewee four questions the field in the Vendor YYY dashboard; this may represent poor customization or no customization. This could lead to missing patient information in the display, a display the decision maker may be relying on:

Int 04 nurse 21-30 years' experience public: So if I was wanting to say you know do we want a platform or a this platform or that

platform? Um, what is it that gets documented? Um, and then look at they are typically not mandatory fields so what is the probability and if I look at diagnostic information and I am not seeing um, particularly significant clinical documentation why is that? If I would expect to see certain kinds of documentation for a diagnosis why am I not seeing it?[para. 68]

Summary

The mostly clinical (and some non-clinical interviewees) obviously work with the vendors' information systems routinely for patient care but they found vendors tended to be difficult to work with. The next section covers the last external factor is the ministry the overall custodian and funder of the acute care system.

External Factor: the Ministry

Introduction

The ministry's role is to fund and oversee the provincial health care system through standards and monitoring. The interviewees provide examples of the ministry improving or decreasing information and information system stability.

Descriptive Statistics

The term "ministry" was coded twenty-one times for 9/20 interviewees: 3/6 nurses, 4/10 non-clinical, 2/3 physicians showing that the clinical interviewees used this term slightly more often (5 vs 4). Interviewee twelve, non-clinical, used the term five times, interviewee eight, non-clinical, four times, interviewee two, non-clinical, three times and the rest, once or twice.

Qualitative Understanding from the Interviewees

Information

Theme: Ministry sets information standards patient identity information and practitioner credentialling:

Int 08 non-clinical 10-20 years' experience ministry: In a nutshell, demographic information is pretty good because we standardize that in terms of PHNs, MRNs, but the qualitative stuff, we don't have a handle on it yet. [para. 11-13] [note: MRN is a patient hospital admission number]

Int 14 nurse 21-30 years' experience health authority: I think we will certainly be aware when we have to conform and with the registry and the credential standards. Those are the external influences to the system that we have to conform with [para. 35]

Given the vendor's unwillingness to customize the system some ministries are creating their own customized information content to improve decision making:

Int 18 physician 10-20 years' experience ministry: that's where we really get high value, where we're starting to reduce variation in

practice and using evidence in a more of an effective way and designing and configuring that content is also a really important piece of the design of these systems, and yet most of us don't end up using the prepackaged contents that come with the systems because they don't fit our geography or our standards or whatever, so we're creating a lot of that on our own, and so there's a lot of responsibility on our side to be sure that that information that goes into the system is also accurate and is the highest quality, because we could be giving ... providing inappropriate guidance [para. 47]

Information system

Theme: Ministry sets information system standards to ensure accurate and complete information

The ministry sets information system performance standards or conformance standards to minimize information and information system instability:

Int 03 non-clinical < 10 years' experience public: we provide a nice set of standards that they need to speak to us in and um, that is part of their conformance that they are following that standard [para. 33]

Int 03 non-clinical < 10 years' experience public: We have a QA team that is responsible so they work with um, organizations that sends us data to ensure that they have a testing plan, and that it meets certain criteria in terms of um, types of things they should be testing and looking for. And we require both, we do it both in internal check as well as required sign off in the organization that is sending us data that they have completed the QA process and are happy with the results. In the case where we have had erroneous data sent um, we have resorted to actually manually looking at each and every record touched to ensure ourselves that they are correct [para. 27]

Adherence to these standards means that the ministry can trust the system will maintain information quality with work saving for the ministry:

Int 07 non-clinical 10-20 years' experience ministry: like I said both within and without health services so it is kind of with stories like that go out it does become a badge of honour that hey, we are using these standards. and the other thing is that when data sources come

to um, the ministry and ask to be to have their clinical information allowed in the EHR if they are following these standards then there is a whole lot of questions that we don't have to ask them and a whole lot of rigor that we don't have to go through [para. 90-1]

Theme: Ministry sets policy direction based on inputs from local entity so there needs to be accurate and complete information for the ministry

Interviewee eight comments that unstable information provided to the ministry by its healthcare partners can result in poor decisions at that level too. This means that the ministry will be giving poor direction:

Int 08 non-clinical 10-20 years' experience ministry: Poor quality, like data quality, is just bad in our area because data is used in radiology or even at the ministries for executives for making decisions. If you get either the wrong information, not enough information. Or information that doesn't tell you anything, and you base your decision on that, then the outcomes could be anywhere from tragic to it didn't make any difference. It doesn't have to be tragic to have bad effects or negative consequences. You could draft a really bad policy [para. 112-5]

Theme: Ministry drives the agenda for implementation and funding

The ministry agenda can increase information instability if a system is rushed into production:

Int 01 nurse 21-30 years' experience public & private: Or what does the ministry know, and it reflects so badly on the people that are trying to do such good things, and it is a good thing home monitoring is a good thing. But don't let the technology and what was happening here was just the push, push, push, get it out, get it out and get it out [para. 62-3]

The ministry funding agenda is short term (based on election cycles) compared to health care's long term support. There is focus on capital spending and not operational information system costs that are very long term. This lack of ongoing funding could increase information system instability and information instability because of poor system maintenance:

Int 02 non-clinical 21-30 years' experience public & private: I think that you can't do it all at once, you know you are not going to get it right the first time and let's just admit that up front right, the organizations have never want to admit that you know politicians that are funding these things that are ok, we are going to give you one time funding and we want you to do everything in the next 5 years and they don't look at the long term and they don't look at the incremental because they can't commit to long term funding, they will never commit to operational funding they have to commit to one time capital funding but they don't do the operational dollars or support these things and the operational dollars are always going to be cut back and they are expensive to build and they are expensive to maintain and you are not going to see your true benefit, financial benefit for a long, long time if ever right [para. 86]

Ministry monitoring for funding drives the clinical agenda:

Int 12 non-clinical 10-20 years' experience health authority: I think unfortunately that at times to my earlier comment that we implement new system, the focus becomes on data on maybe the information that we have to submit to the ministry, where this information truly should be used for clinical purposes [para. 44]

Summary

The small number of interviewees have provided examples in the interviews where the ministry has similar issues as the local entity, health care organization or health authority, such that the ministry can provide benefits to information and information system stability in a setting of competing agendas driven by funding.

5.3.12 Summary Tables

Tables 17 to 23 summarize the major codes with a separate table (developed from the a priori groups from five key areas) for each of acute care, information quality (overview and instability and remedies), information system (instability and remedies and the three systems example), users and external factors.

Each major code table has the same headings of person, information and information system used to organize all the themes derived from the coded interviews. There is a sub table for each

major code used in Chapter Five with a reference to section number in brackets in each table heading.

Table 17: Summary Table of Ch. 5 Interview Codes & Themes: Acute Care Context

Interview Question Major Code: Acute Care Context (5.3.3)	
	Themes from Interviews
<u>Patient</u>	<ul style="list-style-type: none"> • there may be missing information at first • the patient state is complex and changing with changing information
<u>Information</u>	<ul style="list-style-type: none"> • there are high information demands in acute care • there is a need for a stable patient identity • there are many high demands on information quality at admission when there may be many unknowns and the patient is unstable • information overload, for example, elsewhere in the hospital such as an ICU that generates such large volumes of information that there could be information overload
<u>Information System</u>	<ul style="list-style-type: none"> • the patient's information may be missing ie not available because it is in a paper chart in a hybrid system of paper and electronic records-this could affect care • information volume for the complex patient who may have many monitoring devices attached, each generating its own volume of information about each monitored body system
<u>Users-staff</u>	<ul style="list-style-type: none"> • Multiple users accessing the system and adding their own data about the patient to the record • patient's information is not available quickly so care providers order new tests and get more information adding to the information volume • user demands: pressure and constraint in acute care • stressed staff not paying attention

The following is a brief summary of the section on acute care contexts (from Table 17). There are several important themes that emerge from these quotes from the clinical and non-clinical interviewees:

- Acute care is complex with a large volume of information generated as the patient's state changes and as the patient is more intensively monitored; this information may be missing and not available for the decision maker
- All interviewees answered this questions so there was an equal balance of responses

Table 18: Summary Table of Ch. 5 Interview Codes & Themes: Information Quality Overview

Interview Question Major Code: Information Quality Overview (5.3.4)	
	Themes from Interviews
	Information Purpose: Make a Decision (5.3.5)
<u>Patient</u>	<ul style="list-style-type: none"> • Patient’s own information must be complete
<u>Information</u>	<ul style="list-style-type: none"> • Types of decisions have determine levels of accuracy-highest level of accuracy for patient care • Decision only as good as the information available to the decision maker • There must be stable information
<u>Information System</u>	<ul style="list-style-type: none"> • Information system must present the information to the decision maker • Electronic system may be more complete provided fields filled out using the drop down boxes so the information is accessible in the relevant modules in the system
	Ideal Information State: Accurate And Complete (5.3.6)
	Information characteristic: accuracy
<u>Patient</u>	<ul style="list-style-type: none"> • Patient identity information is key
<u>Information</u>	<ul style="list-style-type: none"> • Patient identity source of truth
<u>Information System</u>	<ul style="list-style-type: none"> • Patient identity is directly linked to the person
	Information Characteristic: Complete
<u>Information</u>	<ul style="list-style-type: none"> • Patient information must be recent and relevant • There must be no gaps or missing information that can affect a decision
<u>Information System</u>	<ul style="list-style-type: none"> • Complete information means information is entered into the system

The following is a brief summary of this section on information quality (from Table 18)

- Patient care decisions require the highest degree of accuracy. The decision maker must have a complete set of data necessary to make the decision. The information must be precise so that changes in the information reflect true changes in the patient state and not random changes.
- Accurate information about an individual both identifies and reflects the true state of the individual. Complete information means that there are no gaps in the information and it must be relevant.

Table 19: Summary Table of Ch. 5 Codes & Themes: Information Instability & Remedies

Interview Question Major Code: Information Instability and Remedies (5.3.7)	
Themes from Interviews	
	Instability: unstructured Data-Handwriting, Free Text
<u>Information</u>	<ul style="list-style-type: none"> • Unstructured data is a source of rich data • Unstructured data lets the staff tell the patient's story
	<ul style="list-style-type: none"> • Unstructured data is there but hard to read • Unstructured data may be missing because of chart structure or charting style • Unstructured data can drift from accuracy • Difficult to standardize
<u>Information System</u>	<ul style="list-style-type: none"> • Unstructured data with redundant information may be a source for error • Non clinicians feel unstructured data is useless for analytics • Unstructured data is difficult to manipulate or link
Instability: Structured Data	
<u>Information</u>	<ul style="list-style-type: none"> • Inaccurate patient identity transcription or data entry changes source of truth • Transcription or data entry in general can corrupt structured data
<u>Information System</u>	<ul style="list-style-type: none"> • Unskilled data merging corrupts structured data by changing accuracy and/or completeness • Effect of structured data instability-means poor decisions • The missing or corrupt structured information does not reflect the true patient state
Remedy: Standardization	
<u>Information</u>	<ul style="list-style-type: none"> • Standardized data enables information sharing • Information standardization contributes to trustworthy data, especially for pharmacy data • Standardized information is useful because it is accurate and complete for better analytics for care and other uses • Standardized information can lead to process standardization downstream • Information standardization is good vendor PR
	<ul style="list-style-type: none"> • Taxonomies may not be adopted because of mapping issues or third party software • Difficult to define source of truth for in-house information standardization • Persistent ancient information standardization that is no longer relevant or safe
Remedy: Identifier Standards	
<u>Information</u>	<ul style="list-style-type: none"> • Personal identifier is on a provincial identity card • The personal identifier should be validated from other provincial data sets • The personal identifier can become corrupted with new information linked to it and no longer is the patient source of truth

	<ul style="list-style-type: none"> Personal identifier can become corrupted with wrong data entry or transcription; this corruption can have a delayed effect on patient care
<u>Information System</u>	<ul style="list-style-type: none"> The personal identifier should remain stable whatever the system The personal identifier can be misread because of a poor screen data display
Remedy: Stabilize Unstructured Data-Templates Control Free Text	
<u>Information System</u>	<ul style="list-style-type: none"> Template design is critical to show a benefit Template or text fields can ensure information is complete Specialized template with clinical criteria may be useful and provide complete information
	<ul style="list-style-type: none"> Template may not improve care and may add to work flow if too many input screens Templates or text boxes too restrictive so possibly conflicting unstructured data added to the record
Remedy: Stabilize Data-Dropdown Boxes and Forcing Function	
<u>Information System</u>	<ul style="list-style-type: none"> Drop down boxes structure the record with mandatory fields such as patient scores etc. as a forcing function Drop down boxes are a convenient way to input data so patient information is more complete Drop down boxes are more suited to quantitative information Drop down boxes are a good forcing function for medication uses but still need human validation checks Drop down medication errors are still less than unstructured data orders so drop down boxes are safer
	<ul style="list-style-type: none"> Critical patient information in an unstructured data text field may be missing if the care provider reviews only the only drop down boxes and not the rest of the record that could have rich important patient information for decision maker
Remedy: Stabilize Data-User Validation Checks	
<u>Information</u>	<ul style="list-style-type: none"> Staff validation checks maintain and preserves patient identity Staff validation checks maintain and preserves other patient information Staff validation checks counteract system assumptions with patient clinical assessment and judgement Staff validation checks still needed to check certain critical systems such as infusion devices dosing decision support Staff validation check workflow for paper hybrid system needs to be replicated for electronic information system, for example, double staff checks for medication orders Staff validation check can also happen after a system check can be for other types of patient information too
<u>Information System</u>	<ul style="list-style-type: none"> User and expert validation check should happen in information system life cycle design and use

The following is a brief summary of this section on information instability and remedies (from Table 19)

- The clinical interviewees noted the desire to “tell the story” but at the cost of information instability for the clinical and non-clinical interviewees including redundant data, missing data and technical issues with data manipulation.
- Poor information quality does not reflect the true patient state for the decision maker.
- The identifier is a key standard data element that is used to create the patient profile on admission to acute care: this profile is assumed to be the source of truth for patient identity. It is important that the identifier not become corrupted and destabilized.
- The interviewees feel that templates and drop down boxes / forcing function are a useful remedy for standardizing unstructured and structured data respectively so mandatory fields such as identifiers or acuity scores so the patient’s own information remains accurate and complete.
- Validation as a remedy involves care providers or experts checking the information to increase its approximation of truth and to correct any potential inaccuracies or gaps that could contribute to an adverse event. Validation can also be applied to system design and use.

Table 20: Summary Table of Ch. 5 Codes & Themes: Information System Instability & Remedies

Interview Question Major Code: Information System Instability and Remedies (5.3.8)	
Themes from Interviews	
	Instability: Hybrid Paper Chart System
<u>Information</u>	<ul style="list-style-type: none"> • Ideal state-patient information should be easy to find • Unstable-information is missing because information is not accurate or complete or can't be found in the chart • The information is missing because the chart is unavailable or parts of the chart are lost • Information is missing because of poor charting • Missing information means a poor decision will result because of delayed transcription • Information is complete but is not useful because can't get sense of the patient • Scanned PDF information inserts are not legible or in wrong place in the chart so the information is unavailable • Staff make personal notes on paper that may be entered into the electronic chart wrongly • Health care may never be completely paperless
	Instability: Electronic Information System
<u>Information System Design</u>	<ul style="list-style-type: none"> • Missing information resulting from poor design may not be immediately obvious but show up later when that bit of information is needed • Programming modifications for Canadian system may create unknown risks • Programming can cause a disconnect between data entry and output so there is an information error • Programming even drops the data entirely so it is missing or makes abnormal data look normal, a false negative result so that either a clinical decision is not made or is made based on missing information • Patient information may seem missing because it is delayed • Accurate and complete information may compensate for missing information
Patient Identifier Effects	<ul style="list-style-type: none"> • Programming to simplify a system can cause problems if some of the system validation steps are lost-this would affect the patient identifier • Programming could allow a dummy identifier in a field where a true one would be so the data set becomes corrupted • Unannounced vendor upgrades that creates an patient identifier to data mismatch so that a decision could be made based on another patient's information
Other Data Effects	<ul style="list-style-type: none"> • Programming to simplify can contribute to an adverse event because removing safety features such as medication alerts to minimize alert fatigue • Poor system design cannot be made usable with training • System does only what the programmers tell it to so it must be right

Implementation	<ul style="list-style-type: none"> • Rushed implementation can lead to programming errors and incorrect information • Some poor information quality is inevitable after implementation because the test environment can never replicate reality so there is some malfunction
User Interface	<ul style="list-style-type: none"> • The demographic information may be difficult to find in the data display • Other data may not be accurate or complete in data displays too • The screen font and contrast may be poor making information difficult to find • Different keyboards layouts can enable wrong data entry of numerical information because the system is not user friendly
System Integration	<ul style="list-style-type: none"> • Poor integration leads to truncation of important information is-as a result the system has no credibility and the information is considered untrustworthy • Poor system integration of system time clocks leads to inaccurate time for clinical event such as time of death • Integration is complex with several points of failure with points of failure increasing as complexity increases • Overall system needs constant tweaks and upgrades that can introduce further error
Legacy System Integration	<ul style="list-style-type: none"> • Integration of legacy systems working beyond their lifespan creates information instability • Legacy system integration and modifications can lead to information instability • Legacy system integration with registry system have potential to corrupt patient identifier • Legacy system integration is difficult because of different HL 7 messages
Decommissioning Legacy Systems	<ul style="list-style-type: none"> • Patient information can get lost and missing through poor data retention practices
	Remedy: Increase Stability
<u>Information</u>	<ul style="list-style-type: none"> • Pro-electronic system provides faster access to patient information for improved care diagnosis and decision making • Pro-electronic information system provides data for health system analytics • Information is more accurate because there is less "noise" from unstructured data • Information is more accurate and legible for safer prescribing • Information is more complete because of forcing function of drop down boxes and mandatory fields • Information is more complete because there is mandated and legible charting frequency • The information will become more complete over time as more information is added to the electronic information system to create an extensive and complete longitudinal record for the patient
<u>Information System</u>	<ul style="list-style-type: none"> • Ministry conformance standards provide information standards for vendors wanting to access provincial data

Design	<ul style="list-style-type: none"> • Ideally, remove the human input factor as much as possible so system is intuitive • Information system will need customization for local users • Information system design to reduce manual data entry and potential for errors • Information system integration should allow for other clinical information modalities such as photos
Reminders	<ul style="list-style-type: none"> • Information system reminders can improve information accuracy and completeness by ensuring tests are done on time • The information system can provide prompts to assist staff with data entry • The information system can provide templates to assist staff with data entry but may increase workload compared to a checklist
Data Display	<ul style="list-style-type: none"> • The information system must have a data display that captures changes in patient state in a usable and easy to read format
Implementation	<ul style="list-style-type: none"> • Information system implementation provides an opportunity to get expert clinical input at design and implementation • Information system implementation with expert clinical input may reduce workarounds that impact information quality
	<ul style="list-style-type: none"> • Information system logging off may not be automated so maintains a potential for error • Natural language processing may provide a structured format for analysis of unstructured data in the future

The following is a brief summary of this section on information system instability and remedies (from Table 20)

- The mostly clinical interviewees use terms such as missing data or inaccurate data entry resulting in poor decisions that are similar to those for unstructured data; this is not surprising given the paper system format holds unstructured data.
- The interviewees have clearly described that there are several types of hybrid record such as paper chart, notes and scanned PDFs all of which can contribute to missing data and information instability for the decision maker making the information inaccurate and incomplete
- The interviewees have provided opinions on how electronic system instability places demands on the information and the users accessing the system primarily through the phases of the system life cycle from design to decommissioning, system integration, user interface with an end result of a fragile system

- The interviewees' remedies explain that better design so that care providers can access and use information that is more structured and subject to less human interference. There is also improved monitoring of the health system as a whole

Table 21: Summary Table of Ch. 5 Interview Codes & Themes: Examples from 3 Systems

Interview Question Major Code: Unstable Information System: Examples from Three Systems (5.3.9)	
	Themes from Interviews
	Pharmacy
<u>Information</u> Admission History	<ul style="list-style-type: none"> • Patient medication information at history taking step is often missing and unstable-this early information can conflict with later information • Inaccurate patient's information validated with the patient's chart may be a source of error if the chart itself does not have accurate or complete information • One remedy for the patient-chart discrepancy in patient information is to have specialized staff to take medication histories with an example
Ordering	<ul style="list-style-type: none"> • Pediatric dosing requires accurate dosing based on weight so needs accurate weight information • Pediatric medications dose uses specific concentrations that vary from manufacturer to manufacturer so can be a source of error • The scientific basis for pediatric doses is weak so may be a source of error
<u>People</u>	<ul style="list-style-type: none"> • After hours staffing with no pharmacists on site is an error risk because of missing validation checks • Medication orders placed off site can miss the staff validation check for accuracy and completeness • Patient medication information passages through many individuals as a source of error • Low staffing may be from chronic underfunding
<u>Information System</u>	Hybrid Paper Chart
	<ul style="list-style-type: none"> • The paper chart can contain disorganized patient information leading to poor care decisions
	Electronic System
<u>Design</u>	
Alerts	<ul style="list-style-type: none"> • Pro-automatic alerts warn the prescriber if the patient is allergic to a medication or the medication is contraindicated for some reason • Con-alert fatigue can lead to medication errors if users ignore critical alerts • Data display design should have clearly visible alerts • Users should have access to a no-blame incident system if ignore critical alerts
Displays	<ul style="list-style-type: none"> • Pharmacy information system programming should reflect the true drug dose patient information
User Interface	<ul style="list-style-type: none"> • Another device design issue is poor display and interface on infusion pumps so the infusion rate could be changed in error
Integration	<ul style="list-style-type: none"> • Information system merging so information truncated and missing
Possible Remedies But...	<ul style="list-style-type: none"> • Bar coding is seen as a potential remedy for medication errors by synchronizing the patient's medication information, the

	<p>medication and the patient's armband but there is nursing resistance to it</p> <ul style="list-style-type: none"> • Bubble pack workarounds cause medication error • Pharmacy decision support may give a false sense of security • Pharmacy decision support difficult to interpret because of excessive risk probabilities • A poor system is still better than illegible handwriting!
	Laboratory
<u>Information System</u>	<ul style="list-style-type: none"> • Interface creates missing information because information is truncated including unstructured data
<u>User</u>	<ul style="list-style-type: none"> • User workarounds to game access
	Radiology-Imaging-
<u>Information System</u>	<ul style="list-style-type: none"> • There are many points of failure in radiology (diagnostic imaging) • There can be a faulty automated linkage of patient information to the patient's image • There can be a faulty manual linkage of patient information to the patient's image

The following is a brief summary this section on unstable information systems (from Table 21)

- Medication errors can start at admission when the threats to information stability are highest. The predominately clinical interviewees provided good examples of information paper and electronic system and user causes such as inaccurate validation, poor decision support and lack of ordering and dosing standards. They also offer remedies and the reminder that medication errors have been reduced greatly by improving legibility alone.
- The interviewees did not speak of up front lab test ordering but of technical behind the scenes data manipulation issues so that the data was missing and incomplete.
- The radiology examples, provided again mainly by non-clinical interviewees point to faulty linking of the patient to their own image so the patient information was inaccurate; some of this linking is manual.

