Information Quality in Secondary Use of EHR Data

A Case Study of Quality Management in a Norwegian Hospital

Geir Inge Hausvik

UiA University of Agder

Doctoral Dissertations at the University of Agder 245

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Abstract

The motivation for undertaking this study relates to my experiences from practice in a public hospital, where I have observed variations in reaching organizational goals of quality management informed by electronic health records (EHR) data. For example, while some departments and units have long-time traditions in meeting the quality goals that are set locally, regionally, or nationally, other departments and units struggle to meet the same quality goals. Thus, generating actionable information by reusing routinely collected EHR data does not necessary lead to action in response to the information. This process of generating information from existing EHR data, and communicating and using such information for organizational purposes, may be challenging in a highly complex environment such as health care organizations. Within this process, information quality (IQ) may influence actors' perceptions of action possibilities the information offers, thus influencing the actual use of the information required to reach organizational goals.

EHR data can be used for clinical purposes at the point-of-care (i.e., primary use) and reused for purposes that do not involve patient treatment directly (i.e., secondary use). Examples of such secondary use includes quality management, research, and policy development. Though it is widely accepted that IQ influences the use of EHR systems and the information generated by EHR systems, research on the implications of IQ on health care processes is limited: the focus of the current literature is concerned with defining and assessing IQ in primary use of EHR data, whereas the role of IQ in secondary use of EHR data remains unclear. Thus, this dissertation investigates the role of IQ in secondary use of EHR data in an organizational context.

This dissertation addresses this practical and theoretical challenge by focusing on the overall research objective of understanding the role of IQ in secondary use of EHR data. To address this research objective, this dissertation explores the following research questions:

RQ1. How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data?

RQ2. What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data?

These research questions were addressed through a qualitative case study of secondary use of EHR data in a Norwegian hospital context. In total, 32 informants from various organizational levels were interviewed to gain deep insights into this phenomenon. The data were analyzed using a critical realist methodology, applying the theory of affordances and the concept of mediators as theoretical lenses.

The main findings of this study were the underlying mechanisms of the secondary use of EHR data, where IQ transforms within a life cycle through the processes of information generation, communication, and use within an organization. In the information generation process, the main goal of the actors was to produce an actionable information artifact for decision-making at managerial levels and enactment at the operational level. To achieve this goal, the actors actualized various action possibilities of multiple information systems (IS; including the EHR system). The quality of the information outcome of the process was influenced by several factors and conditions of the actions performed in the three subprocesses: data extraction, organization, and presentation. In the information use process, the actors' perceptions of the IQ influenced the actual use of the information. Thus, IQ influenced whether action possibilities of the information were perceived. For example, for information users to be able to perceive the action possibilities, the information needed to be specified at the correct organizational level (i.e., granularity) in an understandable manner (i.e., understandability). Perceiving the action possibilities of the information was, however, insufficient for information users to commit to an action in response to the information. Information users also needed to perceive the information as relevant, urgent, and useful for their daily work. Information users' perceptions of IQ, including relevancy, urgency, and usefulness, were found to be influenced by how the information was communicated.

This dissertation contributes to the IQ research, the theory of affordances, and to practice. The contributions to IQ research include extensions of the life-cycle view of IQ and the theory of affordances in the context of secondary use of EHR data. The main contribution to the life-cycle view of IQ is the integration of communication. Since secondary use of EHR data relies heavily on interpersonal communication, this dissertation shows how communication influences users' perceptions of IQ. To the theory of affordances, this study provides a deeper understanding of affordances and the actualization process of affordances: the theory is extended by (1) distinguishing

between affordances of IS and affordances of the information artifact; (2) describing how affordances are interconnected; (3) describing the role of IQ in perceptions of affordances; and (4) separating the factors making affordances perceivable and available for users in a given context from the factors influencing actors in actualizing the affordance, thus influencing the outcome the actualization process.

The practical contributions of this study highlight how organizations can improve the processes of information generation and communication through understanding information users' perceptions of IQ. By focusing on important IQ dimensions, users may be able to perceive the intended action potentials of the information, a prerequisite for realizing the action in response to the information. Furthermore, by identifying the underlying mechanisms of the IQ life cycle, this study provides insights into the factors making the action possibilities available for information users' and the factors influencing actors to realize the action possibilities. Such factors can be managed by organizations to improve the process of secondary use of EHR data in achieving organizational goals.

Based on the findings, this study presents the following six areas for future research: (1) investigating the phenomenon by applying theories other than the theory of affordances; (2) validating the identified mechanisms; (3) extending the research on how interpersonal communication influences IQ; (4) validating the usefulness of the life-cycle view, particularly by discriminating the life-cycle view from the manufacturing view; (5) validating the proposed definition of IQ in other contexts; and (6) validating the contributions offered to the theory of affordances.

List of Abbreviations

Abbreviation	Full form
BSC	Balanced Scorecard
CQ	Communication Quality
DIQ	Data and Information Quality
DQ	Data Quality
EHR	Electronic Health Records System
ICD	International Classification of Diseases
IQ	Information Quality
IS	Information Systems
ISO	International Organization for Standardization
IT	Information Technology
OIPT	Organizational Information Processing Theory
SHT	Sørlandet Hospital Trust
UiA	University of Agder

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> The challenge is to discern good quality information from the less-reliable quality information. Unfortunately, you kind of need a Ph.D. to do that.
>
> *Margaret O'Kane, President of the US National Committee for Quality Assurance (Webb, 2010, p. 7)*

1 Introduction

Electronic health record (EHR) systems capture patient-level clinical and administrative data that are collected by clinicians and administrative personnel. Clinical data includes documentation of clinical services delivered to patients, clinical findings, patient history, clinical orders, allergy details, and laboratory results (Ward, Marsolo, & Froehle, 2014), while administrative data includes demographic, socioeconomic, financial, and logistics data (Davis & LaCour, 2014; Jensen, Jensen, & Brunak, 2012). The use of EHR data can be broadly categorized into primary and secondary use (Mann & Williams, 2003). Primary use of EHR data concerns data that support patient care directly (Cabitza & Locoro, 2017) by aiding clinicians in clinical decision-making at the point-of-care, whereas secondary use is the reuse of EHR data outside of direct health care delivery (Safran et al., 2007). Examples of secondary use include service planning, resource allocation, performance monitoring, clinical auditing, and quality management (Cabitza & Locoro, 2017; Hripcsak et al., 2014; Mann & Williams, 2003).

By leveraging EHR data to understand clinical and operational processes, secondary use of EHR data holds promises to help actors reach their organizational goals (Jeffs, Nincic, White, Hayes, & Lo, 2015). For example, secondary use of EHR data can help actors make appropriate changes to improve clinical and operational outcomes (Gallagher & Rowell, 2003). However, transforming routinely collected EHR data into management information alone is not sufficient to achieve actors' engagement in reaching organizational goals (Jeffs et al., 2015). Current research states that insufficient information quality (IQ) of EHR data is one of the major sources limiting the potential organizational impact of secondary use of the EHR data (Byrd et al., 2013; Perimal-Lewis, Teubner, Hakendorf, & Horwood, 2015; Prybutok & Spink, 1999). In an EHR system context, IQ is referred to as information that is appropriate for health care interventions and processes, encompassing human, social, and technological elements of the context, where information is generated, communicated, and used (Cabitza & Batini, 2016).

This dissertation focuses on IQ in the secondary use of EHR data for organizational management. The motivation for this study is based on my experiences from working for more than 18 years in the administration of a Norwegian public

hospital. Through tasks such as EHR systems administration, analysis, and reporting (internally and externally) of EHR data, I have first-handedly experienced challenges in the process of secondary use of EHR data. Such challenges relate to generating, communicating, and applying the information based on EHR data: sometimes, actionable information that is generated based on EHR data is not enacted by actors as intended, thus leading to a failure to achieve the organizational goals. Through a publicly funded Ph.D. scholarship (public organization–university collaboration), I was able to investigate this practical phenomenon in depth by analyzing qualitative data collected from my organization.

By conducting a literature review, I discovered that this was not only a practical problem but also a gap in the existing body of knowledge. Research on IQ in health care contexts has focused predominantly on the primary use of EHR data (Cabitza & Batini, 2016). Such research is often done from a technological viewpoint (Mettler, Rohner, & Baacke, 2008; Mohammed & Yusof, 2013) and includes how IQ issues may lead to adverse events (Mettler et al., 2008), such as medical errors (Pipino & Lee, 2011; Welzer, Brumen, Golob, Sanchez, & Družovec, 2005). While some research on IQ in secondary use of EHR data exists, it is limited to quality challenges when structured EHR data (Vuokko, Mäkelä-Bengs, Hyppönen, & Doupi, 2015) is aggregated at regional or national levels (Cabitza & Batini, 2016), for example, in clinical research (e.g., Weiskopf & Weng, 2013) and health care policy planning (Häyrinen, Saranto, & Nykänen, 2008). Only a handful research articles address how IQ impacts organizations in the secondary use of EHR data (Vuokko et al., 2015); nevertheless, studies have shown that high-quality information is critical for effective and efficient management of health care systems (Richards & White, 2013) in terms of economic costs, organizational planning, and quality and safety of care (Liaw et al., 2013a).

In the conventional view of IQ, information is often treated as a product, where raw data are manufactured into information products (artifacts) by the technology. In this view, information is the product of a well-defined information production process (Lee, Pipino, Funk, & Wang, 2006; Wang, Lee, Pipino, & Strong, 1998). This view of information is particularly challenging in the secondary use of EHR data for several reasons. First, unlike the manufacturing view, the process of

obtaining value from EHR data is not well-defined, but is rather characterized as ad hoc, with no standards in terms of empirical measures of core processes and a lack of understanding of information needs (Botsis, Hartvigsen, & Weng, 2010; Foshay & Kuziemsky, 2014). Thus, treating information processing as a standardized manufacturing process provides a static view without addressing the dynamics of the process.