Table 22: Summary Table of Ch. 5 Interview Codes & Themes: Users

Interview Question Major Code: Users (5.3.10)	
Major Codes from Interview Questions	Themes from Interviews
<u>Users</u>	Physicians
	<ul style="list-style-type: none"> • physicians have a dual role-data extractors and creators • physician power as decision makers and initiative opponents • physician power-secrecy around physician adverse events
	Nurses
	<ul style="list-style-type: none"> • Nurse power-use workarounds to oppose new processes
<u>Information</u>	<ul style="list-style-type: none"> • Physicians and nurses support unstructured data, although nurses have resentment and reservations • Physicians and nurses want autonomy to tell the patient's story
	User Assumptions about the Information System
<u>Information System</u>	<ul style="list-style-type: none"> • There is the critical assumption that the system will be there for the decision maker with the patients accurate and complete information readily available • There is assumption around the permanence of the information (and reliance on others without checking) when in fact this is not the case • Users assume that all systems are the same especially staff who have worked on different systems at different sites • Users assume they know what the alerts and messages are without reading them. They get desensitized to the messages • Users assume they can input missing data easily as a workaround • Users assume system will save them from errors • Users assume system will warn them about allergies • Users assume system will warn them about drug interactions • Users assume system will alert them for almost everything so the user doesn't have to think or may not be aware • Electronic system means a new way of thinking is needed

The following is a brief summary of this section on users, information and information systems (from Table 22)

- Those who provided comment speak strongly about the importance of health care provider autonomy in a system that is increasingly restrained under the guise of information standardization. This need for autonomy can be at the expense of information quality
- The clinical and non-clinical interviewees have provided examples that staff assume on

the one hand that the system will protect them as a safety net because they may have unrealistic expectations about the information system, while on the other hand, they feel they can over-ride the system to replace missing data.

Table 23: Summary Table of Ch. 5 Interview Codes and Themes: External Factors

Interview Question Major Code: External Factors (5.3.11)	
Major Codes from Interview Questions	Themes from Interviews
	Local entity-health authority
<u>Information</u>	<ul style="list-style-type: none"> • Health authority standardize charting and data entry • Health authority or its funded hospitals may not have any standards or policies • Health authority as funding body sets the information and information system agenda
<u>Information System</u>	<ul style="list-style-type: none"> • Health authority standards can improve hybrid paper chart information accuracy and completeness • Health authority is a source of legacy systems
	Vendor
<u>Information System</u> New System	<ul style="list-style-type: none"> • Vendors are unwilling to customize new systems extensively for the Canadian setting • Vendors force social engineering on users • Vendors seem quick to blame their client’s requirements when implementations go sideways • Poor alert design example • Unannounced vendor upgrades impact information quality • Vendor YYY has poor design
	Ministry
<u>Information</u>	<ul style="list-style-type: none"> • Ministry sets information standards patient identity information and practitioner credentialing
<u>Information System</u>	<ul style="list-style-type: none"> • Ministry sets information system standards to ensure accurate and complete information • Ministry sets policy direction based on inputs from local entity so there needs to be accurate and complete information for the ministry • Ministry drives the agenda for implementation and funding

The following is a brief summary this section on the role of local health authorities, vendors and the Ministry (from Table 23)

- Local entity policies and procedures, if known, can standardize care and the information needed to document that care so it is more accurate and complete for the decision maker, and the correct patient the decision is about if logging off procedures are followed. However, the organization or health authority can also be a destabilizing factor through unclear direction including information system acquisition.
- The mostly clinical (and some non-clinical interviewees) obviously work with the

vendors' information systems routinely for patient care but they found vendors tended to be difficult to work with.

- The small number of interviewees have provided examples in the interviews where the ministry has similar issues as the local entity, health care organization or health authority, such that the ministry can provide benefits to information and information system stability in a setting of competing agendas driven by funding.

The next section summarizes this chapter for the final discussion and conclusion chapter, Chapter Six.

5.4 Summary

While a health care provider needs accurate and complete information to make a decision about a patient there is a constant tension between stability and instability of information and information systems as the users access and use the information within the systems. The next chapter, Chapter Six, provides a unifying framework for the literature review and results with some refinement of the information, information and person triad. The next chapter also includes sections on contributions to knowledge and limitations and future research.

Chapter 6: Discussion and Conclusions

6.1 Introduction

This chapter provides an overview of the main findings from the study and discusses the implications of the findings in the development of a framework that can be used for considering information flow and quality in healthcare in relation to information technology. The results presented in Chapter Five from the semi structured interview questions' analysis show that:

- Acute care is complex with a large volume of information generated as the patient's state changes and as the patient is more intensively monitored; this information may be missing and not available for the decision maker.
- There is ongoing use of free text and unstructured data that, although it tells the patient story, is likely have missing information, be difficult to manipulate and lack the precision for detecting true change in a patient's condition. The interviewees explain that creating more structured data through the use of drop down boxes and validation may increase stability.
- There is information instability through the ongoing use of paper chart and legacy electronic information systems to create an unwieldy error-prone hybrid system. Remedies include, again, reducing unstructured data and improving data display and automation.
- Unstable information systems can cause adverse events for patient whose information is accessed in the key information systems including pharmacy, laboratory and imaging.
- The front line users are a source of much of the information instability from their need to tell the patient's story, to have autonomy within the system and their assumptions about the system.
- The factors external to the front line users such as the organization, health authority or ministry or vendor(s) that mandate standardization but undermine these efforts with their own competing agendas.

The next step in the research will show how the analysis fits together in a model and links back to the literature review in the Discussion in the next section before presenting Limitations and final Conclusions and Contribution to Knowledge in the final sections.

6.2 Discussion

6.2.1 Organizing the Interviewees' Interviews

The interviewees have years of wisdom that they have shared and that has been coded and organized to highlight issues with information and information system quality, namely issues around information instability and the factors that contribute to this instability. The interviewees have also provided remedies to lessen this instability. There is a need to organize and validate the Chapter Five findings further into a framework, such as the Systems Engineering Initiative for Patient Safety (SEIPS) Model, that has been used in health care settings. This model can be expanded and improved⁶⁰ in light of the interviewees' information. This Model was found at the end of the Chapter Five analysis phase at the research and was evaluated for use as shown in Appendix I.

6.2.2 SEIPS Model

The Systems Engineering Initiative for Patient Safety (SEIPS) model is a socio-technical model that includes the following elements matched to the interview results key sections:

- Person (this equates to the person part of the triad including patient and users [section 5.3.10 (Users) and throughout section 5.3]).
- Task (this is making a decision [sections 5.3.4 (Information Quality) and 5.3.5 (Information Purpose)]).
- Technology and tools or system (the interviewee's understandings and interpretations about information systems [sections 5.3.8 (Information System Instability) and 5.3.9 (Unstable Information System) and throughout 5.3]).
- Organization (this equates to the acute care context [section 5.3.3 (Acute Care Context)] and local entity [section 5.3.11 (External Factors)]).

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- Physical environment (the interviewees were not asked about this).
- External environment (this equated to the ministry and vendor [section 5.3.11 (External Factors)]).
- Patient outcomes and patient safety when adverse events were mentioned [section 5.3.9 (Unstable Information System)].

These six elements were used to organize the discussion of the key findings in Chapter Five⁶¹.

There are many models to choose from, [Appendix I](#) outlines the steps used to evaluate this model to confirm it was helpful for organizing the discussion in this Chapter.

The tenet of this model is that individuals use technology and tools to perform tasks in an environment under certain organizational conditions. This model has a focus on patient safety that is one of the five key areas in the research literature review and semi structured interview questions. This model has been used extensively in health care, for example see Holden et al. (2013), Carayon et al. (2014) and Salahuddin and Ismail (2015) for a list of studies.

Carayon (2014 p. 15, 17) provides information on the sources of the SEIPS Model such as Donabedian. This model builds on Donabedian's "Structure Process Outcome" model that includes "structural, process and outcome measures of healthcare quality". Donabedian's (1988) description of "healthcare structure is rather limited with a focus on material resources (e.g., facilities, equipment), human resources (e.g., number and qualifications of staff) and organizational structure (e.g., organization of medical staff, methods of reimbursement)".

Carayon et al. (2014 p. 17) extended the Structure Process Outcome model and "replaced the 'Structure' by the work system". "This improvement produces a more systematic approach to analysis and improvement of healthcare quality and patient safety" (Carayon et al., 2014 p. 17). The SEIPS model is the "conceptual framework" for "methods used to evaluate healthcare work systems and processes and their impact on healthcare quality and patient safety including ...interviews" (Carayon et al., 2014 p. 21). There are several depictions of the SEIPS model but

⁶¹ These finding are summarized in Tables 17 to 23 at the end of Chapter Five: these tables were used to find the relevant informant findings for the discussion of each of the six elements in this Chapter. Please note that information is part of the SEIPS Model diagram and will be discussed below in section 6.2.10.

the simplest for the purposes of this research is that of Carayon et al.'s figure 1 diagram, Figure 8, below (2014):

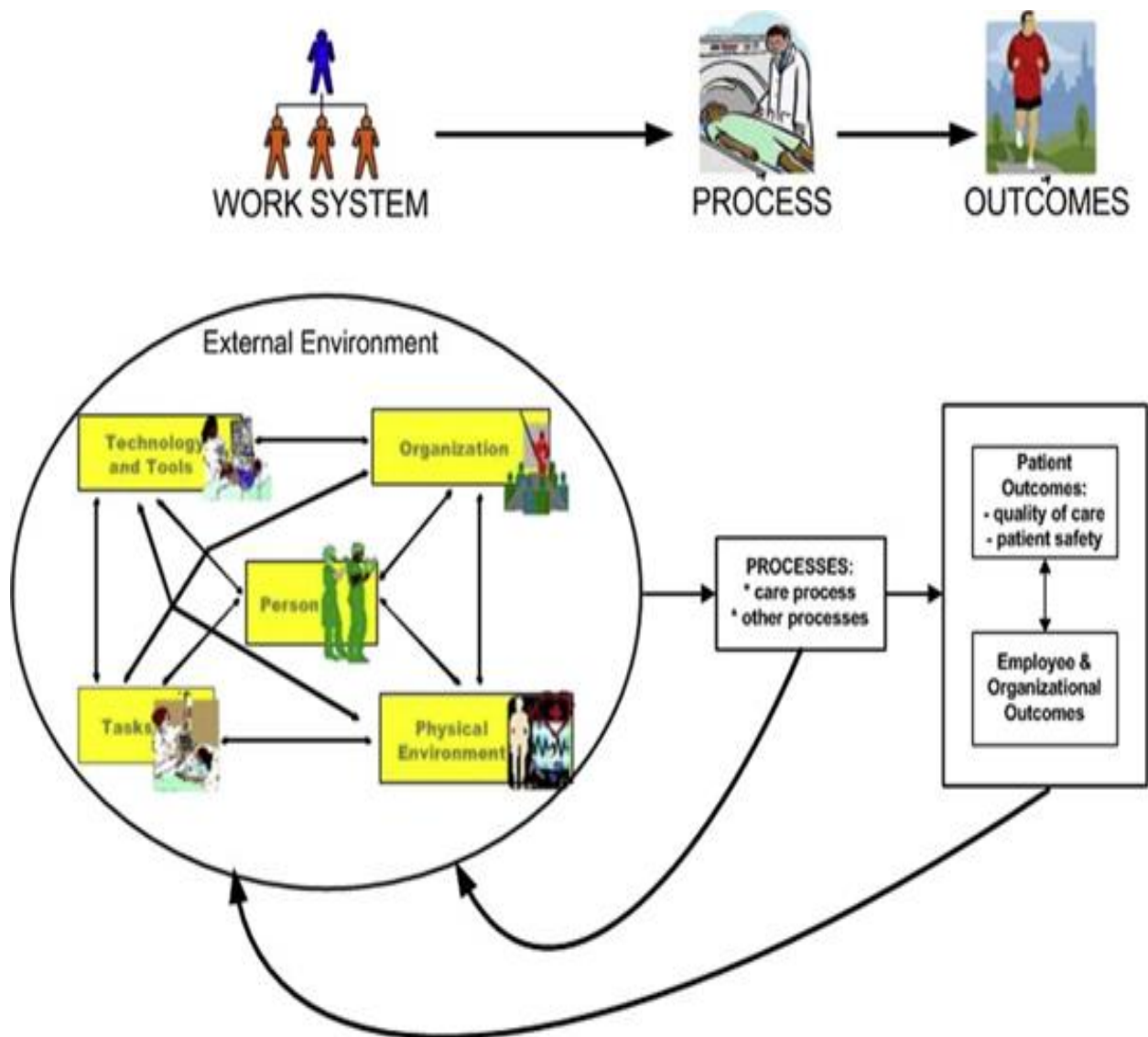


Figure 8: SEIPS Model. Reprinted from Carayon et al. (2014) Figure 1.

The model has work system inputs to the model such as persons, task, technology and tools, physical environment and organization within an external environment. Each of these elements support care processes that provide quality safe care to the patient.

The Salahuddin and Ismail (2015 p. 879, 880, Figure 2) model refinement blends parts of the DeLone and McLean model⁶² and the SEIPS model by including the DeLone and MacLean criteria of “system quality” (usability, compatibility, response time, reliability), “information quality” (completeness, relevancy, timeliness) and “service quality” (tangibles, responsiveness, assurance) within the SEIPS’ tool and technology category.

However, it can be argued that Salahuddin and Ismail are being *too restrictive* by placing information quality within the tools and technology category. This restriction means that we do not know what the black lines joining the parts of the model mean in Figure 8. In essence, the interviewees in this theses have provided their understandings and interpretations about the part of the model and how they can affect the patient outcome.

The next section will summarize first, the five SEIPS model elements within the external environment bubble in Figure 8 in the context of the interviewee’s comments where relevant, and then, discuss information as the separate step linking the parts of the model together within the context of the health care decision in the acute care setting.

The segregation of information and information quality fits with Holden’s further refinement of the model with his concept of “configuration” which states that “while all components of the work system potentially interact, only a subset of all possible interactions is actually relevant in a given work process or situation” (Holden et al. 2013, p. 1673). “What is ‘relevant’ is based on the strength of influence of the interactions on work process performance” (Holden et al. 2013, p. 1673). “Thus, for a particular process or situation, one can distinguish a configuration of a finite number of relevant elements that interact to strongly shape the performance of that process” (Holden et al. 2013, p. 1673). However, this research will take a broader view of information and information quality based on the wise understandings and interpretations from the interviewees.

6.2.3 SEIPS Model Elements, Results and Discussion

The SEIPS Model elements within the external environment bubble in Figure 8 will be discussed in the context of the findings of this dissertation in the following order: external environment,

⁶² For more information on the DeLone and McLean model please see the following link:
http://is.theorizeit.org/wiki/Main_Page

organization, physical environment, person, task, technology and tools, and finally, information including information quality.

Each SEIPS Model element will have:

- SEIPS Model element description.
- Summary of interviewee understandings and interpretations and themes, the epistemological “evidence”.
- Possible discussion based on the literature review of the five key areas as well.
- Possible literature review of specific themes or issues raised by the interviewees in Chapter Five. This literature review will explore some of the themes more deeply and provide validation for some of the specific key interviewee themes. Not all the themes were reviewed in this manner.

6.2.4 SEIPS Model Element: External Environment-Ministry

In the SEIPS Model, “the external environment is comprised of extra-organizational rules, standards, legislation, and enforcement, as well as characteristics of the healthcare industry in general and the healthcare workforce” (Carayon, 2014 p. 16).

Interviewees and Literature Review

Consistent with the SEIPS model, interviewees commented on the external factors related to the British Columbia Ministry of Health, which sets information and information system standards. The Ministry is an important funder of information systems with the caveat that their timelines are politically driven by election cycles that are shorter than the long-term demands of health care (see also Clarke et al. 2015 p. 5). Kushniruk et al., (2013), Magrabi et al. (2013) and Williams and Weber-Jahnke (2010) discuss standards and other jurisdictional methods as part of risk reduction remedies for information systems.

It is prudent to remember Roberts et al.’s (2009 p. 9) comment that decision making about systems, for example at a ministry or health authority level, is difficult because quantitative data and risk assessment methods such as a randomized control trial are difficult to do because all the variables cannot be controlled because of “cost constraints”.

6.2.5 SEIPS Model Element: Organization-Local Entity-Health Authority

The SEIPS Model includes “formal and informal organization, organizational culture and climate, rules and procedures, organizational structure and management” (Carayon, 2014 p. 16 Table 1). Salahuddin and Ismail’s (2015 p. 886, Table 9) survey has comments on the barriers to safe use of information systems that include staffing and/or the absence of standard procedures or inaccessible procedures. Hospitals funded and managed by health authorities provide acute care services that form the environmental context for the interview setting and the decision making tasks.

Interviewees and Literature Review

Some of the interviewees had similar comments about staff shortages especially in emergency settings and pharmacy. Some also mentioned the difficulties of implementing standardized care

plans and of missing policies and procedures. Salahuddin and Ismail's (2015 p. 886) survey also mention training and teamwork. These topics did not figure in the interviewees' the understandings and interpretations other than one comment that any amount of training will not enable use of a poorly designed system. The interviewees also mentioned information system issues such as legacy systems: this will be discussed in the SEIPS Model element Technology and Tools in section 6.2.9.

The organization represents the key elements of the health care system: the "blunt end" of Reason's model and health care system complexity (Please see section 2.7.3 (Causation Model for a description of Reason's Model). Reason's "blunt end" represents the physical system, engineering design, management, and regulatory behaviour that support the decisions about patient care at the "sharp end." The "blunt end" is the site of Nakamura and Kijima's (2009 p. 33) technical classes of failure, class III, the social and organizational causes of failure that are "outside the system boundary and are unpredictable at the design phase" as noted in section 1.1.3 (What are the Types of Failure).

The literature review references show the organization can provide an overall structure for information quality through the three systems. Chung et al. (2005 p. 232-237) in section 2.3.2 (Information Quality) mention factors such as the mechanical system such that organizations create bureaucracies and operating procedures, the mechanical system such that organizations create bureaucracies and operating procedures and the human system, an open system because people interact with the organization and with each other (i.e. people must be satisfied with the information before they will use it).

The acute care system has complexity as a result of the interactions of the individual components of the system and is therefore a "complex adaptive system" a collection of individual agents with freedom to act in ways that are not always predictable, and whose actions are interconnected so that one agent's actions change the context for other agents" (Reiman et al., 2015 p. 81). Complex adaptive systems or organizations are self-organizing with "distributed, not centralized, control" and have "emergence with practices and processes that emerge from the characteristics of the agents or staff and their relationships" (Reiman et al., 2015 p. 81). The freedom to act creates risks for the organization such as "normalization of deviance",

“organizational drift”, restricted information flow and system accidents so the organization needs to create boundaries and standardize the activities and behaviour to minimize adverse events (Leveson et al., 2009 p. 244; Reiman et al., 2015 p. 83, 87). “Norms and policies” impact the hierarchies within acute care (Karsh & Brown, 2010 p. 676) and the interviewees’ discussion about nurses’ workarounds and physician preferential treatment reflects this.

Standardization with “policies and procedures” counter the organizational risk of “practical drift which is the slow steady uncoupling of practice from written procedure because of constant demands for local efficiency” (Bowman, 2013 p. 7; Reiman et al., 2015 p. 83). Standardization can also increase information flow more widely. Interviewee fourteen in particular commented on the struggles to standardize charting in a climate of normalization of deviance and organizational drift. Workarounds are another example of self-organizing behaviour.

Although the interviewees do not discuss organizational complexity per se, they do give a sense of clinical complexity of acute care centred around unstable heavily monitored patients looked after by many specialized care givers and the information and information system demands. This fits with Nemeth’s (2004 p. 689) “hyper-complex” notion of health care. Complexity and complex adaptive system will appear again below when discussing tools and techniques (section 6.2.9) and information (section 6.2.10)

6.2.6 SEIPS Model Element: Physical Environment

The SEIPS model includes “physical layout, workstation design, noise, lighting, temperature and humidity, air quality” (Carayon, 2014 p. 16, Table 1).

Interviewees and Literature Review

The interviewees did not comment on the physical environment, however they did comment on data display that is discussed further in information system section 6.2.9 . The literature review did not discuss this topic.

6.2.7 SEIPS Model Element: Person-Patient and Users

In the SEIPS Model, the person is the individual at the center of the system in the SEIPS model. This can be a “single individual (e.g., physician, nurse, patient) or can be a group of individuals

(e.g., team, organizational unit)” (Carayon, 2014 p. 16, Table 1). The person is a member of the person, information system and information triad used in the results chapter, Chapter Five.

Interviewees and Literature Review

The results chapter, Chapter Five, has shown that the patient is the central individual because it is the patient who holds his/her identity, the “source of truth”, and generates clinical information used by the decision maker as a key source for creating the patient profile and directing care. The patient provides his/her information either as unstructured information as a narrative history or as structured data in a monitoring system. The patient’s information must be accurate and complete in the information system, paper or electronic, for the decision maker and other care providers. Breaks in the link between the patient and the patients information leads to information instability and a likelihood of errors at the sharp end of the health care system. Menon et al. surveyed US risk managers and health care lawyers and found that wrong patient identifiers was the third most common safety concern (2014 p. 17, Table 3).

The other individuals are the users, the physician(s) who direct care and make decisions about the patient based on the patient’s information, and the nurses who provide care plans, chart and administer treatment to the patient. The physicians are data creators and extractors while the nurses are singled out as being famous for workarounds. We saw that user workarounds can (as in the bubble pack example) cause an adverse event: this is an example of people knowingly doing things that are risky (Busby & Bennett, 2008 p. 797) and creating a “moved-vulnerable” file possibly because the information system is clumsy (Johnson and Willey, 2011 p. 40).

Flanagan et al. (2013 p. e 59) classify workarounds into three types: “1) mostly harmless actions that do not necessarily change work practices or affect data accuracy, 2) circumvention of health IT processes or procedures as a result of user interface flaws or human–technology integration factors, or (3) necessary actions to complete a task”. The bubble pack example comes under type 2 or 3 given the information we have. Workarounds that can be “small changes in this initial task” may also represent unpredictable emergent global behaviour seen in complex human work systems (Karwowski, 2012 p. 983). This provides another setting for complexity.

Unstructured information is important to nurses and physicians because they both are involved in creating and telling the patient's story. We shall see more about the patient's story below in the information discussion in section 6.2.10. The interviewees also mentioned the theme of user information overload in acute care.

Information Overload: A Symptom of Complexity

Caban and Gotz (2015 p. 260) note that information overload happens “when individuals try to analyze a number of variables that surpass the limits of human cognition” with the result that they “ignore” or “misinterpret” critical patient “information”. This could lead to an adverse event. Information overload is “widespread” in health care because of the large volume of information generated for a given patient (Caban & Gotz, 2015 p. 260).

Although information overload is described as a user phenomenon in this research, Jackson and Farzaneh (2012 p. 525, Table 1, 526, 527) list other information overload factors that touch on many parts of the SEIPS model including:

- “Personal factors: personal factors are made up of multiple factors combining level of prior experiences, personal skills, cognitive style, motivation of the person, and personal situation”; these factors directly affect an individual's information processing capacity. The interviewees did not mention this point.
- “Task”: this includes task “novelty” and “complexity” that are relate to the number of alternative actions, multiple and/or conflicting goals, uncertainty goals, interruptions and a lack of time for tasks. Some interviewees mentioned staff shortages that suggests that remaining staff do not have time to complete tasks.
- “System”: “pushed” information is information that the recipient has little control over, and pulled information is information that is on demand and can be searched for and used when required by the recipient so there is less information overload. The interviewees did not mention pushing or pulling information, i.e. the system, adding to overload; they spoke of the volume of information generally.
- “Information”: volume of information, level of “complexity associated with information and level of ambiguity, novelty, intensity or uncertainty add to information overload;

complex information could be higher quality but needs more time to process. The interviewees spoke of missing or inaccurate information creating problems for them.

Patterson et al. (2016 p. 229, 230) consider overload as user and system with system resilience, where the system is a joint cognitive system (JCS) composed of multiple experts aided by sophisticated technological artefacts. “The loss of system resilience, i.e. overload, is due to increased difficulty in performing macro cognition functions: (a) sense making due to less effective cognitive warm-up and collaborative framing strategies; (b) detecting events due to not being able to adequately resolve conflicting information, missing trends in data, and changes to orders; and (c) coordinating due to less clinical knowledge during scheduling and updating information and less effective cross-checks” (Patterson et al., 2016 p. 229). An electronic health record implementation “facilitates sharp-end practitioners to shed resilience-augmenting activities in order to reduce workload burdens, even when these dropped activities are not conducted by the system or other personnel” (Patterson et al., 2016 p. 241). These sharp end effects enable adverse events.

Information overload is an example of how introducing a new system to reduce harm, such as medication errors from illegible writing, “introduces new risks of its own” (Greenhalgh et al., 2009 p. 759).

User Assumptions

Although some of the user assumptions described in the Chapter Five analysis could be grouped under the substitution myth mentioned by Dekker (2011 p. 83) or the functionality assumptions mentioned by Myers et al, (2011 p. 72, Table 3) or Dekker (2011 p. 83) that technology can do a task better, faster or cheaper than a human and it can catch errors (see section 2.5.6), the interviewees mentioned other assumptions including all systems are the same and that systems are easy to bypass. These are similar to the fallacies mentioned by Waterson (2014 p. 160, Table 6), fallacies that need to be dispelled for implementations to succeed in Waterson’s case, the NHS. These assumptions can contribute to an adverse event.

6.2.8 SEIPS Model Element: Task - Making a Decision

The SEIPS Model includes description and characteristics of tasks: variety, content, physical and psychological demands for communication and care coordination (Carayon, 2014 p. 16, Table 1; Salahuddin & Ismail, 2015 p. 883, Figure 5). Salahuddin and Ismail (2015 p. 887) speak of the workload as a task component because workload leads to “workarounds” and skipping policies and procedures.

Salahuddin and Ismail (2015 p. 887) also describe time pressures so staff do not do validation checks or miss drop down boxes . The interviewees provided information in the interview that staff missed validation checks for medications and drop down box mistakes.

Interviewees and Literature Reviews

The key task shown in the model in the context of the research in this dissertation is making a decision about a patient. The decision maker relies on accurate and complete information that is only as good as the information used, including the presentation by the system, to make the decision.

The interviewees mentioned workload and workarounds and how management needs to encourage staff to complete care plans and other documentation so the manager knows the work has been done: this has been discussed in the section 6.2.7 on people. The literature review mentioned that the main constraints on a successful task derive primarily from the information system and how well that meshes with the task and users, or not (Butler et al., 2000 p. 220; Liljegren, (2006 p. 345). This is the concept of fit mentioned in section 2.7.4 (Patient Safety Concepts) which we shall discuss further later in section 6.2.10 (Measuring Quality).

6.2.9 SEIPS Model Element: Tools and Technologies

The SEIPS Model describes “health information technologies as medical devices, other tools and technologies, electronic or paper records, medical devices and monitors, and equipment supplies” (Carayon, 2014 p. 16 Table 1). The healthcare “team uses various health information technologies such as electronic health records and health information exchange systems to communicate and share patient information” (Carayon, 2014 p. 16). Salahuddin and Ismail (2015 p. 884 Table 2) looked at tools and technologies in more detail. Their work included looking at system quality and topics discussed by interviewees such as interface design (usability) and interoperability .

As mentioned in Chapter Two section 2.5.2 (Types of Systems) information system is interpreted broadly to include (Brender et al., 2006 p. 129): “administrative system” (i. e. clerical systems including booking-note this was not the focus of this research but interviewees did imply this when speaking of admissions), “production support systems” (i. e. “laboratory information systems, radiology information systems”, “clinical systems” (electronic health care record), and, “decision support systems” (i. e. “knowledge-based systems, decision support systems and expert systems”). Information systems may also include the paper chart where needed.

Interviewees and Literature Review

The interviewees provided many understandings and interpretations on the information system. There were understandings and interpretations on the following key topics: system development life cycle including design, implementation, system use, user interface; natural language processing, and integration. These key topics, beginning with the system development life cycle, will be discussed briefly below with some highlights from some of the recent literature to provide further insight.

System Development Life Cycle

The information system results discussion was organized around the concept of the system development life cycle (SDLC) of requirements, design, and implementation where the SDLC is viewed as a single stage in defining a detailed physical form for the technical component of an information system (Benbya & McKelvey, 2006 p. 15). The life cycle has been identified as a

risk category in health risk assessment (Chua, 2009 p. 35 Table 1; Pare et al., 2008 p. 3 Table 1) in section 2.5.7 (Information System Risk Categories). The first step in the system development life cycle is design.

Design

Interviewees and Literature Review

The interviewees mentioned programming errors contributing either to missing information or a disconnect between the patient and his/her information. These type of errors can show up later during implementation or use when the missing information is needed, for example alerts missing because of programming error (Virginio & Ricarte, 2015 p. 56, 57)(section 2.5.5 (Non Functional Requirements)). This has also been noted in the literature review (MacIntosh-Murray & Choo, 2006 p. 373; Van Der Meijden et al., 2003 p. 241). Some of these class I failures can be caught during routine trouble shooting too (Nakamura & Kijima, 2009 p. 33).

Programming may be done to customize an information system for a Canadian setting, although vendors are unwilling to do this, or to simplify responses to user demands. If done right, programming can improve information quality by reducing manual entry, or standardizing data entry through templates or drop down boxes. For example, templates must not be designed to auto-populate with information that may not be relevant to the patient's clinical situation (Bowman, 2013 p. 5, Virginio & Ricarte, 2015 p. 56, 57). However, by not customizing systems to local Canadian settings the quality of information can be put at risk (as was noted by a number of interviewees). An example could include inaccurate US to SI unit conversion such as "pounds to kilograms" (Bowman, 2013 p. 3).

Design: Representing the Real World

Wand and Wang (1996) provide insight into what design means and its effects on information quality. This is an aspect of the research that will be discussed further below in the information section 6.2.10. One of the interviewees mentioned that information should reflect the patient state, so too the information system *should* be an accurate mapping or interpretation (with data or

information) of the world external to the system, in our case the acute care setting. This is shown in the diagram, Figure 9, and explained below⁶³.

Wand and Wang take a view of the information system (information system in the lower box in the diagram) which means that the system requirements (the design) are an accurate and complete representation of the real world (in the left hand cloud). The real world is also subject to the user's direct observation (upper cloud). When the user accesses and uses the data in the information system the user is interpreting the data and comparing the data to the real world. If the user notices discrepancies between the information system presentation of the real world via the data and the user's direct observation, there is a problem. Wand and Wang show this as a data deficiency in the right hand part of the diagram in Figure 9⁶⁴. Wand and Wang suggest that the information system design will never be a true 1:1 mapping or interpretation of the real world but should represent the "known aspects of the real world" as some "real world states cannot be represented" (Wand & Wang, 1996 p. 88, 94 Table 4).

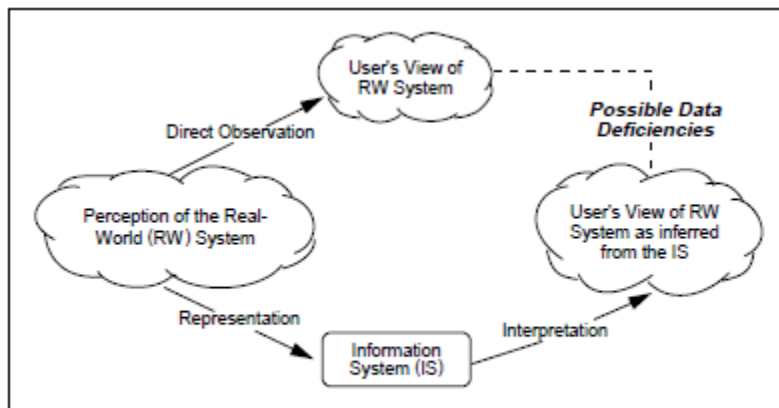


Figure 1. Possible data deficiencies in the data quality model

Figure 9: Wand & Wang's Information System Design. Reprinted from Wand & Wang, (1996) Figure 1.

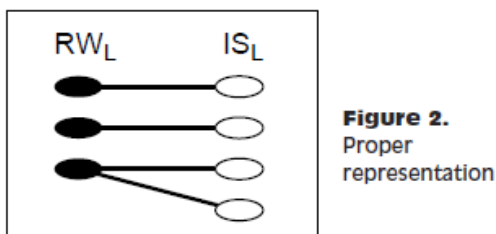
There are three assumptions to this model: representation, interpretation and inference (Wand & Wang, 1996 p. 88, 89):

⁶³ Smith and Koppel have provided similar research creating a set of scenarios or use cases using grounded theory for the different realities of EHR use (2014). They do not cite the earlier work of Wand & Wang.

⁶⁴ (c) Reproduced by permission of Association for Computing Machinery. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

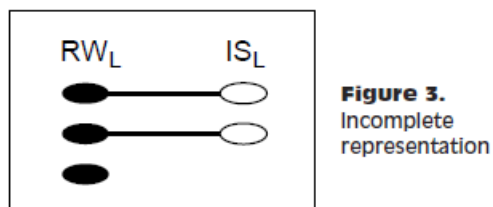
- “Representation Assumption”: “An information system is a representation of a real-world system as perceived by users”; that “all relevant knowledge about the real-world system should be represented in the information system” by creating “the information system and populating it with data”. Ideally, “it should be possible to map the information system state back to the “correct” or original perceived real world state” if the requirements describe the real world state. The black ovals represent the real world (RW) and the white ovals, the information system (IS) representation.

Wand and Wang’s Figure 2⁶⁵ shows the ideal state (p. 90):



It is important to note that Wand and Wang (1996 p. 89) do not discuss the users interpretation of visual data display because this is outside of the design focus of their paper. Wand and Wang describe some representation design errors such as:

- incompleteness, where a part of the real world is not completely mapped to the information system. Wand and Wang’s (1996 p. 90, 91) Figure 3⁶⁶ shows this with one lonely black oval:



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- ambiguity, where the information system maps to two states in the real world showing a lack of precision concerning the identifier that a couple of the interviewees mentioned (for example in Chapter Five, Electronic Information System Instability with technical changes to the identifier - an example of this would be a postal code that does not clarify in the system if it is a home or work postal code). Wand and Wang's (1996 p. 90, 91) Figure 4⁶⁷ shows this with the information system lower oval containing two representations of the real world:

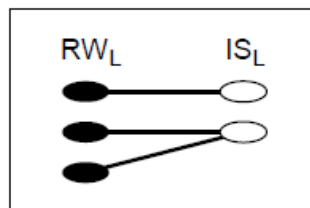


Figure 4.
Ambiguous
representation

- “meaningless state” where part of the information system does not map to the real world (this can be detected only with information system failure since the information system will continue to function). Wand and Wang's (1996 p. 90, 91) Figure 5⁶⁸ shows this with the bottom information system oval representing something, but not the real world:

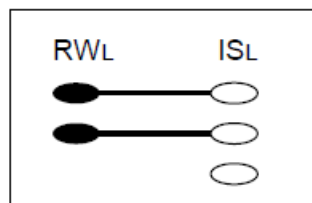


Figure 5.
Meaningless state

The literature review in Chapter Two also noted these design inconsistencies as technology induced errors (Borycki et al., 2010 p. 1; Borycki & Kushniruk, 2008 p. 95; Despotu et al., 2012 p. 46) in section 2.7.2.

⁶⁷ (c) Reproduced by permission of Association for Computing Machinery. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

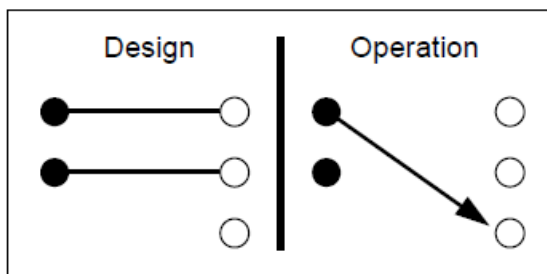
⁶⁸ (c) Reproduced by permission of Association for Computing Machinery. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

The interviewees' comments about information system programming relate to representation because this is part of design within the system life cycle.

Wand and Wang (1996 p. 91) also speak of data deficiencies that can happen when the information system is being used (operation). The perceived real world information can be mapped to a wrong information system for example during data entry on admission when staff enter the wrong PHN or the system does not record changes in the real world.

- “Interpretation Assumption”: An “information system is built for use by the user whose view of the real world system is captured in the design of the system”; “both representation and interpretation transformations need to perform flawlessly for the information system to function properly” (Wand & Wang, 1996 p. 89). Wand and Wang mention problems that can happen when the system is used in the interpretation phase where the mapping of the real world to the information system design is correct but the user infers a wrong real world state because there is wrong data entry or wrong information about changes in the real world. The interviewees mentioned data entry errors.

Wand and Wang's (1996 p. 91, 92) Figures 6⁶⁹ and 7⁷⁰ shows this (they call this garbling) where the top white circle maps to the real world but this is not carried through in operation/use:



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⁷⁰ (c) Reproduced by permission of Association for Computing Machinery. Further reproduction, distribution or transmission is prohibited, except as otherwise permitted by law.

Figure 6. Garbling (map to a meaningless state)

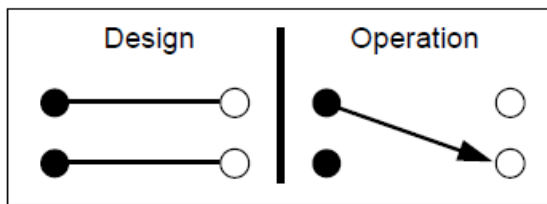


Figure 7. Garbling (map to a wrong state)

The errors in Wand and Wang’s garbling show how a patient’s own information can go missing from the patient’s information system data if we visualize the patient data as the black dot mapped to the patient’s information system.

- “Inference Assumption”: “The information system can create a perceptible representation from which the user can infer a view of the real-world system as represented in the information system” (Wand & Wang, 1996 p. 89). This suggests that the users trust the information system to reflect the real world system, in our case, the patient in the acute care setting. As we know, the patient state is constantly changing.

Wand and Wang (1996) represent design as one dimensional in the diagrams to make an important point but the reality is more dynamic in complex systems.

Benbya and McKelvey (2006) looked at user requirements in more detail to see why information systems fail in the context of complexity. User requirements are an important step in the Wand and Wang representation process. Requirements are first, difficult because it is the step translating the real world into the information system and then, complex because the requirements are always changing as the organization changes (Benbya & McKelvey, 2006 p. 14).

Benbya and McKelvey (2006 p. 16, 17) feel that the information system is subject to “complexity theory” describing “order emerging through the interactions of organisms or agents”; and is a “complex adaptive system” that directs “its activity towards its own

optimization as it poised between order and chaos”. The information system alignment with the organization and its users is a process of adaptation where they “co-evolve” and are “mutually interdependent” (Benbya & McKelvey, 2006 p. 15, 20). This dynamic interaction between the information system and users fits with the ensemble view of technology as an “embedded system” (Orlikowski & Iaeono, 2001 p. 126).

The interviewees have a more traditional view that an information system is inert and does only what it is programmed to do. The interviewees also allude to an adaptation process when the interviewees mentioned staff using the information system in ways the system can’t support and so needs the constant upgrades and tweaks “as needs change” (Benbya & McKelvey, 2006 p. 22). Leveson et al. (2009 p. 234, 235) notes in the Chapter Two literature review that accidents often result in complex systems from interaction among perfectly functioning (reliable and non-failed) components when the independent decisions and organizational behaviours interact in dysfunctional ways. These are the users pushing the system in new ways as well as system designers. We have learned this too from the interviewees, for example, interviewee one.

Implementation

Interviewees and Literature Reviews

The interviewees provided some good insights about implementation. On the one hand, implementation provides an opportunity for clinical input that might reduce workarounds. On the other hand, the interviewees spoke about system implementation as a period of information system instability because the implementation is rushed or because the test environment never replicates the work environment exactly. This may be because the implementation process did not have the expert clinical input mentioned by the interviewees to take into account workplace complexity and variation so the system was not designed in the first place to fit well with the users and their information requirements (Abbott et al., 2014 p. e 13, Novak et al., 2013 p. e 332 ; Virginio & Ricarte, 2015 p. 56 Table 1, 57). This likely represents either a data misfit or usability misfit mentioned by Strong and Volkoff in the dissertation section 2.7.4. Braithwaite et al. (2014 p. 321) used a Grounded Theory approach to describe the following organizational barriers to implementation that cause care quality issues: “when people fail to prepare, have insufficient capacity for implementation or when the setting is resistant to change”.

Implementation is a vulnerable time for an information system. The implementation phase was the phase in the information system lifecycle that accounted for 48% of the incidents (Magrabi et al., 2015 p. 201, 202). The system needs to support the fluid and dynamic user and information “demands” of health care in a “complex adaptive system setting” (Braithwaite et al., 2014 p. 325; Eason & Waterson, 2014 p. 190, 195; Saleem et al., 2015 p. 506; Waterson, 2014 p. 158 Table 4). However, this is not usually the case as we shall learn from analysis of the interviewees in the next section on system use.

System Use

Interviewees and Literature Reviews

The interviewees commented on the advantages and disadvantages of the electronic and paper chart systems. For the electronic system, they noted that design is key for templates. Both templates and drop down boxes help ensure information, especially quantitative information, is complete through the use of forcing functions and easy input. However, users must take care to pick the correct drop down selection (Bowman, 2013 p. 3; Cresswell et al., 2014 p. e 199). Others have suggested that a lack of system flexibility may increase the likelihood of error (Cresswell et al., 2014 p. e 198). These tools are not so useful for unstructured data and do not do away with other workload steps such as validation or information discrepancies between the structured and the unstructured data (Bowman, 2013 p. 3). Another form of unstructured information not mentioned by the interviewees is the use of diagrams for operative procedures etc. (Clarke et al., 2016 p. 4) that would be difficult to capture in a template.

Rosenbloom et al. (2011 p. 182) note that templates and dropdown boxes are a form of information standardization in real time because the standardization happens at data entry; however, these templates are cumbersome to use and do not add to user satisfaction because of “poor interface technologies”. Interviewees note in the literature that templates add to information redundancy and can produce bland information for administrative compliance (Embi et al., 2013 p. 720; McCormack & Ash, 2012 p. 1305). As one interviewee noted, you may just have nicer notes.

Some interviewees saw the information system as rigid and inflexible. One interviewee, interviewee twelve, mentioned this inflexibility as a form of “social engineering” analogous to Apple phone products.

Information system inflexibility may be more than simple vendor unwillingness to customize, but may also be because the vendor has been asked to provide a system that must have many roles in the health care system as Eason and Waterson list (2014 p. 189): “(1) the working tools of health-care teams as they sought to diagnose and treat the conditions of their patients; (2) a means of undertaking administrative procedures; (3) archives of past clinical and administrative information; (4) support for transactional activities, for example, a means of ordering tests; (5) communication channels in ‘handovers’ between agencies; (6) control mechanisms to enforce prescribed procedures for undertaking care; (7) sources of management information; (8) providers of audit information in the event of complaints and disputes; (9) a source of information for patients (in some cases); and (10) components in a database used for research, planning and policy development” (also Carayon, 2014, p. 189-190).

Cresswell et al. (2015 p. 2) provide interesting insights because they led a series of vendor focus groups about vendor opinions of NHS implementation. Cresswell et al. (2015, p. 8 Box 4) make the following recommendations: “taking time throughout procurement processes to assess organisational needs and base, that is, a simple phased approach based on needs rather than wants, product/vendor selection on this need, meaningful long-term engagement with different vendors and assessment of a range of products, harnessing implementation expertise of vendors and making this explicit in contractual arrangements, choosing products that are likely to be able to cope with future challenges surrounding secondary uses of data and interoperability”.

Salahuddin and Ismail’s (2015 p. 884 Table 3) survey data confirm interviewee comments with information about the “rigid modelling of the work process into health information technology inhibiting the fluency of medical care as well as creating workarounds strategy” and forcing staff to by-pass the system. Examples of these workarounds included: paper-based amendments to the electronic medication orders, to perform additional steps such as double-checking the orders, and to perform additional tasks such as adding paper notes from a shift to the record.

Eason and Waterson (2014 p. 197) also comment that systems are primarily management tools for reporting and management control systems for users to input required information in care plans for standards compliance and staff surveillance. Some of the interviewees also commented on this that there was a need for management to see that the work had been done as a form of techno-vigilance (Dixon-Woods et al., 2013 p. 447, 448). This use of the system as an organization risk reduction method was mentioned above in the health authority section of the SEIPS Model 6.2.5.

Menon et al. (2014) surveyed US risk managers and health care lawyers on future EHR use and potential for future safety events. The participants noted the following three: “failure to follow up on abnormal test results due to computer or user input error; some aspect of EHR data display that is incomplete, inaccurate, or misleading; and reliance on inaccurate or incomplete patient-generated health data” (Menon et al., 2014 p. 18 Table 1). The interviewees had similar concerns.