Second, the information manufacturing view assumes that quality is achieved when the information is "meeting or exceeding consumer expectations" (Kahn, Strong, & Wang, 2002, p. 185). However, quality is often described as a relational concept where there may be multiple actors passing different judgments on the quality (Lillrank, 2003), thus leading to a paradox between quality and time; defining quality as meeting or exceeding consumer expectations assumes that the consumers, including their quality requirements, are identified ex ante information generation (Lillrank, 2003). In reality, however, information is often the subject of interpersonal communication within health care organizations (Avison & Young, 2007; Rogers & Agarwala-Rogers, 1976), where the actual use of information often resides outside of the information producer's control (Mettler et al., 2008).

Third, since the output information of the information generation process (information artifact) is the subject of interpersonal communication (Avison & Young, 2007; Mettler et al., 2008), viewing information as a technological service provided by the EHR system is insufficient. Thus, to achieve appropriate actions in response to the information artifact, both the information artifact and the communication process need to be perceived as value-adding from a consumer's perspective (Alenezi, Tarhini, & Sharma, 2015).

Fourth, the manufacturing view of information treats the output information as a fixed artifact. However, transforming and filtering the information artifacts is likely to happen in the process of interpersonal communication (Rogers & Agarwala-Rogers, 1976), thus modifying the information artifact. Hence, we need to take a more balanced view of IQ (Mettler et al., 2008; Neely & Cook, 2011) to understand not only how data transforms in the information generation process but also how IQ evolves through communication processes and information use processes, including the interplay of technical and social processes involved.

This dissertation aims at understanding the role of IQ in secondary use of EHR data. To capture both the social and the technical aspects of this phenomenon, I have applied the theory of affordances as a theoretical lens. This theory provides an understanding of how the relation between human capabilities and technological features creates action possibilities that, through human agency, may lead to desired organizational outcomes (Pozzi, Pigni, & Vitari, 2014). The theory of affordances has previously been applied in an EHR system context (e.g., Strong et al., 2014), but not as a lens of understanding IQ. Thus, through this theoretical lens I will be able to understand how the relationship between organizational actors and artifacts may lead to action possibilities in the processes of information generation, communication, and the use of EHR data for organizational purposes, such as quality management. The following section presents the research questions addressed in this dissertation.

1.1 Problem Statement

Since research on secondary use of EHR data still is in its early stage (Botsis et al., 2010) and existing research on IQ focuses primarily on the primary use of EHR data (Cabitza & Batini, 2016), the overall research objective of this dissertation is to understand the role of IQ in secondary use of EHR data. For this purpose, I have formulated the following research questions.

RQ1. How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data?

The aim of this research question is to understand how IQ changes throughout the process of secondary use of EHR data, which includes the information generation process, communication process, and the use process, where information users' intentions of using the information is influenced by their perceptions of IQ. To answer this research question, this research needs to account for (1) the dynamics of the process and the ad hoc nature of obtaining value from EHR data (Botsis et al., 2010; Foshay & Kuziemsky, 2014); (2) the paradox between quality and time, where information needs are not always identified ex ante (Lillrank, 2003); and (3) the interpersonal communication of information and modification of information

in the secondary use of EHR data (Avison & Young, 2007; Rogers & Agarwala-Rogers, 1976).

The first research question aims to understand how IQ evolves by focusing on various actors throughout the process of secondary use of EHR data and their perceptions of IQ. To gain a deeper understanding, the second research question aims to uncover the sociotechnical interplay underpinning the process of secondary use of EHR data. Thus, the second research question in this study is as follows:

RQ2. What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data?

The aim of this research question is to identify the underlying mechanisms that explain how IQ keeps changing within the life cycle of the secondary use of EHR data. This research question is a response to the fact that IQ research is often performed from a technological viewpoint (Mettler et al., 2008; Mohammed & Yusof, 2013), and to the call for more sociotechnical balance in IQ research (Mettler et al., 2008; Neely & Cook, 2011). This research question involves identifying the action possibilities (i.e., affordances) arising through the relation between technological features and abilities of the goal-oriented actors, and examines the factors influencing the actors in realizing such action possibilities. Figure 1-1 illustrates the research framework for this study.

Since the agenda of this dissertation is both explorative and explanatory in nature, where the purpose is to uncover the underlying mechanisms of a highly sociotechnical phenomenon, I have applied a critical realist case study (Wynn & Williams, 2012). The primary data were collected through semi-structured interviews, and additional data included observation data, meeting minutes, audit and performance reports, and examples of balanced scorecards (BSCs) from the focal organization. Thirty-two interviewees, representing various organizational levels, were recruited using respondent-driven (snowball) sampling (Berg, 2009).