While interviewees, especially the clinical interviewees, liked the paper chart system so they could tell the patient’s story, they did admit that the paper chart systems were a major risk contributing to missing information because the chart was not available, was disorganized, had missing data because paper notes were entered late or had illegible PDF records. The unstructured data in the paper chart will be discussed later in the information section. Another issue raised by the interviewees was the user interface; this includes data display reminders, alerts and prompts.

User Interface

Interviewees and Literature Reviews

Interface issues such as data displays or dashboards were mentioned as a source for information system instability because information is missing, hard to find or read because of poor contrast or font, or may not capture the patient state in an accurate, complete, useable and easy to read format. One interviewee provided a lab example of truncated missing data contributing to an adverse event. The interviewees found reminders, prompts and alerts useful so tests and orders

were done on time, but they could be annoying and they could also end up being ignored, especially for medications. Salahuddin and Ismail (2015 p. 885 Table 7) report similar findings.

The literature confirms what the interviewees are saying. Horsky et al. (2012 p. 1204 Table 1) mention that the interface must ensure that the information is made available clearly and on time to the clinician when he/she is making a decision. Poor interface design can contribute to adverse events by cognitive overload, engender workarounds, and alert fatigue (Bowman, 2013 p. 3; Horsky et al., 2012 p. 1203). Menon et al. (2014 p. 18 Table 1) surveyed US risk managers and health care lawyers and found that the data display was one of the most common EHR safety concern (the other was open or incomplete patient orders).

Poor interface design may result from the designer's difficulty in capturing health care complexity (Kumar et al., 2014 p. 172). Interface designs become idiosyncratic, inflexible, or inefficient, and place the "burden" of entering the data in a structured format on a busy healthcare provider (Rosenbloom et al., 2011 p. 182; Salahuddin & Ismail, 2015 p. 884 Table 2 ; Zahabi et al., 2015 p. 808, 812). The existing interfaces among the different parts of the record such as social history and clinical notes may not meet clinical needs⁷¹ (Chen & Garcia-Webb, 2014 p. 408) particularly for complex patients (Jensen & Bossen, 2016 p. 50). There may be issues such as inaccurate conversion from US measures to SI units, discrepancies between the paper record and the electronic, and choosing the wrong drop down box (Bowman, 2013 p. 3, Virginio & Ricarte, 2015 p. 57). All of these could contribute to an adverse event.

The interviewees also mentioned alerts and templates. These are interface tools for decision support with design recommendations to reduce errors (Horsky et al., 2012 p. 1026 (3.1)).

Interface issues are an important contributor to adverse events. Virginio and Ricarte (2015 p. 57, 58) note the following: missing allergy data, complex screens, buttons with the same labels but different uses. Wright et al. (2016 p. 1072) mention that vendor "upgrades" to data codes or fields are "known high-risk event" contributors to clinical decision support adverse events. The interviewees also commented on vendor unannounced programming changes contributing to data

⁷¹ As an example of this, Chen and Garcia-Webb (2014 p. 408) describe how HL-7 and SNOMED languages do not capture all the nuances of alcohol use. The context is different but the same principles may apply in acute care.

loss. Nakamura and Kijima (2009 p. 33) classify interface errors as Class II errors because the root causes are “outside the system boundary but predictable at the design phase”. The adverse events reporting systems provide data about the scope of these errors (section 1.1.2 (Human Cost)).

- Myers et al, (2011 p. 72 Table 3) report FDA user interface-poor display of information or difficult to use system (52.5% of 73 reports).
- Magrabi et al. (2015 p. 47 Table 1) report FDA Information output which showed a machine output display error (28% of 712).

There are also other techniques to make the data display easier to use, some of these such as contrast and font size, were mentioned by the interviewees. These techniques include (Zahabi et al., 2015 p. 824-827 Table 5; Tsopra et al., 2014, e108):

- Patient identifier information on every screen and confirm patient identity with new upload or entry.
- Reduction of the number of screens to facilitate navigation and to promote efficient interactions.
- Use of appropriate font sizes, acceptable contrast between text and background, and meaningful consistent colors to improve readability and navigation.
- Organization of information (e.g. grouping similar pieces of information together) to facilitate on-screen searches.
- Display of important information in more prominent positions to ensure that it is seen.
- Use of tables, graphs, buttons, scroll bars, and iconic languages to ensure that the density of information is appropriate. Space-filling approaches such as Treemaps⁷² principles may also help to maximize the amount of information that can be displayed in the available display space.

It is important to note that the interface guidelines will also need to conform with any relevant ISO or other standards.

⁷² For information on tree maps as a data presentation tool, please see the following link as an example: <http://www.remi-coulom.fr/Publications/CGOlympiad2002.pdf>

Natural Language Processing

Interviewees and Literature Reviews

One of the interviewees, a physician, mentioned natural language processing may provide a structured format for analysis of unstructured data in the future. Although it is a rare item in the interview data, it represents an information system technique that turns unstructured information into a structured format for analysis. This is why natural language processing is mentioned briefly in the SEIPS Model tools and techniques section.

Rosenbloom et al. (2011 p. 182) review the two main methods of natural language processing. One method is one we have seen already, the use of templates to provide a “structured” data format remedy that preserves unstructured data at the expense of slow cumbersome interfaces compared to paper, as mentioned above in section 5.3.7 (Information Instability Overview). The other method is to convert the unstructured data to structured data after data entry, text processing by simple text searching or mapping to searchable concepts, but this is not yet clinically reliable (Rosenbloom et al, 2011 p. 183) as one of the physician interviewees noted. These text manipulations will need accurate or standardized coding input to make the data useful for further retrieval but applying structure and coding to the EHR will be an “additional workload” (Morrison et al., 2014 p. 498, 499).

The interviewees also provided insight on system integration and data merges and their effects on information.

System Integration

Interviewees and Literature Reviews

The interviewees’ comments provide another reason for information instability, that is, issues with information system integration, especially with legacy systems. Integration, if not done properly, can lead to data truncation and corruption of patient identity information with a possible contributing factor being different HL-7 messages. The interviewees mention that the likelihood of failure increases as system complexity increases (this can create “disorder elsewhere in the system” (Greenhalgh et al., 2009 p. 759). Systems work beyond their lifespan

and the resulting tweaks to keep them functioning introduce error. The interview data shows that there was a truncated lab message from integration and that radiology patient and image messages are truncated from manual or automated linkages. Other issues with interoperability include information “delay” from one system to another (Virginio & Ricarte 2015 p. 58). The interviewees also mentioned information missing for this reason.

This is an example of a system issue affecting the information. Bouamrane et al. (2015 p. 2) mention that there are three types of interoperability: “i) technical interoperability (i.e. the exchange of data between two systems), ii) semantic interoperability (i.e. the shared meaning of data across systems), and iii) process interoperability (i.e. the integration of systems within work processes)”.

It is not clear from the interviewees’ comments which of these interoperabilities are referred to but the obstacles mentioned by Bouamrane (2015) likely underlie the Canadian situation too. These obstacles include (Bouamrane 2015 p. 2): “heterogeneous data formats across systems, clinical information complexity, knowledge specific to certain medical specialties, over-complexity of standards, the lack of shared-meaning, and misunderstandings between system suppliers and end-users”. Salahuddin, and Ismail’s (2015 p. 884 Table 3) survey data emphasize “systems integration problems with other systems were the primary reason for incomplete and lost requests sent to other departments as well as for missing results”. The literature reviews confirms this with the NHS *Guidance* document highlighting legacy system migration as a special risk (2009 p. 77; see also (Borycki et al, 2012 p. 100; Liaw et al. 2013 p. 18; Menon et al., 2014 p. 19; Pierce, 2005 p. 9; Williams & Weber-Jahnke, 2010 p. 81).

We now move to information and its flow through the SEIPS Model components.

6.2.10 SEIPS Model Element: Information – Central but Minimized in the Model

The SEIPS Model **does not** have information as a separate component of the Model. Each of the three review articles about the SEIPS Model treats information differently. Carayon et al. (2014 p. 19) place it in task because it is related to “patient-related information processing and management (e.g., need for duplicate data entry in multiple health IT applications)”, or, in

organization: “where there are organizational obstacles to the effective use of health IT such as delay in access to patient-related information”.

Holden et al. (2013 p. 1677, 1679) acknowledge that there is information processing or “management” in clinic visits and that the model’s current components may need “unpacking” such as information. Salahuddin and Ismail (2015 p. 883 Figure 5) use the DeLone and MacLean definition of information quality and place it in the tools and technology group, but they do provide many useful examples from the literature. Each of these authors takes a narrow view of information and information quality, a view that does not fit well with the role of information in the acute care setting.

Interviewees and Literature Reviews

The interviewees were clear about what they had to say on information quality. The information must be accurate and complete so the care giver can make the right decision for the patient. The most important data element is patient identity, the source of truth, that must at all times be directly linked to the patient because that creates the patient profile in the electronic and paper chart.

It is difficult to make good decisions when the information is missing or wrongly linked to the patient. The clinicians preferred the rich information in unstructured data such as narrative because it allows them to tell the patient’s story at the expense of missing data, poor analytics or linking with the data. The unstructured data may be unstable, but there are remedies such as standardization; templates, drop down boxes, and forcing functions to organize paper charting; and validation.

Missing and unstable information can happen in an electronic system through programming errors, user interfaces or system integration with some evidence from the interviewees that adverse events happened because of this instability, particularly in the context of pharmacy. Information quality issues such as missing or corrupt information appear in all five of the key areas, information quality, acute care, information system, risk as a function of poor information quality and patient safety, in the literature review showing that information and information quality is truly the glue.

This section on information will look at information and information quality in the following topic areas: clinical documentation, patient identifiers, unstructured and structured information as the glue, concepts of information and information quality including accuracy, completeness and missing information, complexity and information flow.

Clinical Documentation

Interviewees and Literature Reviews

The interviewees are all working from, and adding patient information to, the patient's clinical record. The interviewees have commented on the different uses of the record including providing data for funders such as the ministry in addition to patient care. Ho et al. (2014) have documented from a survey that there are five uses for the medical record:

- “Clinical”-“patient care is an important, if not the most important, purpose of documentation” (Ho et al. 2014 p. 156).
- “Administrative”-“there are administrative needs such as billing and compliance requirements that must be met” (Ho et al. 2014 p. 157).
- “Legal”-“documentation to provide evidence to defend the provider against malpractice allegations” (Ho et al. 2014 p. 157).
- “Research”-“an important function of the data collected in documentation” (Ho et al. 2014 p. 157).
- “Education”-“documentation as a teaching tool” (Ho et al. 2014 p. 157).

The patient identifier is an important data element in the chart and will be discussed next.

Patient Identifiers

Interviewees and Literature Reviews

The interviewees stressed the importance of the patient identifier and patient identity as a key component of patient information quality because that is the “hook” that creates and maintains the patient profile during the acute care admission. The interviewees have provided evidence that the patient identifier can become corrupted through poor data entry or linkages. The literature confirms the vulnerability of this important information.

The most serious errors in Emergency Rooms are “misidentification” errors because of missing confirmation of information either with the patient or from registries or through wrong personal identifier data entry (Hakimzada et al., 2008 p. 169, 170). The interviewees have provided similar reasons for misidentification. Henneman et al. (2008 p. 503) have shown how easy it is to make these errors even in simulated settings and are serious because misidentification errors can affect two individuals: the individual whose correct information is missing and the other individual who now may have two identifiers. The interviewees have also mentioned this.

Sopan et al. (2015 p. 1059 Table 2) have suggested some techniques based on task analysis and ranked by effort and safety impact to reduce wrong patient errors that need to be verified with further research. Some of the “high-ranked” effort and safety impact suggestions include:

- “Recall patient”: “use patients’ photos and other information”.
- “Select patient”: provide clues that similar names exist, use RFID⁷³ technology, always show patient’s full name”.
- “Verify selection”: “highlight selected name when leave list” and fade out other patients on list.
- “Confirm order”: include the identity of the patient in submit button.

The interviewees and the literature has each stressed the importance of the patient identifier for safe patient care and decision making. The next section will now look at information itself in more detail.

The Glue: Unstructured and Structured Information

Tacit Knowledge And Unstructured Data

Interviewees and Literature Review

Although the overall approach to the interviews treated data and information the same, in some cases the interviewees made a distinction by saying that the information provided by physicians

⁷³ RFID means Radio-frequency identification that uses electromagnetic fields to identify and track tags attached to objects including people. Please see the following link for more information: https://en.wikipedia.org/wiki/Radio-frequency_identification

represented interpretation in a narrative form. This made the information better. There were also many understandings and interpretations about the benefits of unstructured free text data as providing rich detailed information (the clinicians) and the disadvantages because there are no analytics (non-clinicians).

The physician's consultation letter of clinical advice, an interpretation in narrative form, is an expression of the physician's tacit knowledge about the case based on the accurate and complete information provided by the health care provider asking for the consult. Johannessen et al. (2001, p. 4) note that tacit knowledge is "difficult to communicate to others as information, and can at best be difficult to digitalize". Tacit knowledge is defined as: "non-codified, disembodied know-how that is acquired via the informal take-up of learned behavior and procedures....This form of knowledge is wholly embodied in the individual, rooted in practice and experience, expressed through skillful execution, and transmitted by apprenticeship and training through watching and doing forms of learning" (Johannessen et al. 2001, p. 4-5).

Unstructured Data – The Patient Story

Interviewees and Literature Reviews

In addition to the physician consultant's letter of clinical advice with its tacit narrative content, the clinicians also spoke of the patient's story and how important it was. Embi et al. (2013) p. 720, Rosenbloom et al. (2011 p. 181, 182) and Varpio et al. (2015 p. 1021, 1026) comment on the importance of the patient's story as fulfilling the following healthcare functions: the patient's story as a cognitive awareness and overview understanding of the "patient's (1) current idiosyncrasies, competence, insight and status, (2) relevant history, (3) data patterns that emerged during care, (4) the care provider's uncertainty about the case and how it is different or similar to other cases to develop a future-oriented care plan" and (5) control over the information in the story beyond a recitation of facts.

Knowing the patient's story is a "core clinical skill" for all professions (Varpio et al., 2015 p. 1021). Narrative provides a way for clinicians "to interpret raw data", the "medical evidence", and weave them into a coherent convincing narrative to make a decision (Johnson et al., 2008 p. 55).

Just as the interviewees provided the pros and cons for unstructured data, so the literature confirms these findings. The paper chart with its unstructured data, or naturalistic prose, has the following benefits to the care provider: clinical notes containing naturalistic prose have been more accurate, more reliable for identifying patients with given diseases, and more understandable to health care providers reviewing patient records (Ho et al., 2014 p. 156; Johnson et al., 2008 p. 55, Rosenbloom et al., 2011 p. 181, 182).

The literature suggests that the unstructured patient information in the electronic chart may be more complete than the patient chart for chief complaint or history of present illness (Boo et al., 2012 p. 15) or in general (Car et al., 2008 p. xx). Attempts to classify or enforce a structure to this data may imply a false certainty to an evolving clinical situation (Morrison et al., 2014 p. 492) that could cause an adverse event. The interviewees did not comment on this point.

However, total unstructured data entry freedom (“free text”) may lead to inconsistencies in the electronic health record including “loss of information” (Bowman, 2013 p. 3; Johnson et al., 2008 p. 55). The interviewees did not comment on this either. Unstructured data is difficult to analyse. Therefore, the interest in structured cumbersome data entry or imperfect natural language processing mentioned above in the tools and technologies section 6.2.9 is important.

Structured Data

Interviewees and Literature Review

Conversely, the literature notes that structured data allows for information to be more easily extracted, reused and interpreted. “Some studies argue that restricting the clinical narrative in documentation can hurt the clinician’s ability to convey fully clinically relevant information because of the increased time needed to document” (Ho et al., 2014 p. 160). Structured data may also lead to “loss of information” (Johnson et al., 2008 p. 55). Structured data is also called “hard metrics” when it is used in dashboards or calculating infection rates or complications; or for administrative purposes such as billing. This is important information also (Johnson et al., 2008 p. 58; Martin et al., 2015 p. 20, 22).

Information Constructs

Interviewees and Literature Review

Furner (2010 p. 174 Figure 4.1) has provided a review of the many concepts of information itself including semiotic and objective. One set of concepts is the *semiotic* family set that compares real world states (information as reality) to the mental representations of those states (information as message, meaning, knowledge and image) and to the linguistic expression (information as signal, vehicle, data, document, thing). The semiotic family set fits well with the Wand and Wang (1996) system design model of reality and representation mentioned earlier in tools and technology (Section 6.2.9 **Error! Reference source not found.** and used further below in the next section, information quality.

The semiotic set also fits with the information, information system and the user triad of the interview analysis because Furner (2010 p. 174 Figure 4.1) writes of information-as-signal or “information-as thing” that fits the system, or, one of information-as-message “information-as-knowledge” that fits the users. In the semiotics school, information is something that is used to produce and exchange of meaning (Mai, 2013 p. 676). Health care is about exchanging meaning for patient care.

The *objective* interpretation of information-as-message suggests that information resources such as text within the information system “have” meanings, that is “discoverable by all” (Furner, 2010 p. 174). “When information is used to communicate and exchange ideas”, for example to make a decision, “it is important that the information can be trusted, meaning typically that it is of good quality” (Mai, 2013 p. 680). This suggests that information quality and missing information can be assessed.

Information Quality

Interviewees and Literature Reviews

The literature review and interviewees provided many terms for information quality but accuracy and completeness were used most often as the key terms for information quality. The literature confirms the importance of these two terms.

Measuring Quality

The literature review showed how difficult it is to capture information quality (Section 2.3.2 but it did not explicitly explore methods to measure it. The Salahuddin and Ismail (2015 p. 880 Figure 2) variant of the SEIPS Model assesses information quality using the DeLone and McLean model that means asking about system use, user satisfaction or net benefit (Petter et al., 2008 p. 238 Figure 2). The net benefits relevant for this research are that information quality has a net benefit on individual performance and decision making. A key use of information in this research is that it is fit for use, or conversely, does not meet any of the misfit categories listed by Strong and Volkoff (2010 p. 737 Table 3).

There are methods for comparing data to gold standards but these are based on “intuitive” measures (Weiskopf & Weng, 2013 p. 148) or internal standards such as mapping narrative data to ICD⁷⁴ codes (Stein et al., 2000 p. 52 Table 12 as an example). There are methods for using fitness for use that are related to a given activity or the Wand and Wang “mapping” of the information system to the real world (Stvilia et al., 2007 p. 1722). This research used the interviewee’s own words, i.e. the users, to interpret what they meant by accuracy and completeness. This is in keeping with the recommendations of Michnik and Lo (2009 p. 850) and Wang & Strong (1996 p. 8).

Stein et al. (2000 p. 53) found that “completeness and accuracy of data in any field depend on the type of field, the type of information contained in the field, the person entering the data, and the timing of the entry in relation to the event or diagnosis”. Accuracy and completeness are the top-ranked terms described in the literature to describe information quality: they will be looked at more closely next.

Accuracy

Accuracy is a characteristic “intrinsic” to the information and means “freedom from mistakes or errors, with errors being easy to find, conformity to truth or to a standard or model”, precise and

⁷⁴ ICD codes are the WHO International Classification of Diseases (ICD) used to classify diseases and other health problems recorded on many types of health and vital records. Each country has its own version. Please see the following link: <http://www.who.int/classifications/icd/en/>

correct (Michnik & Lo, 2009 p. 852; Wang & Strong, 1996 p. 14 Table 1; Weiskopf & Weng, 2013 p. 148). It is the most common term used to describe information in some studies (Wang & Strong, 1996 p. 7). Wang and Strong (1996 p. 14 Table 1) analyzed survey responses with study subject sorts and found Cronbach's alpha of 0.87 suggesting good agreement on the term.

Wand and Wang (1996 p. 93) take a systems' approach by saying that accuracy means the information system maps to the perceived true real world state. They describe several scenarios when this doesn't happen usually because of poor requirements and/or programming (Wand and Wang, 1996 p. 93, Table 5). These scenarios are described more fully in section 6.2.9, tools and technologies:

- Ambiguity or imprecision-two states of the real world are mapped to one information system state when there should be 1:1 mapping.
- Meaningless state-the information system cannot be mapped to the real world, but it may look legitimate until detected with a system failure.
- Garbling-the information system maps to the wrong real world because of data entry.

The interviewees spoke of programming and vendor difficulties affecting information quality: these scenarios provide some mechanisms. Stvilia et al. (2007 p. 1723, 1724) explain that there is both intrinsic information quality that can be measured against a "reference standard" and relational information quality where information maps to a to an "external" real world condition similar to Wand and Wang except that it is not a system mapping to the real world but information. One can see that accurate patient identity information that can be measured against provincial standard registries has intrinsic accuracy while other accurate patient information is relational as it represents the patient state.

Completeness

Completeness is an information characteristic that is contextual to the task meaning the information has all the necessary elements (Michnik & Lo, 2009 p. 852; Stvilia et al., 2007 p. 1729 Table 3). Wang and Strong (1996 p. 15, Table 1) analyzed survey responses study subject sorts and found Cronbach's alpha of 0.98 suggesting excellent agreement on the term.

For Wand and Wang (1996 p. 91, 93), “completeness is the ability of an information system to represent every meaningful state of the real world system” and incompleteness happens when the real world is not mapped “exhaustively” to the information system. This definition is broader than a data-or variable-based definition of completeness because combinations of mandatory or optional variables can be used. This meaningful state of the real world echoes the true (real world) patient state mentioned by one of the interviewees⁷⁵.

Salahuddin and Ismail (2015 p. 885) note that “information completeness serves as a measure of the prevalence of missing information” with impacts on patient care if information was missing: the interviewees also commented on this. In some cases, the missing information can be measured against a “gold standard” (Weiskopf & Weng, 2013 p. 146). This is the case with patient identity information that has a provincial standard or some patient measures such as blood pressure that some interviewees had a local entity standard.

Missing Information in General

The interviewees provided many examples of information instability and information system instability and the effects of missing information on decision making. Aside from the obvious missing information because there has been no data entry there is more subtle missing information based on the fact that for a given patient in acute care it will never be possible to know everything about the patient, an uncertainty “because we do not have perfect information” (Bawden & Robinson, 2015 p. 1969).

There is a further aspect to missing information because information system design requirements itself may not “exhaustively” replicate the real world or patient state exactly so there is uncertainty there too (Wand & Wang, 1996 p. 91).

Uncertainty or Entropy

Wand and Wang (1996) do not provide detail about the real world, or the patient in our case, that the information system maps to. Bawden and Robinson (2015 p. 1969) provide interesting insight into the real world: the observable real world exists as a set of macrostates that set the

⁷⁵ For example, informant 16 (p. 197) mentions if one has complete information one can compensate for missing information e.g. dropped transducer.

“limit of our information”. However, embedded within the “macrostates” are “microstates” of “uncertainty” or “entropy”, with the corollary that if the microstates mapped perfectly there would be no entropy (Bawden & Robinson, 2015 p. 1969).

When we look at a system, “entropy is a measure of uncertainty about one message among all the possible messages that a communications source can produce” (Bawden & Robinson, 2015 p. 1972). This uncertainty or entropy is interpreted to exist either “before the message is received”, “a prior uncertainty”⁷⁶, for example by an interface or “after the message is received” (Bawden & Robinson, 2015 p. 1974).

There is going to be missing information or entropy within the patient’s complex biological system that is constantly changing because complexity itself “needs continual change” (Bawden & Robinson, 2015, “Carnot” p. 2184). This suggests constantly changing macro-and micro-states compounded with the inherent uncertainty to the information message in the information system itself. This information message can be unstructured or structured data.

This brings us to the last information construct, complexity.

Complexity

There are further layers of uncertainty and complexity because the patients and users are part of a “complex adaptive healthcare system – dynamic, nonlinear, consists of a number of independent agents” (Kumar et al., 2014 p. 172). We have seen earlier that the information system itself is also a complex adaptive system. There is a third aspect of complexity by adding the triad of the person, information system triad, the information.

Section 6.2.10 Information, the Glue, mentions that the medical consultant’s note conveys tacit knowledge to the reader. Bawden (2007 p. 318) places information in an ontology of Popper’s the three worlds:

- “World 1: the physical world, of people, books, computers, buildings, etc.”

⁷⁶ The prior uncertainty or prior entropy is also called the “Shannon entropy” and can be measured to estimate uncertainty about an electronic signal (Bawden & Robinson, 2015 p. 1971).

- “World 2: the internal, subjective mental state of a conscious individual, including their personal knowledge, or understanding.”
- “World 3: the world of communicable, objective knowledge, or information.”

This suggests that the physician’s consultation letter of advice is the consultant’s recording in world 3 of his/her internal world 2 knowledge or understanding of the case at the macrostate level. The consultant’s information is documented in the World 1 system. This would be true for all health care documentation. The patient also has a World 2 knowledge or understanding of their own clinical (macrostate) state that they express usually in unstructured information to the clinician, who then captures it in a world 1 system of a chart, electronic system or monitoring device. There is uncertainty or entropy because of the many unknown microstates existing in the users, the patient and the information system. We know that information is not static, it flows among the individuals via the information systems. This will be discussed in the next section when we put it all together.

6.3 Conclusion: Putting it all Together: Enhancing the SEIPS Model with Information Flow and Quality

6.3.1 Information Flow

The Chapter Two literature review referenced information flow. Blanchard and Fabrycky (2010 p. 4) categorized system components into three groups by their attributes including flow components the materials, energy, objects, data, or information being flowed or altered in the system. There is also information flowing among the different “levels” of the health care system from the sharp end to the blunt end and vice versa (Karsh & Brown, 2010 p. 67).

What we do know is that information does “flow” among the different elements of the SEIPS Model.

6.3.2 Information Flow and Quality in the SEIPS Model

The existing SEIPS Model was selected as described in [Appendix I](#) because *most* parts of the SEIPS Model (except physical environment that was not asked of the interviewees) provided organising headings for the interviewees’ understandings and interpretations about the external environment, organization, task, tools and technology, person, quality of care, and patient safety⁷⁷ as well as about information and information quality.

The three key review articles on the SEIPS Model did not provide clear guidance on the role of information and information quality within the model framework. The Chapter Five analysis of the interviewees’ interview data provide a clear place for information and information quality within the model. The existing SEIPS Model has the black lines and arrows joining the different parts of the model but does not say what these lines are. Figure 10 on the following page enhances the existing SEIPS model as shown below. The following table, Table 24, highlights these enhancements in green with reference to the interview findings:

⁷⁷ The mapping of the key Chapter Five sections to the model is above in section 6.2.2.

Table 24: Comparison of Existing SEIPS Model and Enhanced SEIPS Model

Existing SEIPS Model Component	Enhanced SEIPS Model Component
External Environment	No Change
Organization	No Change
Physical environment	No change
Person	Two Persons: Person as Patient-underlined Person as User-underlined
Technology & Tools	Two types of information systems: Paper information system-underlined Electronic information system-underlined
Task	Task: Making a Decision-underlined
Process	No change
Patient Outcome Employee & Organizational Outcome	No change
Black Lines	Added Information and Information Quality
	Structured and Unstructured Information and Information Quality (section 6.2.10) Accuracy Completeness Applies to Information as: Representation, Interpretation, Transmission (section 6.2.9) Marked by green box, dotted outline box and arrows
	Information Contexts: Rare, Wicked, Complex, Uncertain From the Literature review (section 2.6.4) Marked by green box, dotted outline and arrow pointing to the entire system

The next page has the diagrams of the current (on top) and enhanced model (below current model) in Figure 10.

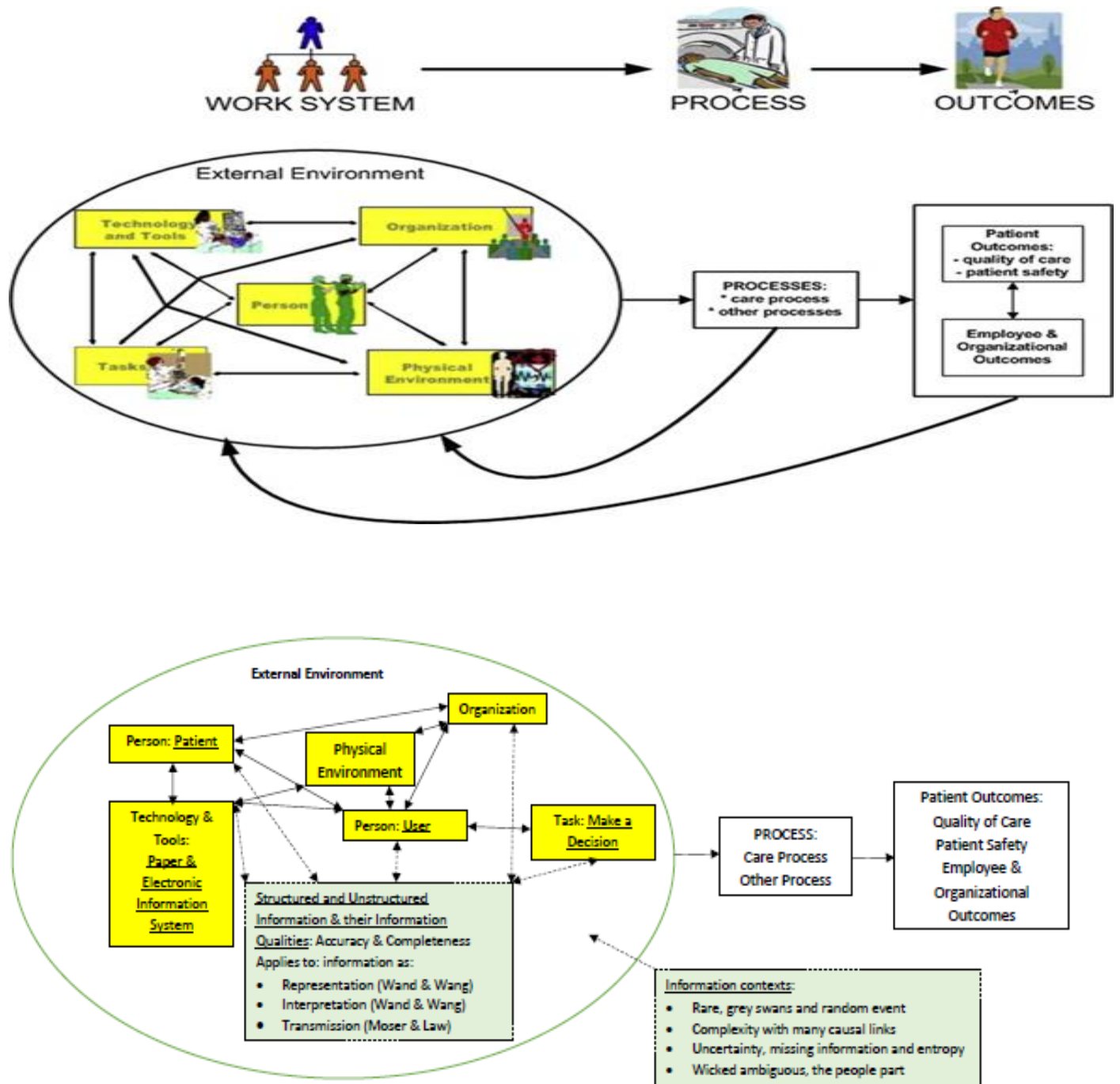


Figure 10: Existing and Enhanced SEIPS Model with Information Flow and Quality. Reprinted and Adapted from Carayon et al. (2014) Figure 1.

Salahuddin and Ismail (2015 p. 883 Figure 5) are being too restrictive by placing information quality within the tools and technology category. Information is the link, the glue, in the model between the people and the information system, the technology and tools. The interviewees have provided their understandings and interpretations about information and its effect on patient outcome for example, contributing to medication errors or truncating laboratory results.

The Chapter Five results highlight the major distinctions between unstructured information largely in the paper chart, and the structured information in the electronic information system. These are the two kinds of flow. The person as patient translates his or her real world state as best they can into a narrative of unstructured text when the care provider, the person as user, takes the initial clinical history from the patient and directly observes the patient. The enhanced SEIPS Model in Table 25 and Figure 10 highlights these important clarifications about information, information system and the person that the interviewees have provided in Chapter Five.

6.3.3 Unstructured Information in the Hybrid Chart

This patient story narrative is unstructured information when received and entered into the patient record. This narrative becomes the clinical information foundation for the decision maker, who along with the other care givers, adds their own narratives to the patient story because they want to tell the patient story. The most flexible information vehicle is the hybrid patient chart but the text box templates in the electronic information system can convey unstructured or narrative information provided the caregivers have the space for their narratives.

The patient's story will always have missing unstable information. The information is missing at the macro or observable level because either the patient misinterprets their own macro state or the care providers misinterprets the patient's macro state, or the real world in Wand and Wang's diagram (see Figure 9). There is also missing or uncertain information or entropy is contained in the patient's micro state that is not observed. The information system itself may change the information. We may not know which is which if we notice information is missing. The first two flows (Flow 1 and 2) discussed below reflect this in more detail. Information flows can also be a hazard (Flow 3).

Flow 1: Macrostate Information in the Electronic Information System

The electronic information system is designed and programmed to reflect the patient's real world macro state embedded in the external reality of acute care but, here again, there is missing uncertain information because system design will never be a true representation either of the external reality of acute care or of the individual. Wand and Wang's diagram (2009 p. 88 Figure 1), 6.2.9, also shows there are deficiencies between what the care giver directly observes and what the system presents: these data deficiencies could be remedied by better design, but there will always be missing information at the macro (and micro) level. Information accuracy and completeness represent the closest representation of the macro real world state. Although the literature on information concepts describe entropy as missing information at the micro level, one could conjecture that missing information at the macro patient and information system level is also entropy if a combination of micro states coalesce to create a macro state gap.

The interviewees provided many valuable insights about patient identity information and how critical it is that this information not become corrupted because it is the source of truth upon which all the other patient data, decision making, and care depend. One could say that provincial standards and processes are designed to reduce the microstates in patient identity information as much as possible so there is minimal entropy. The patient information coming from a monitoring device is structured information that in theory reflects the patient state more accurately and completely provided the instrumentation is calibrated and working properly. Entropy could be minimized here also.

Flow 2: Information System Changes Information

Moser and Law (2006 p. 61) comment that the prevailing view in health informatics is that information flow in electronic system means that the information itself is fixed, codified, without noise and complete for the end user because the information system is designed or programmed to hold it in shape, what Moser and Law call an "immutable mobile". The interviewees commented on this also, the information as a "passive vehicle".

Both the literature review and the interviewees describe missing uncertain information impacts on acute care and decision making where uncertain or missing information is entropy. Entropy is

described as a fixed property of information because it is impossible to represent accurately and completely the real world state of a patient.

Moser and Law (2006 p. 68) also say that information is incomplete not because of inherent entropy but because information is “fluid” and “unstable” (mutable” based on the format and the different contexts of decision making by different actors in the health care system. Blanchard and Fabrycky (2010 p. 4) mention that information is altered in the information system “flow component”; Moser and Law (2006 p. 68) suggest this is because the information “gets corrupted” in the system interfering with the flow.

Flow 3: Flow as a Hazard

The Despotu (2012 p. 46) bow tie diagram in Figure 4 shows hazards causing an adverse event (accident) and a ‘corrupt data record’ as system specific fault or failure contributing to the hazard⁷⁸. We could, as an analogy to the SEIPS Model, describe the information lines flowing from the failure to the hazard as failures on their own. Poor information quality is a fault leading to a wrong action by the decision.

The interviewees mentioned that information can be missing for the decision maker. The literature review discusses information entropy and fluidity as two information states that may or may not be mutually exclusive. The users are themselves a source of information change for Moser and Law and for the interviewees.

6.3.4 The Users add Randomness to Information

The interviewees have provided their understandings and interpretations about the users, primarily physicians and nurses, who add a randomness to acute care because they want to tell the patient’s story, are unwilling to use standards such as SNOMED, and use the information system under unrealistic assumptions that the electronic system will save them from making mistakes. The decision makers, the physicians, especially want both “good data” that reflects the patient state and autonomy to use unstructured information, a fact the nurses resent. This is in contrast to the non-clinical interviewees who prefer unstructured data because it is easier to work

⁷⁸ Despotu also makes the point that an act can also be a hazard. Please see section 2.7.2 above.

with and analyze.

The interviewees provided many insights about the hybrid paper chart system and the electronic system. The former is a source of rich, messy unstructured data that contains the patient narrative while the latter has other patient story information in a more structured format either through templates or dropdown boxes that may or may not be used willingly.

As we move further back from the “sharp end” at the coal face of patient care, the local entity and the ministry set information standards, and information conformance standards. They also add their own randomness such as aggressive timelines and supporting legacy systems because of funding restraints. The interviewees mention that local entity standards such as introducing medication bubble packs may encourage the organizational deviance workarounds they are designed to prevent.

Vendors are another source of comment for the interviewees because they are unwilling to customize for Canada, force social engineering on users and do not always notify their clients of upgrades sometimes with adverse outcomes. The occasional unpredictable vendor behaviour also influences information and information quality and can contribute to adverse events.

6.4 Limitations and Future Research

6.4.1 Limitations

Disadvantages of Qualitative Research

Qualitative research has been seen by some as having “variable quality” or less “rigorous” than quantitative research (DeLuca, 2008 p. 51). Many studies use a Grounded Theory approach to disguise weak research ideas or methodology (Bryant, 2002 p. 32). These concerns have been addressed in the data collection section in Chapter Four (4.3 Methodology) and the results in Chapter Five and the coding examples in the [Appendix H](#).

Renn (1998 p. 54 Table 1) alerts us to three biases that arise in qualitative assessments. First, there is the bias of “availability”, which means that “events that come to peoples mind immediately are rated as more probable than events that are less medically available”. Another is the “anchoring effect” in which “probabilities are adjusted to cognitive routines or the perceived significance of the information”. The third bias is “representativeness”, where “unique events experienced in person are preferred over information on probabilities when people make predictions or inferences about probabilities”. It is not possible to address these biases in this research because these biases of unique personal experience are difficult to validate with member checking of the findings with the interviewees because these biases are integral to the interviewee’s interview data itself. Member checking (described in sections 4.43 and 6.4.1) shows that the researcher’s interpretation of the overall data was agreeable to the interviewees.

Participant Recruitment

Sample

The researcher was provided the names of ten other individuals who declined to be interviewed. This means that there was a selection bias because only those volunteering to be interviewed provided data to the researcher. Study participants can be “hostile” and unwilling to assist in the research because they do not want to share information that may be confidential or sensitive or they are too “busy” to be available (Curry & Knowles, 2005 p. 56). Solutions to the problem include assuring the study participants that this research has ethics approval, their information will be kept as confidential as possible, and their identity anonymous.

Pan and Tan (2011 p. 167) note that snowball sampling may be the only realistic way of identifying interviewees because the researcher does not have “inside information” of who these people are; however, there is a risk of bias because the sample has not been “selected objectively”.

At some point there would be sufficient data to end data collection because the new data does not add new insight and all available leads have been followed up. This is called saturation (Eisenhardt, 1989 p. 533, 543; Runeson & Höst, 2009 p. 147). However, given the small sample size of many research studies, the point of saturation is rarely reached (Pan & Tan, 2011 p. 169): this was the case with this research (Please see section 4.6.1 (Participant Recruitment) and Appendix C.

Snowball sampling was used initially to recruit interviewees “who best represent or have knowledge” to ensure sufficient data for analysis (Morse et al., 2002 p. 18). Please see Appendix C for a description of sample recruitment..

Member Checking

All of the key informant interviewees agreed to be contacted after the interview for member checking. The researcher performed member checking by sending the dissertation presentation of summary findings to 15/20 interviewees (note that 5 of the 20 interviewees could not be reached as the emails that these individuals had initially given at the beginning of the study were no longer valid). Ten interviewees responded that they agreed with the summary findings. The other 5 who were emailed out to at a valid email addresses did not respond.

Bias of a Small Sample

Wagner et al. (2010 p. 588) note that the biases of this sample can be reduced by the following techniques:

- “Let one or more members of the organization nominate the most knowledgeable persons for the respective topics and choose them as informants”. This research: this was true for some of the interviewees where an interviewee suggested other people to interview.
- “Ask the selected informants for a self-assessment of their competence to answer the questions (either regarding the whole questionnaire or for each topic separately) and

encourage them to provide “no answer” if they do not feel to be sufficiently competent”. Exclude interviewees who consider themselves not to be sufficiently competent. This research: the interviewer did not ask the interviewees for this assessment of themselves; the interviewees did comment if they did not know the answer to a question.

- “Ask informants how long they were involved with the topic under investigation and use this global indicator to validate the plausibility of the informants’ self-assessments and exclude informants who were involved only for a very short time. However, never include s who consider themselves not to be sufficiently competent, even if they have been involved for a long time”. This research: most of the interviewees were very experienced with at least a decade or more of experience as shown in the descriptive statistics in Chapter Five section 5.2 (Descriptive Statistics).

Interview

Telephone Interview Both Kempf and Remington (2007 p. 120, 121) and Musselwhite et al. (2007 p. 1066) describe risks such as “dropped calls”, “call screening” and interviewee disengagement with the process, and interviewees being in an unsafe place such as “driving”. This was not an issue for the interviews except for one dropped call for interviewee eighteen; the interview continued after reconnecting.

Disadvantages of interview Creswell (2009 p. 179 Table 9.2) and Walsham (1995 p. 77) point out the disadvantages of interviews: there is researcher bias, the researcher as an “outside observer” has no direct observation of a process but an indirect interpretation by the interviewee. Bias can be reduced through the use of “mirroring” during the interview; this is using the study subject’s own words to create “subsequent questions” (Myers & Newman, 2007 p. 17).

There is also the worry that the information provided by the interviewees does not reflect “external reality” accurately (Murphy et al., 1998 p. 122). While this may be true for some of the themes in Chapter Five, the themes reflected the expressed external reality of the interviewees and that were validated by the literature review in Chapter Two and/or the literature review on some topics in this chapter, especially the information and information quality discussion.

In addition, the interview is seen as artificial in the sense that the interviewee is a “complete stranger” who may not “trust” the interviewer or the process or the interviewer may not have “access” at the right level or enough “time” to get the necessary information (Myers & Newman,

2007 p. 4). Section 4.6.2 provides the rationale for telephone interviews in this research. The fact that the researcher had a medical background and was familiar with the acute care setting did engender trust and a common understanding as shown in the reflexivity examples.

Mitigation strategies include fully informed consent, member checking and researcher awareness of and documentation of assumptions and limitations. These mitigation strategies were discussed above in sections 4.4.3 (Member Checking), 4.5.3 (Consent), and this section, 6.4.1(Limitations).

Interview Questions

Although questions in all the five context areas were answered, there was less complete information provided for final sections of Risk and Patient Safety. These questions were at the end of the interview, so running out of time may have been a factor. Some questions were answered by more than half of the interviewees: Q 01 [information quality], Q 04 [acute care sector], Q 10 [Risk]. Some questions little or no response: because the question was not asked [Q 11, Q 15] because of time restraints and the interviewer felt that the question has been answered by earlier questions. A mitigation would have been to ask fewer questions in the same time.

Coding

This was the researcher's first attempt at inductive coding and using the MAXQDA 12 software. The coding was closely based on the interviewee's actual words. A more experienced coder could well end up with different conclusions about information quality. The Grounded Theory coding is selective and should be consistently applied at all times: the use of actual words as coding elements helped ensure consistency.

Generalization: Use of Theory or Model

A form of validation is generalization or the use of theory. We saw this earlier at the beginning of this chapter in section 6.2.2 about adopting the SEIPS Model and using Lee and Baskerville's judgement calls test to support using the SEIPS Model as described in [Appendix I](#). Lee and Baskerville's use of theory is different from Gregor's use of theory that describes the SEIPS Model as a Type 1 analytic theory framework because Lee and Baskerville provide criteria for using a theory or framework in the first place. If a theory or framework meets Lee and Baskerville's test then the theory or framework, in this case, the SEIPS Model, can be used with

confidence. Lee and Baskerville’s validation test supports the adoption of the SEIPS Model as a Gregor Type 1 analytic framework for structuring and further validating the Chapter Five research results.

This research used the literature review gaps⁷⁹ that are about the lack of information from key informants in a Canadian acute care setting in Chapter Two and the ontology, epistemology and paradigm in Chapter Four section 4.2.2 (Qualitative Method) to guide the research “design and data collection” (Walsham, 1995 p. 76). Walsham (1995 p. 79 Table 3) also provides four examples of generalizations that are used at the end of the research: “develop concepts, generate theory, draw specific implications, and contribute rich insight”. These examples are explanations of particular phenomena derived from empirical interpretive research in specific information system settings, which may be valuable in the future in other organizations and contexts.

Validity and Reliability

Table 25⁸⁰ shows how this research meets most of the validity criteria listed by Venkatesh et al. (2013 p. 33) except confirmability that will need further research:

Table 25: Validity Criteria applied to this Research

Validity in Qualitative Research	
<p>Design Validity: how well a qualitative study was designed and executed so that the findings are credible and transferable.</p>	<ul style="list-style-type: none"> • <i>Descriptive validity</i>: The accuracy of what is reported (e.g., events, objects, behaviors, settings) by researchers. <p><u>This research</u>: verbatim transcripts checked against the recording were used for analysis. The pilot study ensured coding consistency. The use of the descriptive statistics tables in Chapter 5 ensured analysis of broad sector of interviewees who were interviewed independently over the course of a year.</p> <ul style="list-style-type: none"> • <i>Credibility</i>: Involves establishing that the results of qualitative research are credible or believable from the

⁷⁹ Please see sections 2.3.2 (Information Quality), 2.4.3 (Summary), . 2.5.3 (Information System Elements and Characteristics for Safety), 2.6.2 (Assessing Risk), 2.6.4 (Classification of Adverse Events), 2.7.2 (Technology Induced Errors), 2.7.4 (Patient Safety Concepts and Frameworks).