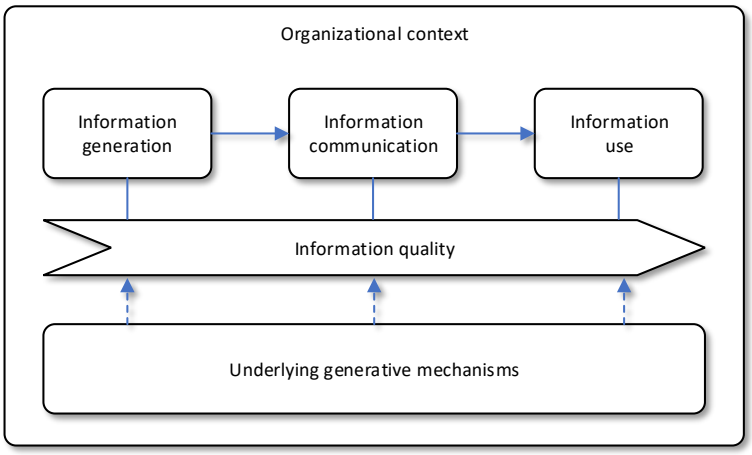


Figure 1-1: Research framework for exploring IQ in secondary use of EHR data.

The following section presents a brief summary of the contributions offered in this dissertation.

1.2 Summary of Contributions

This dissertation offers main contributions to three major areas: (1) IQ research (2) the theory of affordances; and (3) practice. Table 1-1 summarizes the contributions.

Table 1-1: *Summary of Contributions*

Contrib. to	Contribution	Brief description
IQ research	IQ as a life cycle	To understand IQ, we need to take a life-cycle view and follow the information from generation to application.
	Interpersonal communication	A user's perception of IQ is influenced by interpersonal communication. Since push strategies of information are also evident in primary use, this dissertation offers insights into how communication affects IQ.
	Modifications of the information artifact	Information, including its IQ, is actively modified through interpersonal communication.
	The role of human actors	Human actors produce the information in secondary use. Information mediators can transport, transform, and/or translate the information to users, thus influencing the action taken in response to the information.

Table 1-1 continued

Contrib. to	Contribution	Brief description
IQ research	Understanding IQ through the affordance lens	Information based on secondary use of EHR data can provide information users with action potential. Thus, IQ must be understood in terms of properties of the information and the conversion factors facilitating and/or constraining users' perceptions of its relevance, urgency, and usefulness.
	Identifying the underlying mechanisms	This study proposes four generative mechanisms: information generation mechanism, information communication mechanism, decision-making mechanism, and accountability mechanism.
	Action potential of information	The dissertation provides an alternative definition of what constitutes acceptable IQ as perceived by information users by drawing on information as potential for action.
	Shift of research focus	This research suggests changing the research focus on IQ from primary use to include secondary use of data in both general IQ research and in EHR systems research.
Theory of affordances	Affordances of multiple IS	The study provides empirical evidence for affordances of multiple IS within a process.
	Facilitating conditions and conversion factors	The study conceptualizes and distinguishes between facilitating conditions for affordances to be available for actualization, and conversion factors affecting the actualization and its outcome.
	Interdependencies of affordances	Affordances were observed to be interdependent, where the outcome of actualizing one affordance served as facilitating condition for the subsequent affordance.
	Distinguishing between IS and information affordances	IS affordances were found to be action possibilities between the IS and actors, whereas information affordances were action possibilities between actors and the outcome information artifact.
	Relation between affordances and mechanisms	The study contributes by offering a clear distinction between generative mechanisms and affordances.
Practice	Contributions and recommendations	The dissertation offers several contributions to practice, including nine managerial recommendations.

1.3 Structure of the Dissertation

This dissertation is structured in four main parts: research foundations, research findings, research contributions, and reflections. Figure 1-2 illustrates the structure.