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	<p>perspective of the participants in the research to convincingly rule out alternative explanations.</p> <p><u>This research</u>: member checking showed interviewees agreed with the findings.</p> <ul style="list-style-type: none"> • <i>Transferability</i>: The degree to which the results of qualitative research can be generalized or transferred to other contexts or settings. <p><u>This research</u>: it is likely this research is transferable to other Canadian acute care settings because the interviewees were from western, central and eastern Canada.</p>
<p>Analytical Validity: how well qualitative data were collected and analyzed so that the findings are dependable, consistent, and plausible.</p>	<ul style="list-style-type: none"> • <i>Theoretical validity</i>: The extent to which the theoretical explanation developed fits the data and, therefore, is credible and defensible. <p><u>This research</u>: the a priori groups were based on the semi structured interview questions (based on a detailed Chapter Two literature review) and the inductive /subjective codes were based on the actual words used by the interviewees.</p> <ul style="list-style-type: none"> • <i>Dependability</i>: Emphasizes the need for the researcher to describe the changes that occur in the setting and how these changes affected the way the researcher approached the study. <p><u>This research</u>: there was no repeat sampling of the interviewees (except in once case to continue the interview) so changes over time did not occur.</p> <ul style="list-style-type: none"> • <i>Consistency</i>: Emphasizes the process of verifying the steps of qualitative research through examination of such items as raw data, data reduction products, and process notes. <p><u>This research</u>: the methodology in Chapter Four was followed and examples of memos are in Appendix B. C Memos were used primarily to organize codes, document next steps or analytic cues to follow up on.</p> <ul style="list-style-type: none"> • <i>Plausibility</i>: Concerned with determining whether the findings of the study, in the form of description, explanation, or theory, fit the data from which they are derived (Sandelowski 1986).

	<p><u>This research</u>: the themes are directly based on the interviewee semi structured interviews using inductive coding and are thus closely linked to the data.</p>
<p>Inferential Validity: quality of interpretation that reflects how well the findings can be confirmed or corroborated by others</p>	<ul style="list-style-type: none"> • <i>Interpretive validity</i>: The accuracy of interpreting what is going on in the minds of the participants and the degree to which the participants’ views, thoughts, feelings, intentions, and experiences are accurately understood by the researcher. <p><u>This research</u>: the results and discussion based on this study sample will need to be confirmed.</p> <ul style="list-style-type: none"> • <i>Confirmability</i>: The degree to which the results could be confirmed or corroborated by others. <p><u>This research</u>: this remains to be confirmed with future research, however, the interviewees did corroborate each other.</p>

Note: Adapted from Venkatesh et al. (2013), Table 4.

6.4.2 Future Research

This research makes valuable contributions about the role of information and information quality in acute care, however, there are opportunities for future research itemized in the bullets below:

- Have fewer semi structured interview questions and ask more in depth questions about what the interviewees’ ideas for risk mitigation of poor information quality specifically.
- Use the SEIPS Model to drill down on missed areas of inquiry, for example, the task and the effect of information quality on specific health care tasks; the physical layout of the work environment and its effects on information quality; and the random behaviour of users.
- Confirm the “information lines” in the improved SEIPS Model with research on other similar models and assess their reliability and validity to health care.
- Examine the real world state (external reality) of the patient and the representation by the system as described in the Wand and Wang (1996) model: how do system requirements

reflect the real world and how can they be improved and comparing the interaction of the care provider with the real world patient and the system. This work would build on the scenarios or use cases created by Smith and Koppel (2014 p. 118) and mapping to the Canadian real world.

- Look at information quality in the three systems, laboratory, pharmacy and imaging, the interviewees told us about: is there a difference and what is the real world representation?
- Look at information quality according to the different degrees of information system integration and propagation of inaccurate corrupt information in the more integrated systems.
- Examine the NIST and Pew Charitable Trust use case recommendations in more detail and trial in a Canadian setting. Follow up on the dissemination and use of the ISO Software quality standards.
- Examine the relationship with vendors and or organizations and ministries and their impacts on information in more detail.
- Examine information quality and fit in more detail, expanding on the work of Strong and Volkoff (2010) and/or assess the five key areas as four exposures (acute care, information, information system, risk as a function of poor information quality) and their relationship with the fifth, patient safety, as adverse events for patients.
- Explore risk as a qualitative concept in more detail starting with an additional literature review including the concepts of wicked, uncertain, complex and rare.

The twenty interviewees who agreed to share their wisdom and experience have provided many fruitful ideas for future research.

6.5 Contribution to Knowledge

Although a theory did not develop from the semi structured interview data, the SEIPS Model was used to organize the responses for further discussion and examine further what missing and uncertain information might mean. Key points from this discussion include how precise the information system maps to the real world, and to the user's perception of the real world.

This mapping can never be totally accurate and complete, so the mapping gaps are missing information. This property of this missing information could be either fixed (entropy) or fluid. The user's perceptions or motives can also change the information through random changes based on the work context.

Understanding information quality (missing uncertain information), within the complex web of the five key areas is an example of wicked, complex and uncertain problems mentioned in the literature review. Richey (2011 p. 7) notes that these problems can be tackled with qualitative methods (because quantitative methods are "relatively useless") with alternative perspectives as provided by the interviewees with discrete alternatives such as we see with the hybrid unstructured information and the electronic structured information, and, presented in a visual representation as we see in the enhanced SEIPS Model.

The discussion of information and information flow enhances the SEIPS Model and places information and information quality in its rightful place as a glue for the acute care system: this is an important contribution to knowledge that is amenable to future research on this wicked problem so there is a better fit between the real world, information, the information system and people.

In addition, this research fills a gap in the Canadian informatics and patient safety field because it extends previous work in these areas such as Baker et al. (2004) or Magrabi et al. (2013). Although Baker's and Magrabi's research is valuable for setting the Canadian context it does not provide information about the understandings and interpretations of Canadian clinical and non-clinical health care experts actively involved with information systems.

The published experience from other jurisdictions is that information systems are expensive

failures with costs to human safety. The Chapter Two literature review that provided a wider view of the five key topics combined with the Chapter Six discussion shows the Canadian interviewees and context are similar to other settings. The issues in the five key areas are universal because they are based on universal human activities and motives i. e. human behaviour. The Chapter Six Discussion shows that the Canadian experts provided information congruent with the Chapter Two Literature Review conclusions .

The research was carried out within the external reality of acute care in Canada using the ontological properties of the interviewees' understandings and interpretations of that external reality. The strongest interpretations of that reality is from the individuals most experienced in that reality. The interviewees interviewed in this research provided strong evidence of their understandings and interpretations of that reality based on a Grounded Theory analytic approach of the semi structured interview questions. The interpretivist paradigm allows for: a dialogue between the researcher and the interviewee, reflexivity, and different understandings and interpretations to answer the question "what does it mean?" or "how do people interpret or understand this?"

The semi structured interviews provide strong evidence that information is missing and unstable within the two key health care information systems of the hybrid paper chart and the electronic system the interviewees mention are still used in their work settings. The hybrid paper system is the main repository of narrative unstructured data and the electronic system, the structured data. The interviewees provided many examples from the pharmacy, laboratory and imaging sectors as well as examples of inaccurate information occurring at different stages of the system life cycle such a design, implementation, and integration with legacy systems.

The interviewees also provided some remedies from their experience to stabilize information such as moving to templates or drop down boxes. The information system users, nurses and physicians in this research, resisted this fettering against their desire to tell the patient story in narrative unstructured data form. The interviewees stressed the importance of stable patient identity information that, ideally, should have no uncertainty or entropy.

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Appendix A: Literature Review Database Search Terms

The literature review identified research published in the literature in five key areas of acute care: health information systems, information and information quality, risk of poor information quality, and patient safety. The literature review covers the period between 2007 to 2016.

Inclusion criteria – Articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Initial Literature Search

An example of the initial literature search using the Web of Science is presented below. There were several subsequent literature searches that are described further below.

Web of Science Search

The advanced search function was used for each database. For example, in Web of Science™ the “ts=” function was used for each term e.g. ts=acute care AND ts=information AND ts=quality for the years 2007 to present.

Other ts=search terms used alone or in combination were “patient safety”, “risk”, “information system”, “health information quality”, “information system failure”, “qualitative research”, ‘grounded theory”.

As noted above, the initial search was done using the ts= function for each of the terms ts=acute care AND ts=information AND ts= quality. The following limits were applied to each search:

- “English”, “article”, “review”
- Years 2007 to 2016 (or the latest year the search was done as the literature search took place over a period of time)
- Web of Science Sources: Science Citation Index Expanded (SCI-EXPANDED) --1900-present; Social Sciences Citation Index (SSCI) --1900-present; Arts & Humanities Citation Index (A&HCI) --1975-present; Conference Proceedings Citation Index- Science (CPCI-S) --1990-present; Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) --1990-present.

The following table show the results of the separate ts= searches and the result using the AND function with the limits:

[60,030](#) (ts=acute care) **AND LANGUAGE:** (English) **AND DOCUMENT TYPES:** (Article OR Review)
1 Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=2007-2017

[960,348](#) (ts=information) **AND LANGUAGE:** (English) **AND DOCUMENT TYPES:** (Article OR Review)
2 Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=2007-2017

[903,029](#) (ts=quality) **AND LANGUAGE:** (English) **AND DOCUMENT TYPES:** (Article OR Review)
3 Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=2007-2017

4 [1,651](#) #3 AND #2 AND #1

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=2007-2017

The search results have side bars giving article counts. In this search there were 338 review articles. The researcher would scan these first. Then to narrow the scope of the entire search (including the review articles) the researcher selected the following categories: Health Policy Services (182), Medical Informatics (69), Computer Science Information Systems (26), Multidisciplinary Sciences (22), Computer Science Interdisciplinary Applications (15), Social Sciences Interdisciplinary (3), Social Sciences Biomedical (9), Information Science Library Science (11), Computer Science Artificial Intelligence (3), Computer Science Theory Methods (1).

The researcher scanned the search output and read the article abstract, if the title of the article looked relevant. If this scan of the abstract revealed a promising article, the article was saved for a more detailed review. The researcher used the “cited by” function to find further articles as well as reviewing the bibliographies of selected articles to find further articles.

Later Literature Searches

The researcher performed a second series of literature searches using CINAHL®, PubMed (basic searches and a more detailed search) and Google Scholar (eight searches in total). The exclusion criteria were similar, but since this search was done after the dissertation was completed, the exclusion criteria were further refined for the search.

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Search 1: CINAHL®

Find all my search terms:

MW acute care AND MW information AND MW quality

Limiters

- Full Text
- Published Date: 20070101-20171231

Search results:

Search Terms	Search Options	Actions
	Limiters - Published Date: 20070101-20161231; English Language; Peer Reviewed; Research Article; Human	
	Expanders - Apply related words	
	Narrow by SubjectMajor: - clinical information systems	
	Narrow by SubjectMajor: - hospital information systems	
<input type="checkbox"/> health information S2 technology AND information quality	Narrow by SubjectMajor: - patient safety	(189)
	Narrow by SubjectMajor: - information systems	
	Narrow by SubjectMajor: - patient record systems	
	Narrow by SubjectMajor: - medical informatics	
	Narrow by SubjectMajor: - information technology	
	Narrow by SubjectMajor: - electronic health records	
<input type="checkbox"/> health information S1 technology AND information quality	Search modes - Find all my search terms Limiters - Published Date: 20070101-20161231; English Language; Peer Reviewed; Research Article; Human	

Expanders - Apply related words

Search modes - Find all my search terms

The researcher scanned the 189 articles from the CINAHL search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 12 articles for further online review of title and abstract
- 2 not selected for further review because they met the exclusion criteria
- 10 reviewed full article in detail and stored
- 2 duplicates
- 3/8 used in the dissertation

Search 2: PubMed Basic Search 1

Search Terms:

((("acute care") AND "information") AND "quality")

From 2007/01/01 to 2017/12/31

Humans

The researcher scanned the 308 articles from the PubMed Basic Search 1 search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 10 articles for further online review of title and abstract
- 10 reviewed full article in detail and stored
- 2 duplicates
- 6/8 used in the dissertation

Search 3: PubMed Basic Search 2

Search Terms:

Search (("qualitative research grounded theory" OR "qualitative research interviews" OR "qualitative research methodology"))

From 2007/01/01 to 2017/12/31

Humans

The researcher scanned the 362 articles from the PubMed Basic Search 2 search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 21 articles for further online review of title and abstract
- 3 not selected for further review
- 18 reviewed full article in detail and stored
- 0 duplicates

- 11/18 used in the dissertation

Search 4: PubMed Basic Search 3:

Search Terms:

"Patient Safety"[Mesh] AND "Hospital Information Systems"[Mesh] AND ("loattrfull text"[sb] AND "2007/08/10"[PDat] : "2017/08/06"[PDat] AND "humans"[MeSH Terms])

The researcher scanned the 126 articles from the PubMed Basic Search 3 search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 4 articles for further online review of title and abstract
- 4 reviewed full article in detail and stored
- 1/4 used in the dissertation

Search 5: PubMed Basic Search 4

"Medical Errors/classification"[Mesh] OR "Medical Errors/epidemiology"[Mesh] OR "Medical Errors/methods"[Mesh] OR "Medical errors/prevention and control"[Mesh] OR "Medical Errors/utilization"[Mesh]) AND ((Journal Article[ptyp] OR Review[ptyp]) AND "loattrfull text"[sb] AND "2012/08/08"[PDAT] : "2017/08/06"[PDAT] AND "humans"[MeSH Terms]) AND (("information systems"[MeSH Terms] OR ("information"[All Fields] AND "systems"[All Fields]) OR "information systems"[All Fields] OR ("information"[All Fields] AND "system"[All Fields]) OR "information system"[All Fields]) AND ("hospitals"[MeSH Terms] OR "hospitals"[All Fields] OR "hospital"[All Fields])) AND (Journal Article[ptyp] OR Review[ptyp])

The researcher scanned the 371 articles from the PubMed Basic Search 4 search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 3 articles for further online review of title and abstract
- 1 not selected for further review

- 2 reviewed full article in detail and stored on the lan
- 0/2 used in the dissertation
- There are diminishing returns because of similar search terms.

Search 6: PubMed Detailed Search

Search Terms:

((("patient safety errors"[All Fields] OR "patient safety incident reporting"[All Fields] OR "patient safety management"[All Fields] OR "patient safety medical error"[All Fields]) AND ((Government Publications[ptyp] OR Journal Article[ptyp] OR Review[ptyp]) AND "loattrfull text"[sb] AND "2012/08/14"[PDat] : "2017/08/12"[PDat] AND "humans"[MeSH Terms] AND English[lang])) AND ((health information exchange[tw] OR hie[tw] OR rhio[tw] OR regional health information organization[tw] OR hl7[tw] OR health level seven[tw] OR "unified medical language system"[MeSH Major Topic] OR umls[tw] OR loinc[tw] OR rxnorm[tw] OR snomed[tw] OR icd9 cm[ti] OR icd 9 cm[ti] OR icd10[ti] OR icd 10[ti] OR metathesaurus[tw] OR patient card[tw] OR patient cards[tw] OR health card[tw] OR health cards[tw] OR electronic health data[tw] OR personal health data[tw] OR personal health record[tw] OR personal health records[tw] OR "health records, personal"[MeSH Major Topic] OR "health records, personal"[MeSH Major Topic] OR ehealth[tw] OR e-health[tw] OR "medical informatics applications"[MeSH Terms] OR "medical informatics applications"[MeSH Terms] OR "medical records systems, computerized"[MeSH Terms] OR "medical records systems, computerized"[MeSH Terms] OR computerized patient medical records[tw] OR automated medical record system[tw] OR automated medical record systems[tw] OR automated medical records system[tw] OR automated medical records systems[tw] OR computerized medical record[tw] OR computerized medical records[tw] OR computerized patient records[tw] OR computerized patient record[tw] OR computerized patient medical record[tw] OR electronic health record[tw] OR electronic health records[tw] OR "electronic health records"[MeSH Major Topic] OR "electronic health records"[MeSH Major Topic] OR electronic patient record[tw] OR electronic patient records[tw] OR electronic medical record[tw] OR electronic medical records[tw] OR electronic healthcare records[tw] OR electronic healthcare record[tw] OR electronic health care record[tw] OR electronic health care records[tw] OR "archives"[MeSH Major Topic] OR ehr[tw] OR ehrc[tw] OR phr[tw] OR phrc[tw] OR emr[tw] OR emrc[tw] OR "health information systems"[MeSH Major Topic]) AND (medical record[ti] OR "medical records"[MeSH Terms] OR medical records[ti] OR patient record[ti] OR patient records[ti] OR

patient health record[ti] OR patient health records[ti] OR "patient identification systems"[MeSH Terms] OR "patient identification systems"[MeSH Terms] OR "patient outcome assessment"[MeSH Major Topic] OR "patient discharge summaries"[MeSH Major Topic] OR healthcare record[ti] OR healthcare records[ti] OR health care record[ti] OR health care records[ti] OR health record[ti] OR health records[ti] OR hospital information system[tw] OR hospital information systems[tw] OR umae[ti] OR "attitude to computers"[MeSH Terms] OR medical informatics[ti]) OR (("medical records systems, computerized"[MeSH Major Topic] OR "medical records systems, computerized"[MeSH Terms] OR computerized patient medical record[tw] OR computerized patient medical records[tw] OR automated medical record system[tw] OR automated medical record systems[tw] OR automated medical records system[tw]) AND ((Journal Article[ptyp] OR Review[ptyp]) AND "loattrfull text"[sb] AND "2007/08/16"[PDat] : "2017/08/12"[PDat] AND "humans"[MeSH Terms] AND English[lang])) AND ((Journal Article[ptyp] OR Review[ptyp]) AND "loattrfull text"[sb] AND "2012/08/14"[PDat] : "2017/08/12"[PDat] AND "humans"[MeSH Terms] AND English[lang] AND jsubsetaim[text])

The researcher scanned the 780 articles from the PubMed Detailed Search search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 43 articles for further online review of title and abstract
- 3 not selected for further review
- 40 reviewed full article in detail and stored
- 20 duplicates
- 4/20 used in the dissertation

Search 7: Google Scholar 1

Search Terms:

Patient safety AND EHR OR electronic health record AND quality 2012-2017

There were 16,000 results and Google Scholar has poor filtering functionality.

The researcher scanned 20 screens of 20 articles/screen (400 articles) search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 69 articles for further online review of title and abstract
- 15 not selected for further review
- 54 reviewed full article in detail and stored on the lan
- 7 duplicates
- 11/ 47 used in the dissertation

Search 8: Google Scholar 2

Search Terms:

Patient safety AND EHR or electronic health record AND quality AND government publications

Since 2013

Used additional term in Advanced Search: Return articles published in “.gov” (US) and “.uk” (UK) to target government publications only.

There were 18,000 results and Google Scholar has poor filtering functionality.

The researcher scanned 20 screens of 20 articles/screen (400 articles) search result using the following criteria:

Inclusion criteria – articles were included in search results that dealt with:

- acute care
- information or information quality
- information systems or health information systems (such as electronic health record, computer provider order entry systems (CPOE), decision support)
- risk, risk management, or risk assessment, patient safety or adverse events

Articles that were not research articles, systematic reviews, or reviews were excluded.

Articles that were not in English, were duplicates, or that dealt with non-acute care settings were also excluded.

Detailed Search Review:

- 17 articles for further online review of title and abstract
- 6 not selected for further review

- 11 reviewed full article in detail and stored
- 3 duplicates
- 8/11 used in the dissertation

Appendix B: Sample Recruitment

Initial Recruitment Steps:

1. an initial invitation letter was given to an expert in the field of health informatics who to start the snowball process, by contacting several other known experts in the area of patient safety with the invitation to participate
2. These individuals (who were initially contacted) were asked to contact other potential interviewees.
3. Those interested in participating contacted the experimenter (by email, as set out in the instructions) to set up an interview with her
4. An interview was scheduled if the participant indicated they wished to be interviewed

Note - the above initial recruitment method did not yield enough participants, so an ethics amendment was made to the ethics protocol to also include recruiting participants using list serves.

Recruitment Steps Using List Serves:

1. An invitation to participate was created to be sent out to a list serve, with the researcher's contact information and email address for anyone interested in participating
2. The invitation was sent out to the HINF-1 list Serve for the University of Victoria's School of Health Information Science Alumni (it was mailed out as a blast to the list serve by the School's administrative assistant)
3. The invitation included instructions for contacting the experimenter to set up an interview
4. An interview was scheduled if the participant indicated they wished to be interviewed

Note:

Individuals who were interested in being interviewed contacted the researcher directly.

A few of the interviewees, approximately three or four, referred other individuals to the researcher. These additional individuals also contacted the researcher directly as a small

additional snowball sample.

Appendix C: Reflexivity Sample

The researcher is a physician with training in laboratory hematology; this put the clinical interviewees at ease when explaining medical issues in their responses as shown in the following two examples.

The first (interviewee 16) is about explaining the unstructured interpretive information in a medical consult such as a specialist would provide.

Inf 16 physician 10-20 years' experience health authority: We are still trying to figure out how that would look in the wild. How can physicians document? What they do is they document differently. We are not ... You do this in hematopathology, right? You won't describe the CBC. You won't tell me what the hematocrit, what the MCV was. It's in there. It's already there. I can see that. It's already listed. What I want from you is the interpretation. What is going on here. That's what physicians are primarily doing, and within an electronic record, that is an important, key part of the documentation that needs to be captured, and failing to do that well, you are at risk of losing that aspect of the record, and losing the ability to understand the patient and understand the thinking of the person who was taking care of them [para. 26]

The second (interviewee 17) is about extubation where the patient removes out the tube rather than the medical professional. This is taken from the transcription.

Base transcript lines 270-288:

Inf 17: Did the staff member pull it out? Then, was it planned or unplanned? But sometimes what happens is, the staff member, you're rolling the patient over and someone doesn't have a good grip on that tube, and you roll them back, and the tube came out. The patient didn't pull it out, kind of the staff pulled it out accidentally. That would be where you would check, "initiated by staff, unplanned." If it was a planned extubation, where they're actually going to intubate this patient, then you would pick, "staff, planned." Now, what we've found, looking at some of the reports, staff aren't really reading, or I don't even know what they're doing, but some of them are picking, "patient initiated, planned."

Liz: Oh.

Inf 17: You'd never do that.

Liz: Yeah, exactly. Yeah, I'm actually a physician by training, so I kind of know what you're talking about, yeah.

Inf 17: Oh, okay. I was wondering when I started going with the whole extubation, like, okay, does she know what I'm talking about?

Liz: Yeah, no. I know what you're talking about.

Inf 17: While ... From a quality perspective, that was really bad.

Liz: Mm-hmm (affirmative).

Appendix D: Memo Examples

This provides examples of the different memos used in this research.

Memo as Comment during Interview

Example 1: comment

Interviewee 17

2015-09-27 4:38:25 PM

Liz comment

Yeah, and I guess people probably write stuff on paper, and then do they enter it into this application, or are they expected to just enter it directly into the application? I guess that's really what they're supposed to do at the bedside. But I can see if you get busy, you might just keep notes on scraps of paper [line number 907]

Response-Yes, exactly. On a normal day, yes. I would expect them to go in, do their head to toe assessments, come out, and document it. Or document if they have a computer in the room, document each system as they complete that system

Example 2: Question-note that this comment asks about drop down boxes generated a response that became a theme used for drop down boxes later in the analysis

drop down transcript

Liz

2015-09-27

2015-09-27 3:36:27 PM

Liz: Mm-hmm (affirmative). How do you find people with all the drop down boxes? Do they tend to ... Do they find them really frustrating, or do they find them really easy, and they just go through them? [line number 391]

Response: In the beginning, we often, when the **unit** [inaudible 00:21:43] goes live, we often get complaints about the amount of clicking.

THEME TOO MANY CLICKS IN DROP DOWN [line number 397]

Example 3: Question when didn't get a good response to the question

Response I don't think um, that I am aware of any issues but there are always potential issues um, so you know based on the past experience we just um, try to learn from errors in the past and try to mitigate any issues that we know that have happened in the past but I can't put my finger on anything at the moment, I didn't really have anything written down for that one and

2015-09-17 3:39:08 PM

Liz-ask what sort of mitigation have you come to use over the years or do now that didn't do before? 713

Response: definitely our testing cycles are a lot more robust um, we you know we do tend to um, try to get you know the most expertise that we can from all of the areas that are impacted and better involved in the implementation um,

Memos for Organizing: MAXQDA 12

Summary of memo label summary

“?” memo-asking clarification question or more detail =green on transcript

“T” memo-commenting or thinking out loud about an interviewee's response or thought=blue on transcript

sticky note-general memo interpretation about the other memo labels

green slash memo-comes under the green a priori groups for the questions-examples

added context eg lab radiology, medication so can sort later

added line number coded transcript so can find for quoting

add context to variables eg front line, non-consultant, regulator, federal Infoway etc. the excel sheet is unchanged

resp 01 no line numbers-done

interviewee 7 font changed from 12 to Arial 10 so can copy over, line numbers will change, make all transcripts Arial 10-done

2015-11-29 11:56 AM

create new document set based on the variables: clinical-nurses, pharmacist and physician vs non-clinical IT

Code Memo Summary

Memo for Q 01 Glue description

This is a priori group that is using ideas derived from the literature review. This process starts with at least some predefined, higher-level areas of interest which are explicitly looked for in the data. (Lewin, p. 180-181)

these codes and their subcodes are coded in GREEN

these tend to be NOUNS

Memo during Analysis

These are examples of the memos that were documented as comment boxes during the analysis of the word documents:

Example 1:

IQ term hand writing, free **text**, unstructured data

This term reveals a double edged sword for information quality: the quality is very high but at the expense of missing information and instability. The clinical informants see hand writing, free text, or unstructured² data as a source of information density and richness, the story or narrative about a patient as can be seen from the following quotes:

Resp 04 nurse 21-30 years' experience public: Um, for others it goes on to the extent of

Commented [L14]: Really free text or unstructured data-define

May move to risk question
Format of information n the chart paper or electronic
Hybrid paper suggest move to system because it is parallel system
Do lit search on unstructured data free text and HIS
Also part of forcing function

Example 2:

Question 11/04: How would you describe the acute care **setting**?

This question is asking about the key informants understanding of acute care and what it means to them.

Descriptive statistic:

Commented [L4]: Will have a separate page for each question now
Have done the clinical and non clinical analysis for all the questions except for information quality where I will do the most frequent sub codes

Example 3:

Memo during Analysis
Later system

Descriptive statistics

19/20 95%

Commented [L1]: Memo:
system assumptions included

included medical devices such as infusion pumps

also forcing function a safety feature eg resp 05 it is all about changing behaviour see resp 12 and social engineering tho that is vendor driven

resp 18 the number of movingparts and the longevity of it makes it a wicked problem??

2015-11-29 11:48 AM
moved to code for system create a set

2015-12-09 11:06 AM
do search on gap, documentation forcing function also part of social engineering systemmaking peole change their behaviour and how that has an influence on information quality-may need to do a lt search on this will need to redo the quote matrix for this one

2015-12-21 1:38 PM

18/11 Do you have direct experience with or know or have ideas about poor information quality as a risk factor for an adverse event?

Although the key informants did not answer this question directly, their responses to other questions provide sufficient material to provide good examples of poor information quality contributing to an adverse event.

Descriptive statistics

0/20 for a response of 0%

Qualitative understanding:

Commented [L2]: No response but may be buried in interviews combine with question above

Poor quality system

Poor quality information

Poor quality user:

Input

Use

Workarounds business practice

Appendix E: University of Victoria Consent Form

Participant Consent Form



**University
of Victoria**

Information Quality (IQ): What is it?

You are invited to participate in a study entitled Information Quality (IQ): What is it? that is being conducted by Elizabeth Key.

Elizabeth Key is a Doctoral Graduate Student in the department of Health Information Science at the University of Victoria and you may contact her if you have further questions by email: ehk@uvic.ca.

As a graduate student, I am required to conduct research as part of the requirements for a degree in Doctorate in Philosophy. It is being conducted under the supervision of Andre Kushniruk. You may contact my supervisor at 250-472-5132.

Purpose and Objectives

The purpose of this research project is:

Expensive health care systems fail and may be unsafe

- ▶ the safety track record of health information systems in acute care is not clear cut
- ▶ UK and US reporting shows missing or incorrect data, data displayed for the wrong patient, chaos during system downtime, and system unavailable for use with adverse events to patients including delay in diagnosis or treatment
- ▶ a common thread is information quality: does poor quality contribute to adverse events?

Importance of this Research

Research of this type is important because:

- ▶ Health information system failure is costly for funders and individuals suffering an adverse event
- ▶ Social and organizational causes underlie these failures
- ▶ Information quality important for care
- ▶ Federal and provincial regulators and funders may be able to improve health information systems if this research provides a better understanding about information quality

Participants Selection

You are being asked to participate in this study because you were selected either by your colleagues or through the HInfListServ on the basis of your expertise.

What is involved?

If you agree to participate voluntarily in this research, your participation will include:

- A recorded telephone interview of semi structured questions lasting approximately one hour. I will also be taking notes
- Possibly one or two follow up requests for information checking if you agree (member checking). Please note I will get your consent for each member checking session.
- Interview will be transcribed by individual who has done this work for UVic and has signed the UVic confidentiality undertaking
- Data analysis possibly using software
- Results of research will be non identifiable
- Results of research may be used for research articles or at conferences
- Results may be published on the UVicSpace dissertation website which is publicly available

Contacting you

I will be contacting you about this research using business contact information or personal contact information [email].

Inconvenience

Participation in this study may cause some inconvenience to you, including time (approximately one hour) plus time for member checking, if needed.

Risks

There are no known or anticipated risks to you by participating in this research. I will be asking for your professional opinion; however, it may happen that sensitive material about an adverse event, for example, may arise.

Benefits

The potential benefits of your participation in this research include how health care information systems can be safer if we can understand how information quality can influence safety.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will be used only if you give permission as noted below under the signature block.

Anonymity

In terms of protecting your anonymity all potential identifiers such as names or locations will be severed from the data after it has been transcribed. Each interview will have a number code such as P1. The source file will be kept separate from the recordings and transcriptions.

Confidentiality

I will be using a snowball sampling technique. I will be asking that you forward the email invitation and consent form to other potential participants using their business contact information so that those participants can contact me. This will ensure the confidentiality of those who choose not to participate.

The data will be stored in a secure cabinet and destroyed securely one year after the research has ended.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways such as conferences or research articles.

Disposal of Data

Data from this study will be disposed by the following electronic data being erased and paper data being shredded one year after the research has ended.

Contacts

Individuals that may be contacted regarding this study include as listed at the beginning of this form.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca). This research has the Protocol Number 13-524.

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researcher, and that you agree to participate in this research project.

Name of Participant [print]	Signature	Date
-----------------------------	-----------	------

Please keep a copy of this signed consent form and scan and send the signed copy to me at the email address above.

At time of withdrawal:

I consent to have my data being used in this study even though I have withdrawn from the study:

- Yes/No [please circle]
- Name:
- Date:

Please scan and send the amended consent form with this updated consent to use data after withdrawal to the email address above. Please keep the original signed copy.

Member checking [clarification at the data analysis stage and/or confirming findings]

- If you are interested in being contacted for ‘member checking’ at a future time please provide your contact information here:

My name is Dr Elizabeth Keay, a PhD student at the University of Victoria, British Columbia. I am currently working under the supervision of Dr Andre Kushniruk of the School of Health Information Science at the University of Victoria. I am interested in getting an understanding from key knowledge experts about identifying factors affecting patient safety of acute care health information systems.

If it is acceptable to you, I would like to record our conversation today which will allow me to perform more detailed analysis later. Let me reassure you that your responses will be kept confidential. Neither your name nor the name of your organization will be linked to your responses when I present my findings. Please feel free to skip any questions you think are not relevant to your experience.

Is this a good time for you for an interview?

Is it OK if I record this conversation?

As this interview has semi-structured questions it could take anywhere from 30 minutes to an hour, how much of your time do we have available?

Do you have any questions before we begin?

Interview Questions - semi-structured interview format:

▪ PART I - Background information

1. You are being asked to participate in this study because you have experience with health information systems and/or patient safety and you are (or have) worked on a regional, provincial or federal health-related project that has implemented health information systems.
2. Which best describes your experience?
3. How many years experience do you have with health information systems, risk management in health care or patient safety?
4. How would you describe your day to day work? Can you please provide a short description of what you do so I have an understanding?
5. Was it in the public sector or private sector or both? If both approximately how many years in each?
6. Do you work with information systems on a routine basis?

▪ PART II - Information quality as a glue in the system

11. How would you describe information quality?
12. Are there specific terms that you would use to define good information quality? Or examples?
13. Are there specific terms that you would use to define poor information quality? Or examples?

Comment about information

For the purpose of this study information quality can be considered a measure of the value of health information in terms of: its accuracy, usefulness, timeliness, reliability, and certainty.

▪ Part III - Acute care is the context

13. How would you describe the acute care setting?
14. Does the quality of information differ between acute care and other situations?
 - Part IV - Health information system is the vehicle
17. Do you have some specific examples of how information systems have increased information quality in your organization?
18. Do you have any examples of how information systems might have inadvertently decreased information quality in your organization?
19. Are there any potential issues for you and your organization regarding information quality when implementing health information systems?
20. Technology-induced errors can be defined as being inadvertent errors that arise in the deployment of new health information technologies. They may arise from different points in the design of health information systems but typically don't manifest themselves until the system is in place and being used.
 1. Have you (or your organization) considered risk of technology-induced errors when implementing systems?
 2. Have you seen such errors? (if so please describe)
 3. Does your organization have strategies for mitigating the risk of such error (in order to ensure the quality of information and safety of patients when implementing healthcare systems)?
- Part V - Risk to describe information quality
26. Can you please explain how poor information quality could be a risk factor for an adverse event?
27. Do you have direct experience with or know or have ideas about poor information quality as a risk factor for an adverse event?
28. How would you describe information quality's role? How was the risk mitigated? Or speculate if you don't have direct experience.
29. Does your organization have a strategy for ensuring the quality of information when implementing health information systems? (if so, please describe)
- Part VI - Patient safety provides models for information quality
30. How do you see health information systems affecting patient safety? Will health information systems improve patient safety and information quality? Please discuss.
31. Can poor information quality be a risk factor to patient safety?
32. Is it worth examining further? If so, how would you do this?
- PART VII - Member checking
33. Would you be agreeable to being contacted further for in case I need clarification at the data analysis stage and/or confirm findings?

34. If so, what would be the best way to contact you? Email? Telephone?

- Part VIII – Closing

26. Do you have something further to add about information quality?

27. Is there someone you could recommend who might be interested in an interview for this research?

If so, could you please provide their Name, Organization, Position, E-Mail, Phone Number

Appendix F: Transcriptionist Confidentiality Undertaking

The transcriptionist signed this University of Victoria confidentiality agreements template:

Confidentiality Agreement – Sample template

(RESEARCH TITLE)

1. Confidential Information

The 'XXXXX XXXX XXXXX' Research Project hereby confirms that it will disclose certain of its confidential and proprietary information to their interview transcriptionist,

_____.

Confidential information shall include all data, materials, products, technology, computer programs, specifications, manuals, software and other information disclosed or submitted, orally, in writing, or by any other media, to _____ by _____.

2. Obligations of Transcriptionist

A. _____ hereby agrees that the confidential XXXXX XXXX XXXXX' research study and is to be used solely for the purposes of said study. Said confidential information should only be disclosed to employees of said research study with a specific need to know.

_____ hereby agrees not to disclose, publish or otherwise reveal any of the Confidential Information received from _____, research assistants or other participants of the project to any other party whatsoever except with the specific prior written authorization of _____.

B. Materials containing confidential information must be stored in a safe location so as to avoid third persons unrelated to the project to access said materials. Confidential Information shall not be duplicated by _____ except for the purposes of this Agreement.

3. Completion of the Work

Upon the completion of the work and at the request of _____, _____ shall return all confidential information received in written or tangible form, including copies, or reproductions or other media containing such confidential information, within ten (10) days of such request.

At _____ option any copies of confidential documents or other media

developed by _____ and remaining in his possession after the completion of his work need to be destroyed so as to protect the confidentiality of said information.

_____ shall provide a written certificate to Owner regarding destruction within ten (10) days thereafter.

With his/her signature, _____ shall hereby adhere to the terms of this agreement.

Signature and Date

Appendix G: Coding and Analysis-Part II Question three as an Example

This section sets out the steps of the analysis from transcription to initial a priori groups to inductive/structural coding to the Chapter Five final results by the researcher working between MAXQDA 12 and word documents. The question is in Part II (Information Quality) question 03 asking about poor information quality.

The first step was recording and transcription.

Recording and Transcription

The first step was recording the interview with each interviewee, sending the recording to the transcriptionist, checking the transcription against the recording and correcting using track changes. Each question in the transcript was highlighted in yellow to mark it out from the rest the transcript. Parts II question 3 (**Q 03**) looked like this in the example below:

Interviewee 01: Part II Q 01 Q 02 **Q 03** Part III Q 04....Further comments during the interview were highlighted in blue and questions in the interview, in green. These comments and questions were added to the Microsoft® Excel® as marked.

Initial inductive/structural codes or thoughts were labelled as “THEME”. Excel, comment or underline mean that the quote was added to the Microsoft® Excel® sheet for later uploading into MAXQDA 12.

This is shown on the next page.

EK Um, how would you of course the opposite would be how would you describe or **define poor information quality?**

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PL Ok, well poor information quality really is when you have either um, well if you have not the chart is not complete right or if you have a situation where charts are mixed up.

Commented [R1]: excel

THEME CHART NOT COMPLETE, CHARTS MIXED UP

EK Yes

PL And that is why at EMP1 you have those ones go right up to a human being to make that decision right.

Commented [L2]:

THEM HUMAN VALIDATION STEP

EK Yes

PL The investigator and you know what there is a much higher risk when you have a hybrid higher situation with your paper charts and the possible electronic charts and don't forget now when I say electronic ok, people survive they live on a continuum, so you will have an acute care clinical information system and you will have a community care and you may have an ambulatory clinic system as well and in each of those areas you are going to have a hybrid situation so there is going to be some paper and so what they are doing in the hospital and so forth is they are scanning it in. Those documents are they are not interactive at all they are just a pdf and they are just scanned in. And once they are scanned in then the process is to destroy the paper chart because now the scanned document becomes the original source right. So there are some limitations and there are some good things with that because now you have the papers inside the electronic but the downside is that it is just an object right. And so you have to read all of these objects separately and try and piece it all together as opposed to the electronic system.

Formatted: Underline

Commented [R3]: excel

Formatted: Font: (Default) Arial, 10 pt, Underline, Highlight

Formatted: Underline

Formatted: Underline

Formatted: Underline

THEME HIGHER RISK IN HYBRID SITUATION
THEME CONTINUUM OF SYSTEMS ACUTE, COMMUNITY CARE AMBULATORY WITH MAYBE HYBRID SITUATION IN EACH
THEME PDFS SCANNED IN SCANNED DOCUMENT BECOMES THE ORIGINAL SOURCE AS PAPER COPY IS DESTROYED
THEME READ ALL OBJECT SEPARATELY AS OPPOSED TO THE ELECTRONIC SYSTEM

THEME CONTINUUM OF SYSTEM / INFORMATION

THEME HYBRID

THEME SCANNED PDFS SAME AS PAPER NOT INTEGRATED REALLY

EK So **the it is almost like a paper chart isn't it then?**

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PL Well it is, it is like a matrix you know and so where is the big risk there, the risk is that if I don't have the documentation standards I don't know where to look right and so there is a consult on some specialists and where is it. Did the clerk, where did the clerk put it.

Commented [L4]:

THEME RISK IF DON'T HAVE DOCUMENTATION STANDARDS SO DON'T KNOW WHERE TO LOOK
THEME WHERE DID PERSON PUT PDF?
THEME STRUCTURE OF THE RECORD

EK So **that isn't standardized is that what you are saying?**

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PL Yes, so I am saying that documentation standards so what we have now is professional is we do have documentation standards but you own by our profession so how does it document to be timely and so

forth. So we have had those forever but in the hybrid paper electronic world you need to be able to have a common understanding of how documents are put together and so it so there is that consult going on the paper chart or does it go on the electronic chart?

Formatted: Font: (Default) Arial, 10 pt, Highlight

Commented [L5]:

THEME TIMELY DOCUMENTATION

THEME DOCUMENTATION STANDARDS NEED TO KNOW HOW DOCUMENTS ARE PUT TOGETHER IN THE HYBRID SYSTEM

THEME DOES IT GO IN THE PAPER CHART OR THE ELECTRONIC CHART

THEME HOW IS THE CHART PUT TOGETHER

The process for interviewee 01 was repeated for each interviewee:

Interviewee 01: Q 01 Q 02 **Q 03** Q 04....Q 17⁸¹

Interviewee 02: Q 01 Q 02 **Q 03** Q 04....Q 17

Interviewee 03: Q 01 Q 02 **Q 03** Q 04....Q 17

Etc for each interviewee up to interviewee 20

MAXQDA 12 Upload

The MAXQDA 12 upload from the formatted Microsoft® Excel® sheet contained 2 parts:

- the interviewee attributes in Part I questions 2 to 6. This was the source for the interviewee variables and description for each quote. The interviewee responses to the rest of the questions-these were the understandings and interpretations documented in Parts II to VI.

The MAXQDA 12 rearranged the questions like this for analysis:

Q 01: Int 01 Int 02 Int 03 Int 04...Int 20

Q 02: Int 01 Int 02 Int 03 Int 04...Int 20

Q 03: Int 01 Int 02 Int 03 Int 04...Int 20

Etc for each question up to Part VI Q 16 and Q 17.

⁸¹ Q 17 asking for more information was a general question whose content was used elsewhere in the analysis. Part VI Q 16 was the last question asking about the five key areas.

Q 03: Int 01 Int 02 Int 03 Int 04...Int 20

Each interviewee who answered Part II Q 03 had a set of themes attached to them that formed the initial set of inductive /structural codes in MAXQDA 12.

The Descriptive analysis of Part I question 5, experience, showed an equal split between clinical and non-clinical interviewees. This became a key analytical point for comparing and contrasting the interview data. The picture below shows these two groupings in the upper left hand box labelled “sets”.

MAXQDA 12 Coding Example

The software preserved the original listing of the interviewees in order in the clinical and non-clinical interviewee sets. The example here shows interviewee 01, clinical. The highlighted code is Part II, Question three, poor information quality. The code “poor information quality” with the red tab is an example of the a priori groups based on the interview questions. The other codes shown below the red tab are the inductive/structural codes from the early themes and later codes added during the reading and re- reading of the interview responses. The highlighted text in blue is Int 01’s response to this question in the retrieved segments window on the right.

C:\Users\Liz\Documents\MAXQDA12\Backup\MAXQDA Dec 14 codes moved from later section .mx12 - MAXQDA 12 (Release 12.1.1)

Project Edit View Documents Codes Variables Analysis Mixed methods Visual tools Reports MAXdictio Help

Deductive Code from Literature\Q 1-3 IQ Glue\Q.03.Glue poor

Document System

- Sets 1338
 - experience=non clin-IT 578
 - Survey Data\RESP02 91
 - Survey Data\RESP03 51
 - Survey Data\RESP07 85
 - Survey Data\RESP08 66
 - Survey Data\RESP09 48
 - Survey Data\RESP10 47
 - Survey Data\RESP11 46
 - Survey Data\RESP12 84
 - Survey Data\RESP13 30
 - Survey Data\RESP15 30
 - experience=clin-nursing OR experience=clin-phy... 760
 - Survey Data\RESP01 117
 - Survey Data\RESP04 101
 - Survey Data\RESP05 77
 - Survey Data\RESP06 48
 - Survey Data\RESP14 72
 - Survey Data\RESP16 82

Document Browser: RESP01

..IQ term hybrid paper

15 But they might be here or they might be in paper or they might be in um, electronic and they might be in a different system so I was just basically said that the new process is that they need to be on the chart at this moment and now we have an informed clinician right, and that is all about the patient safety.

..IQ term timely

16 timeliness yes and it is making sure that the information is in the right hands at the right time

..poor mismatch

17 well poor information quality really is when you have either um, well if you have not the chart is not complete, right or if you have a situation where charts are mixed up

18 that is why at EMPI you have those ones go right up to a human being to make that decision, right

19 The investigator and you know what there is a much higher risk when you have a hybrid situation with your paper charts and the possible electronic charts and don't forget now when I say electronic ok, people survive they live on a continuum, so you will have an acute care clinical information system and you will have a community care and you may have an ambulatory clinic system as well and in each of those areas you are going to have a hybrid situation so there is going to be some paper and so what they are doing in the hospital and so forth is they are scanning it in. Those documents are they are not interactive at all they are just a pdf and they are just scanned in. And once they are scanned in then the process is to destroy the paper chart because now the scanned document becomes the original source, right. So there are some limitations and there are some good things with that because now you have the papers inside the electronic but the downside is that it is just an object right. And so you have to read all of these objects separately and try and piece it all together as opposed to the electronic system

..IQ term hybrid paper

20 Well it is, it is like a matrix you know and so where is the big risk there, the risk is that if I don't have the documentation standards I don't know where to look right and so there is a consult on some specialists and where is it. Did the clerk, where did the clerk put it.