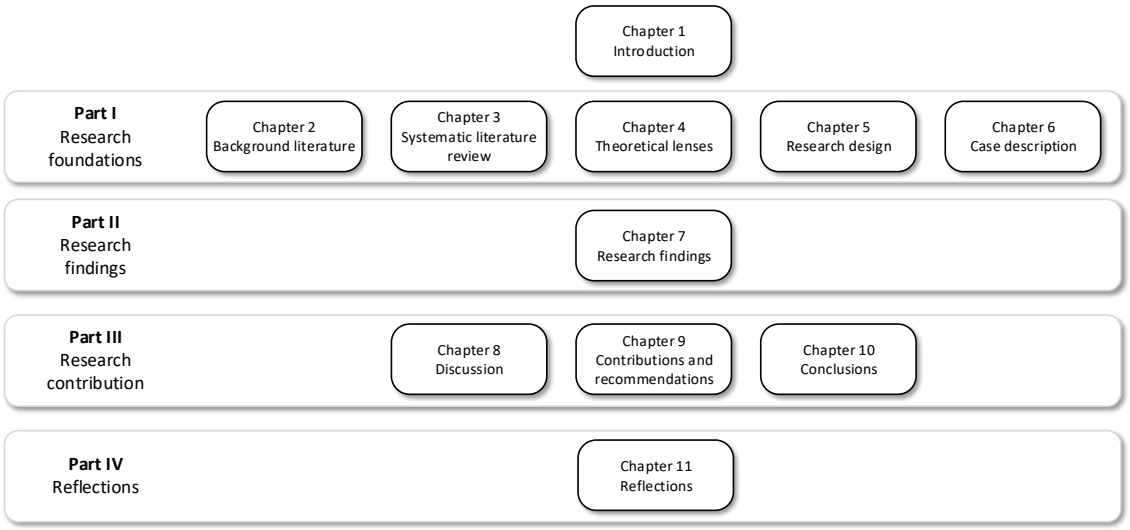


Figure 1-2: Dissertation structure.

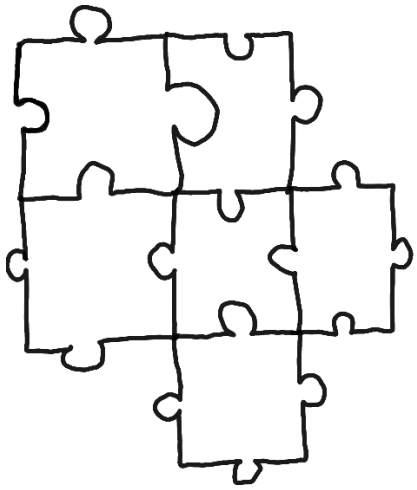
Part I, comprising Chapters 2–6, introduces the foundations of the study, including the background literature. Chapter 2 summarizes concepts such as EHR systems and IQ. Chapter 3 presents the two-staged literature review. Chapter 4 introduces the theory of affordances and the concepts of mediators as theoretical underpinnings of the analysis. Chapter 5 presents the research design, including the philosophical worldview, strategy of inquiry, and research method, and Chapter 6 presents the case.

Part II comprises Chapter 7, which presents the research findings of this study.

Part III presents the contributions of this dissertation. Chapter 8 discusses the findings against existing literature, and Chapter 9 addresses the theoretical contributions, practical contributions, and managerial recommendations. In Chapter 10, the conclusions are drawn, followed by the limitations of this study and potential avenues for future research.

Finally, in Part IV, comprising Chapter 11, I provide some personal reflections of the research process, theories and concepts, and philosophical considerations.

Part I
Research Foundations



2 Background Literature

As described in Section 1.1, this dissertation focuses on IQ related to secondary use of EHR data. This chapter provides detailed descriptions of relevant background literature, including research on EHR systems, on the concept of IQ, and IQ related to secondary use of EHR data.

2.1 EHR Systems

The structure and contents of EHR systems have varied over time (Häyrinen et al., 2008), and homegrown systems from academia and medical centers can be traced back to the late 1960s when data entry moved from punch cards to keyboards, and the displaying of data moved from printed format to computer screens (Tripathi, 2012). Through rapid technological progress in the 1990s, such as increased computing power and lower costs of computing resources, EHR systems became commercialized and increasingly more advanced and available (Tripathi, 2012). Though national differences, adoption of EHR systems in industrialized countries has increased substantially in the recent years. For example, the adoption rate of EHR systems in U.S. hospitals in 2016 was close to 96 % (Kanakubo & Kharrazi, 2019). EHR systems has been viewed as technology that have the potential to transform health care organizations from relying on paper-based information handling, to having information available instantly, anywhere at any times (Menachemi & Collum, 2011). Thus, EHR systems have an important role in health care organizations to achieve potential benefits, such as "clinical outcomes, (e.g., improved quality, reduced medical errors), organizational outcomes (e.g., financial and operational benefits), and societal outcomes (e.g., improved ability to conduct research, improved population health, reduced costs)" (Menachemi & Collum, 2011, p. 47).

The following subsections define the current EHR systems and describe their contents, functionalities, and uses.

2.1.1 Definition of EHR Systems

EHR systems have been defined and used differently in various health care contexts (Greenhalgh, Potts, Wong, Bark, & Swinglehurst, 2009). Table 2-1

presents an overview of various technologies used in a health care context that fall under the overall umbrella definition of EHR systems.

Table 2-1: *Overview of Various EHR Systems, Adapted from ISO (2005)*

Abbreviation	Full name	Brief description
EMR	Electronic medical record	Medically focused EHR systems. Term widely used in North America and Japan.
EPR	Electronic patient record	Institution-specific EHR systems mainly used in acute hospitals or specialist units. Term originates from the UK.
CPR	Computerized patient record	Term synonymous with EHR. Originates from the US.
EHCR	Electronic health care record	Term synonymous with EHR. Originates from Europe.
ECR	Electronic client record	Special case of EHR systems where the scope is defined by non-medical professionals utilizing the system within their health discipline (e.g., chiropractors and physiotherapists).
DMR	Digital medical record	Web-based record that can offer the functionality of the EHR system.
CDR	Clinical data repository	Service-centric EHR system, rather than patient centric. Term originates from Canada.
CMR	Computerized medical record	EHR systems of scanned images and digitized paper-based records.