..IQ term standardizer

21 so I am saying that documentation standards so what we have now is professional is we do have documentation standards but you own by our profession so how does it document to be timely and so forth. So we have had those forever but in the hybrid paper electronic world you need to be able to have a common understanding of how documents are put together and so it so there is that consult going on the paper chart or does it go on the electronic chart?

So I am a clinician and I am trying to make a decision on treatment for this client and if I don't know where to look I am not aware of this consultation even I was thinking that ok maybe the consultation hasn't note hasn't arrived yet because I don't see it in the chart so it probably caught in transcription somewhere but it could be on the chart so ok. so now this is where it gets interesting if the consultation is there then it is presumed that I as the clinician has access to that information and that I am making my decision based on all of the information. If in fact the you know the way that information is filed is um, not allowing me to efficiently and timely have timely access then, you know and I make the mistake and somebody health is compromised because of it.

Code System

- IQ term available 6
- IQ term complete 9
- IQ term reliable 5
- IQ term timely 14
- IQ term PHN identifier 18
- IQ term hybrid paper 22
- IQ term standardized 44
- IQ term accuracy 32
- IQ term privacy 8
- Q.02.Glue terms or example 4
- Q.03.Glue poor quality 18
 - poor alter change information 2
 - poor transcription 8
 - poor misdirection mis file merging 14
 - poor mismatch 3
 - poor no value 2
 - poor-opposite antonym 11
- Q.4-5 Setting 0
- Q.04.Setting acute care description 20

Retrieved Segments

- Survey Data
- RESP01
 - 17 - 17
- Deductive Code from Literat...
 - Q 1-3 IQ Glue
 - Q.03.Glue poor quality
 - experience: clin-nursing
 - sector: public & private
 - years experience: 21-30
 - work environment: private
 - IS routinely: not hands on

Simple Coding Query (OR combination of codes)

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Organizing the Quotes into Clinical and Non-Clinical Interviewees

MAXQDA 12 has a sort function. The comment bars in the MAXQDA 12 Quote Matrix table further sort the interview data for analysis such as removing potential identifiers, in this case, Enterprise Master Patient Index (EMPI), a provincial registry mentioned by interviewee 01 just below the first highlighted segment.

Quote Matrix

	experience=clin-pharmacist	experience=clin-nursing	experience=clin-physician	experience=non clin-IT
Q.03.Glue poor quality	well poor information quality really is when you have either um, well if you have not the chart is not complete, right or if you have a situation where charts are mixed up that is why at EMPI you have those ones go right up to a human being to make that decision, right. The investigator and you know what there is a much higher risk when you have a hybrid situation with your paper charts and the possible electronic charts and don't forget now when I say electronic ok, people survive they live on a continuum, so you will have an acute care clinical information system and you will have a community care and you may have an ambulatory clinic system as well and in each of those areas you are going to have a hybrid situation so there is going to be some paper and so what they are doing in the hospital and so forth is they are scanning it in. Those documents are they	Yeah, it's numbers or data that's inaccurate, that's not readily available, that's not usable, or not reflective of the patient's state. I'd say that. I think the opposite would be true. Survey Data\RESP16: 12 - 12 (0) I'm sure the list can be very very long on any given day. Sometimes it's as simple as the gender's wrong, right. Sometimes the information of how we're linking data with patient identity and so on, so sometimes the wrong information is attached to the wrong patient. Or the right information goes to the wrong patient. So we have lots of issues like that. e of our major projects we're doing right now, again around the e-safety part is standardized report distribution. So I've got lab reports and diagnostic imaging reports and	Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text but that is a lot of reading and people aren't going to read through it just free text like long documents and clinician will we typically only read one page so if it is, you know if you need to be concise and concise is right and in other words include the information for quality. The structured and <12-49??> when it comes to be codified and you can use it, and so it depends on the use of the information if you are doing it for analysis or if you are doing it for, if you are treating individuals or looking up populations, so if you are looking at data across multiple locations and you are doing any data mining you need to have information that is consistent and codified and structured. snowmed or ICD 10 or any good vocabulary that say you have	Commented [L49]: Commented [L39]: Commented [L40]: Commented [L50]:

Further Sorting

The clinical and non-clinical Part II question three quotes were moved to a word document with comments in the margin for other inductive/structural codes or general comments. This enabled tracing and using these other quotes as needed. MAXQDA 12 was also used using a lexicon search tool to find more examples of inductive/structural codes in the MAXQDA 12 interview data. After several iterations all of the quotes were sorted under different inductive/structural codes such as “mixed up”, “merging”, “standardized”. A code such as standardized would be highlighted with the comment, but the text would be moved to another word document for Part II Q 01 information quality standardized group that can be seen 3 lines above with 44 segments in the MAXQDA 12 coding example picture.

This is an example of how a priori groups based on the question did not preclude moving coded text segments to other inductive/structural code groups. The “Standardized” coding group became quite large; this group was further fractured into groups based on information or information system depending on what a given interviewee said.

The researcher worked between the word document and the MAXQDA 12 to update the software and the word document respectively to keep the coding current.

Clinical

Nursing

poor information quality really is when you have either um, well if you have not the chart is not complete ,right or if you have a situation where charts are mixed up resp [b1]

Commented [L2]: Charts mixed up mismatch

And it also extends into business practices and policies but the systems themselves or the technology or performance really is around for example for EMPI it is how do you merge or unmerge right. Resp [b1]

Commented [L3]: merging

forever but in the hybrid paper electronic world you need to be able to have a common understanding of how documents are put together and so it so there is that consult going on the paper chart or does it go on the electronic chart?So I am a clinician and I am trying to make a decision on treatment for this client and if I don't know where to look I am not aware of this consultation even I was thinking that ok maybe the consultation hasn't note hasn't arrived yet because I don't see it in the chart so it probably caught in transcription somewhere but it could be on the chart so ok, so now this is where it gets interesting if the consultation is t here then it is presumed that I as the clinician has access to that information and that I am making my decision based on all of the information resp [b1]

Commented [L4]: mixed up, can't find, don't know chart structure, records standards mitigate

well it seems that most of it is um, the merging of records of people that don't have the skill to manage or merge records. So they are not matching on sufficient data elements that um, they will accept let's say names going in any format so a name could actually have a number in it or it is good enough to use nicknames not identified as nicknames um, those kinds of things that would if we are talking about a client registry situation where um, you know you can end up with some different ways to identify the same a certain person resp [b4]

Commented [L5]: merge records a risk

Again, if there isn't a standard or distinct process that's applied and observed in collecting the data, I consider that poor data. Resp [b4]

Commented [L6]: no standardized collection ie same as emerge point of entry??

One of the things we try to do, so this is general [inaudible 00:16:51] to create a drop down, for example, that you could have that will allow you to pick only one. Or we have another type of drop down which will allow, what they call, "multi-select." We try to be very prescriptive, to say, "Okay, here's our drop down, would you ever pick more than one of these things?" If the answer is, "Yes," then we have to make it multi-select, right? Resp 17

Commented [L7]: Drop down does not make sense

Now, what we've found, looking at some of the reports, staff aren't really reading, or I don't even know what they're doing, but some of them are picking, "patient initiated, planned." From a quality perspective, that was really bad. Resp 17

You can't remove a choice from a list that's already been created in the database somebody may have charted that, and you have to keep what somebody may have charted to maintain the integrity of the chart resp 17

Commented [L8]: Drop down issue and legal record if change it

Right or whatever so it is not that it is happening obviously whoever entered that didn't know but so then so it doesn't seem reasonable to have to have everybody know that little piece of information, that is a privileged piece of information that you may know for whatever reason you know that others wouldn't know. Resp 05

Commented [L9]: Transcription data entry

Um, there is never there doesn't seem to be, as long as the person is entering the data is entering the right data the system doesn't make a mistake it is the person entering the data that makes the mistake. Resp 06

Commented [L10]: Transcription error do search on data entry

I think we need to be extremely cautious because that begins in the emergency department when the patient is entered in to the system and every single um, discipline within the system needs and uses that information. Resp 06

Commented [L11]: transcription

There is one thing that I want to stress is that the information is only as good as the person entering it. resp 06

Commented [L12]: transcription

Non clinical

Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text but that is a lot of reading and people aren't going to read through it just free text like long documents and clinician will we typically only read one page resp b2

Commented [L17]: unstructured data considered poor quality

poor quality I guess when we are talking about poor quality um, the frequency of we talked about how the errors rates maybe made in typing in data and that type of thing so the frequency with which that happens um, to me defines good quality versus poor quality resp b3

Commented [L18]: transcription data entry

I think one of the things that can result in poor quality information is um, is it manipulated? so whether that be you know by manual intervention or whether it be through some interface or integration where information is filtered in some way or um, you know altered in some way. Resp b7

Commented [L19]: can change data or not?

for us the clinical implications are that um, the document is in the registry um, and that it may be retrieved by someone looking for something else Or it may be the record that they are looking for but they may also get this record which might contradict that So maybe the question might be um, validity of the information, we don't want that because whenever and you probably know this u m, you know if you don't trust the information you can't use it resp b7

Commented [L20]: Contradictory information wont trust information

Poor would be put in whatever you want. Resp b8

Commented [L21]: Transcription data entry

When you lack that and you just say it's a five point scale without any criteria attached to them, well it's always a one or two if you're the ordering physician because you want to get it through faster. If you don't have criteria there, then that's very poor quality resp b8

Commented [L22]: No standards or criteria

Adding Interviewee Attributes or Variables

Once they were sorted the interviewee information was added to the final version: e.g. for interviewee one: Int 01 nurse 21-30 years' experience public & private as seen on the next page. Note that coding was still happening with ongoing reading of the interview data, for example, interviewee 02 interview comment on "free text" was moved from poor information quality to unstructured information in unstructured data free text word worksheet for that inductive/structural code..

Qualitative understanding:

Resp 01 nurse 21-30 years' experience public & private: well poor information quality really is when you have either um, well if you have not the chart is not complete ,right or if you have a situation where charts are mixed up [para. 17]

Commented [L51]: Also mismatch

Resp 04 nurse 21-30 years' experience public: well it seems that most of it is um, the merging of records of people that don't have the skill to manage or merge records. So they are not matching on sufficient data elements that um, they will accept let's say names going in any format so a name could actually have a number in it or it is good enough to use nicknames not identified as nicknames um, those kinds of things that would if we are talking about a client registry situation where um, you know you can end up with some different ways to identify the same a certain person [para. 6]

Commented [L52]: Merging identifier

Resp 05 nurse 21-30 years' experience health authority: I would guess it would just be the opposite of all those things really um, just disorganized and hard to follow ya um, I think poor information quality [para. 5]

Commented [L53]: Example of opposite

Resp 14 nurse 21-30 years' experience health authority: It'd most likely be opposite. Again, if there isn't a standard or distinct process that's applied and observed in collecting the data, I consider that poor data [para. 7]

Commented [L54]: Data collection important

Resp 16 physician 10-20 years' experience health authority: Yeah, it's numbers or data that's inaccurate, that's not readily available, that's not usable, or not reflective of the patient's state. I'd say that. I think the opposite would be true [para. 12]

Resp 02 non clinical 21-30 years' experience public & private: Inaccurate, unreliable, if it is unstructured too, not very useful but a lot of textual information, clinicians like to have free-text but that is a lot of reading and people aren't going to read through it para. 6]

Commented [L56]: Free text

Resp 03 non clinical < 10 years' experience public: poor quality I guess when we are talking about poor quality um, the frequency of we talked about how the errors rates maybe made in typing in data and that type of thing so the frequency with which that happens um, to me defines good quality versus poor quality [para. 7]

Commented [L57]: Free text transcription

Resp 07 non clinical 10-20 years' experience ministry: I think one of the things that can result in poor quality information is um, is it manipulated? so whether that be you know by manual intervention or whether it be through some interface or integration where information is filtered in some way or um, you know altered in some way [para. 7-8].

Resp 08 non clinical 10-20 years' experience ministry Poor would be put in whatever you want. In the last four years, we've come up with in consultations with the radiologist, through the Medical Imaging Advisory Committee and the BCRS, a prioritization scheme for CT and MR. When you lack that and you just say it's a five point scale without any criteria attached to them, well it's always a one or two if you're the ordering physician because you want to get it through

The responses in this final format were further organized into the triad of user, information and information system as seen in the Chapter Five analysis.

Appendix H: Evaluating the SEIPS Model/Framework

Frameworks: an Incremental Approach

This research will use a broad interpretation of theory to include “conjectures, models, frameworks, or body of knowledge”, that is, a practical theory or framework so “knowledge” accumulates “in a systematic manner” (Gregor, 2006 p. 613, 614). Avison and Malaurent note that even if a new theory does not emerge from the research, the research can still “contribute” to research and practice (2014 p. 330). Walsh notes that Grounded Theory theorizing has two forms: “incremental theorizing, that is, theorizing while using existing concepts/constructs or rupture theorizing, that is, theorizing while using new concepts/constructs” (2015 p. 533). This research will use incremental theorizing as a way of organizing the results in an “iterative process”: this is also one of the uses of theory in interpretive studies such as this research (Walsham, 1995 p. 76).

We saw earlier in Chapter Four, 4.3.7 (Analysis Next steps), that Gregor described five types of theory, the most basic of which is a theory for analysing (Type 1) (Gregor, 2006, p. 622, 623, 624). This theory has the following characteristics and uses:

- Analytic theory (Type 1) “analyze "what is" as opposed to explaining causality or attempting predictive generalizations”: it forms the basis for the other theories
- Analytic theory (Type 1) “describe or classify specific dimensions or characteristics of individuals, groups., situations, or events by summarizing the commonalities found in discrete observations”
- Analytic theory (Type 1) can be used in Grounded Theory where the “Grounded Theory method gives rise to a description of categories of interest”
- Analytic theory (Type 1) enables revising “a previous classification system could be revised as new entities come to light, or some preferable way of grouping or naming categories is identified”

The Chapter Five research results describe the current state “what is” in the Canadian context of information quality based on the categories of information (unstructured vs structured), information system (paper/hybrid vs electronic system), and the people (patients and users) in an acute care setting. Information, information systems and people are the main categories of interest with the characteristics fleshed out in the Chapter Five results and themes. We will see that these categories fit with the Type 1 analytic theory within the SEIPS Model framework.

The following table, Table 26, places the SEIPS Model in the Gregor structural characteristics of a Type 1 analytic theory.

Table 26: Structural Components of Theory and the SEIPS Model

Structural Components of Type 1 Analytic Theory	
Theory Component (Components Common to All Theory)	Definition as applied to Analytic Theory (Type 1)
Means of representation	The theory must be represented physically in some way: in words, mathematical terms, symbolic logic, diagrams, tables or graphically. Additional aids for representation could include pictures, models, or prototype systems. <u>SEIPS Model</u> : words, diagrams represent the theory
Constructs	These refer to the phenomena of interest in the theory (Dubin's "units"). All of the primary constructs in the theory should be well defined. Many different types of constructs are possible: for example, observational (real) terms, theoretical (nominal) terms and collective terms.* <u>SEIPS Model</u> : developed from Donabian’s Structure Process Outcome and the DeLone and MacLean models
Statements of relationship	These show relationships among the constructs. Again, these may be of many types: associative, compositional, unidirectional, bidirectional, conditional, or causal. The nature of the relationship specified depends on the purpose of the theory. Very simple relationships can be specified: for example, "x is a member of class A." <u>SEIPS Model</u> : bidirectional flows within an external environment. Bidirectional flows between the following: person, task, technology and tools, organization, physician environment and a

	unidirectional flow from the external environment to care process and patient outcomes
Scope	The scope is specified by the degree of generality of the statements of relationships (signified by modal qualifiers such as "some," "many," "all," and "never") and statements of boundaries showing the limits of generalizations. <u>SEIPS Model</u> : healthcare work systems and processes
Causal explanations	None
Testable propositions	None
Prescriptive statements	None

Note: from: Gregor (2006), Table 3.

*Note: Dubin (1978) defines a real unit as one for which an empirical indicator can be found, and a nominal unit as one for which an empirical indicator cannot be found. Collective units are a class or set of units while member units are the members of the class or set. Further distinctions are made between enumerative, associative, relational, statistical, and complex units (Gregor 2006 p. 620).

Applying the SEIPS Model

Now that we have identified the theory structure of the SEIPS Model as a Type 1 analytic theory, that is, a model or framework, we need to see how well it can be applied to our research setting by using Lee and Baskerville's (2012 p. 749) criteria about "generalizing a theory to a new setting", although they do not define what a theory is, they use the technology acceptance model⁸² as an example.

Lee and Baskerville (2012 p. 749, 751, 752) call these criteria the "four judgment calls". The four judgement calls are listed in Table 27 below in the left hand column. The SEIPS Model was matched to each judgment call criterion. Once the SEIPS Model has been mapped to each judgment call criterion then the Chapter Five criteria were mapped to the SEIPS Model to see how closely they match. If Chapter Five maps closely to the SEIPS Model then we can say that SEIPS Model is a useful tool for organizing and discussing the Chapter Five findings further as noted in the right hand column. The criteria can be "similar conditions" for a close match to the criterion, "sufficiently similar" or "partial" for a less close match. "Gaps" label no match. Table 27⁸³ presents this as a table.

Table 27: Lee & Baskerville Four Judgment Calls

Lee & Baskerville Criteria for applying Theory in New Setting (Applying Chapter Five Findings to existing SEIPS Model [from Lee & Baskerville, 2012]			
Lee & Baskerville Criteria: Four Judgment Calls	SEIPS Model Criteria mapped to each Judgment Call	This Research (Chapter Five) mapped to SEIPS and Judgment Call	Comment: assessing match of Lee & Baskerville criteria to SEIPS Model and Findings
1. "uniformity of nature": the principle that the <i>future will resemble the past</i> , in that when sufficiently similar situations recur, similar effects follow.	1. Sources: Salahuddin & Ismail, (2015) Data from 2002 to 2014 Carayon et al., 2014 Holden et al. 2013 list SEIPS Model projects	2015	12 years of research used to refine the SEIPS Model is <i>sufficiently similar</i> for SEIPS Model. Research is only one year but similar time period to SEIPS Sources

⁸² For more information on the technology acceptance models please see this link: http://is.theorizeit.org/wiki/Main_Page

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<p>2. "sufficient similarity in relevant conditions": <i>the setting which is being generalized from, and the setting which is being generalized to, are indeed sufficiently similar.</i></p>	<p>See rows below From: Salahuddin & Ismail, (2015)</p>		
	<p>2. CPOE (44%) being most common. Other popular health IT that were evaluated in the studies were EHR/EMR (27%), and e-prescribing (14%).</p>	<p>CPOE, EHR, and e-prescribing</p>	<p><i>Similar condition to SEIPS Model for setting in Chapter Five</i></p>
	<p>3. 60% of the studies reported health IT safety usage concern in US. However, slightly over a quarter (27%) of the reported studies were conducted in Europe, while a very few (7%) of the studies conducted in Australia.</p>	<p>Canada</p>	<p>Predominately US but also Australia and Europe, ie western health care <i>Similar conditions to SEIPS Model for jurisdiction in Chapter Five</i></p>
	<p>4. The most frequent settings were found to be hospitals which records nearly three-quarters (74%) of the health care context.</p>	<p>Acute care (hospitals)</p>	<p><i>Similar conditions to SEIPS Model for acute care hospital setting in Chapter Five</i></p>
	<p>5. Majority of the health IT safety issues took place in large healthcare settings such as hospital</p>	<p>Acute care (hospitals)</p>	<p><i>Similar conditions to SEIPS Model for acute care hospital setting in Chapter Five</i></p>
	<p>6. Clinicians included doctors, nurses, and pharmacists were found to be the dominant group of research participants. Slightly over a third (38%) of the studies reported the involvement of clinicians while slightly less than a quarter (22%) involved combination of clinicians and non-clinicians such as health IT vendors,</p>	<p>Doctors, nurses and pharmacist and non-clinicians 50:50</p>	<p>This research had a higher proportion of non-clinicians. The clinical component is a <i>similar condition to SEIPS Model</i> while the non-clinical component could be considered <i>sufficiently similar to SEIPS Model</i></p>

	administrators, IT staff, and technicians.		
3. "successful identification of <i>relevant variables</i> ": theory, as already empirically tested and confirmed in an empirical setting, indeed specifies all of the variables that have any influence in shaping the phenomenon of interest	Health IT safety use antecedents can be classified into five categories based on the SEIPS model. The categories are; (1) person, (2) technology, (3) tasks, (4) organization, and (5) environment.		
	7. Person: competency practitioner Holden et al. 2013 mention patient	Practitioner and patient	<i>Similar conditions to SEIPS Model</i>
	Technology: see rows below		
	8. System quality (usability, compatibility, response time, reliability)	Usability (display interface) Compatibility (tasks and system) Fast access Reliability	<i>Similar conditions to SEIPS Model</i>
	9. Information quality (completeness, relevancy, timeliness)	Completeness Relevancy (alerts, overload, missing information)	<i>Similar conditions to SEIPS Model for model adoption but Salahuddin & Ismail (2015) quality terms too restrictive</i>
	10. Service quality: (tangibles, responsiveness, assurance)	Not discussed	<i>Gap compared to SEIPS Model</i>
	11. Environment: layout, noise	Not discussed	<i>Gap compared to SEIPS Model</i>
	12. Organization: teamwork, training, organization resources.	Staff shortage, procedure and policy Teamwork and training not discussed	<i>Partial conditions to SEIPS Model because interviewees were not asked about or mention teamwork and training</i>
	13. Task: interruptions, cognitive load, time pressure, workload	Cognitive load Staff shortage could be time	<i>Sufficiently similar to SEIPS Model</i>

		pressure and workload	
4. "theory is true": no theory may ever be conclusively proved true or positively stated to be true, even if it has survived innumerable prior empirical tests in whatever variety of settings.	14. Must assume this		Must assume this

Table 27 has fourteen testable criteria (column two row six has two parts); this research has similar conditions to eight SEIPS Model criteria, three sufficiency similar conditions, one partial, and two gaps. Information does not fit well into the SEIPS Model as highlighted in the grey box; this meant it needed further work and analysis was presented in the section on information, 6.2.10.

We can safely assume that the SEIPS Model can be used to structure the overall discussion because the findings met eleven of fourteen Lee and Baskerville criteria.