Following Häyrinen et al. (2008), this dissertation uses the definition of EHR systems adopted from the International Organization for Standardization (ISO, 2005):

> A repository of patient data in digital form, stored and exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose is to support

> continuing, efficient and quality integrated healthcare. (Häyrinen et al., 2008, p. 293)

This broad definition includes the systems presented in Table 2-1 into the definition of EHR systems.

2.1.2 Content of EHR Systems

EHR systems typically capture patient-level clinical and administrative health data. Clinical health data include documentation of clinical services delivered to patients, clinical findings, patient history (e.g., family, social, surgical, and medical history), clinical orders, allergies and immunizations, and laboratory results (Ward et al., 2014). Administrative health data include demographic data (e.g., name, address, birth date), socioeconomic data (e.g., marital status, religion, ethnicity), financial data (e.g., for reimbursement), and logistics data (Davis & LaCour, 2014; Jensen et al., 2012).

EHR data generally falls into three categories: structured, unstructured, and semi-structured data (Raghupathi & Raghupathi, 2014). Structured, or discrete data (Marsolo & Spooner, 2013), can be numerical data and/or data entered into discrete data fields by selecting predefined codes. Predefined codes can be classified locally, regionally, nationally, and internationally. For example, International Classification of Diseases (ICD) is one such international classification. Structured data (e.g., clinical codes, demographics data, and administrative data) are collected by clinicians, clinical assistants, and administrative personnel by entering data into structured data fields in the EHR user interface (Davis & LaCour, 2014). Unstructured, or free-text (Marsolo & Spooner, 2013) data, includes clinical narratives describing the reasonings for patient treatment (Jensen et al., 2012). Examples of such unstructured data include hospital admission documents, discharge documents, and clinical notes (Raghupathi & Raghupathi, 2014). Unstructured data (e.g., clinical notes) are typically entered by clinicians (or clinical assistants by transcribing audio recordings of clinicians) into electronic documents. Such notes typically take the form of free text, where the documentation may be guided by predefined templates (Davis & LaCour, 2014).

2.1.3 Uses of EHR Systems and EHR Data

Practice and academia have both urged for the "meaningful use" of EHR systems, meaning the transmission of information between relevant actors, using information for decision support, and generating information that is important to patients, health care practices, and for public health (DesRoches et al., 2010, p. 639). However, scopes and functionalities of EHR systems may vary substantially between vendors, and are often distinguished between "basic" and "comprehensive" EHR systems (e.g., DesRoches et al., 2010, p. 640), or between "core" and "extended" EHR systems (ISO, 2005, p. 14). Such differences refer to the variations in functionality that vendors have bundled into the EHR systems (Mandl & Kohane, 2012). Basic/core EHR systems are principally concerned with clinical data (ISO, 2005), and they offer basic functionalities that need to be supplemented with other systems for more advanced exploitation of EHR data (Mandl & Kohane, 2012). Comprehensive/extended EHR systems, however, are supersets of the core/basic EHR systems, and they include not only clinical data, but also a broad spectrum of data related to patients and functionalities supporting the data processing of such data. These functionalities include patient administration; scheduling; invoicing; decision support; access control and policy management; demographics; order management; guidelines; terminology; population health recording, querying and analysis; health professional service recording, querying and analysis; business operations recording, querying and analysis; and resource allocation (ISO, 2005).

The processing of data can generally be categorized into primary and secondary use of EHR data (ISO, 2005; Mann & Williams, 2003). Whereas core/basic EHR systems mainly support primary use of EHR data, comprehensive/extended EHR systems have additional functionalities supporting both primary and secondary use of EHR data (ISO, 2005).

Primary use of EHR data. Primary use of EHR data refers to use that directly supports patient care (Cabitza & Locoro, 2017) by providing primary users (i.e., clinicians) real-time data for clinical decision-making at the point-of-care (Safran et al., 2007). Thus, in primary use, the purpose of the EHR system is to provide a documented record supporting present and future care by one clinician, or as a means of communication among clinicians contributing to the care of a patient

(ISO, 2005). Since primary use of EHR data is not the focus of this dissertation, literature on this subject will not be discussed herein.

Secondary use of EHR data. Secondary use of EHR data refers to using the collected data for a different purpose to what was intended (Hripcsak et al., 2014) in a non-direct care use (Safran et al., 2007). The potential benefits of secondary use of EHR data are:

> Secondary use of health data can enhance health care experiences for individuals, expand knowledge about disease and appropriate treatments, strengthen understanding about effectiveness and efficiency of health care systems, support public health and security goals, and aid businesses in meeting customers' needs. (Safran et al., 2007, p. 1)

Examples of secondary uses of EHR data include service planning, resource allocation, performance monitoring, clinical auditing, and quality management (Cabitza & Locoro, 2017; Hripcsak et al., 2014; Mann & Williams, 2003; Safran et al., 2007). Table 2-2 presents an overview of various secondary uses of EHR data, adopted from ISO (2005). Secondary users include quality assurance personnel, quality auditors, managers, administrators, researchers, analysts, insurers, legislators, and policy-makers (Cabitza & Batini, 2016).

Table 2-2: *Secondary Uses of EHR Data, Adopted from ISO (2005)*

Type of secondary use	**Description**
Medico-legal	Evidence of care provided, indication of compliance with legislation, reflection of the competence of clinicians.
Quality management	Continuous quality improvement studies, utilization review, performance monitoring (peer review, clinical audit, outcomes analysis), benchmarking, accreditation.
Education	Training of clinicians and other health professionals.
Research	Development and evaluation of new diagnostic modalities, disease prevention measures and treatments, epidemiological studies, population health analysis.

Table 2-2 continued

Type of secondary use	Description
Public and population health	Access to quality information to enable the effective determination and management of real and potential public health risks.
Policy development	Health statistics analysis, trends analysis, case-mix analysis.
Health service management	Resource allocation and management, cost management, reports and publications, marketing strategies, enterprise risk management.
Billing/finance/reimbursement	External use of data, for example, by insurers, government agencies, and funding bodies.

Secondary use of EHR data involves producing information artifacts from EHR data that is collected for primary use at various levels of aggregation: from individuals (i.e., patients and caregivers), to various organizational levels within hospitals, to health authorities (Cabitza & Batini, 2016). This process of producing information artifacts from EHR data is, however, still characterized as ad hoc in most health care organizations, where data is manually extracted from EHR systems, and manipulated into useful forms using supplementary data-processing tools (Botsis et al., 2010; Foshay & Kuziemsky, 2014). The process of generating information artifacts in secondary use of EHR data is illustrated in Figure 2-1. The illustration is exemplifying different types of data and is thus not providing a complete overview of data types.

Secondary use of EHR data may be exploited for managing individual patient care, for example, through clinical decision-support systems. Thus, secondary use of EHR data can be classified into management of individual patient care, management of organizations, and research (Verheij, Curcin, Delaney, & McGilchrist, 2018). In this dissertation, however, the definition provided by Safran et al. (2007) is applied, excluding the secondary use of EHR data for direct patient care. Furthermore, since use of data for medical research is out of the scope of this dissertation, secondary use of EHR data relates only to the management of organizations (e.g., quality management, policy development, and health care management) in the remainder of this dissertation.

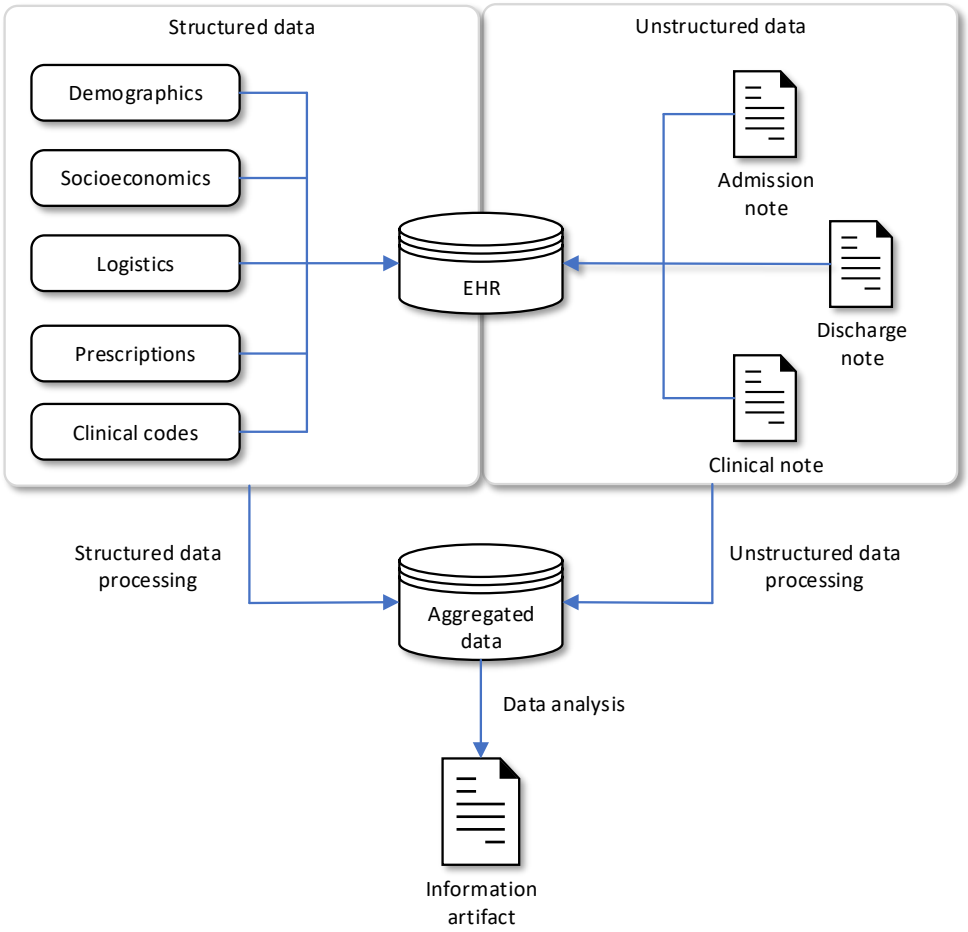


Figure 2-1: The process of generating information artifacts in secondary use of EHR data, adapted from Abernethy, Gippetti, Parulkar, and Revol (2017).

IQ is important in the process of secondary use of EHR data. Based on the quality of the data extracted from EHR systems, including the maintenance, visualization, and transmittal, the information may enable secondary users actions that can contribute directly or indirectly to adverse outcomes (Cabitza & Batini, 2016; Pipino & Lee, 2011). The concept of information quality is presented in the following section.

2.2 Information Quality (IQ)

This section presents the concept of IQ, which includes definitions of data and information quality (DIQ), the elements of quality, different views of IQ, actor roles involved in data processing, and research on IQ in the health care context.

2.2.1 Data and Information

The difference between "data" and "information" has been discussed extensively in many fields of research over a long period. By adding "knowledge" and "wisdom," the discussion becomes more philosophic and involves epistemological and ontological questions. As this dissertation does not aim to participate in this discussion, which can be further investigated elsewhere (e.g., Tuomi, 1999), I use the following common distinction between data and information:

- **Data** are symbols representing properties of objects and events (Ackoff, 1989) that are unconnected and not arranged into a form that human beings can understand and use (Laudon & Laudon, 2012).
- **Information** is processed data (Ackoff, 1989) that are arranged into a form that is meaningful and useful to human beings (Laudon & Laudon, 2012).

2.2.2 Perspectives of IQ

Existing IQ research often uses the terms "data quality" (DQ) and "information quality" (IQ) interchangeably (Baškarada & Koronios, 2013; Helfert, 2001; Knight & Burn, 2005; Madnick, Wang, Lee, & Zhu, 2009), and sometimes combines them as data and information quality (e.g., Neely & Cook, 2011) or IQ/DQ (e.g., Knight, 2011). While there is no consensus about the distinction between DQ and IQ, there is a tendency to relate the former to technical issues and the latter to nontechnical issues (Madnick et al., 2009; Zhu, Madnick, Lee, & Wang, 2014). Following the definition of data and information described in the previous subsection, this dissertation uses the following distinction: DQ relates to the quality of the raw and unconnected representation of objects and events (data), and IQ relates to the quality of data that have been processed and arranged (information).

Existing literature has presented several different views of IQ (Batini, Cappiello, Chiara, & Maurino, 2009; Ge & Helfert, 2007); Table 2-3 briefly summarizes some examples.

Table 2-3: *Summary of Selected Views on IQ*

Perspective	Description
Hierarchical	IQ comprises intrinsic quality, quality within a context, representational quality, and quality related to the accessibility of the data/information (Wang & Strong, 1996).
Ontological	IQ relates to the discrepancy between users' view of the real-world system and users' perception of the information representing the real-world as inferred from the IS (Wand & Wang, 1996).
Semiotic	IQ comprises syntactics (basic representations of symbols), semantics (meaning of symbols representing real-world objects or events), and pragmatic (the information processes and use) levels (Helfert, 2001).
Internal and external	IQ comprises internal quality—the correspondence between the information produced and the information that should have been produced—and external quality—the correspondence between the information and the user needs and expectations (Devilliers & Jeansoulin, 2006).
Artifact and deliverable	IQ comprises the quality of information as an artifact—the technical quality of the information—and information as a deliverable—negotiated meaning between producer and receiver (Lillrank, 2003)
Life cycle	IQ comprises collection quality, organization quality, presentation quality, and application quality, and transforms through the information life cycle (Knight, 2011; Liu & Chi, 2002).
Product	IQ is the quality of the information product (artifact) produced by the information manufacturing system (Wang, 1998).
Product and service	IQ comprises product quality—the quality of the information artifact produced by the information manufacturing system—and service quality—the quality of the information service delivery process (Kahn et al., 2002).
Content and media	IQ comprises content quality—quality of the actual information—and media quality—quality of the delivery process of the information (Eppler, 2006).

Traditionally, information has most often been viewed as a product and refers to quality as *product quality* (Kahn et al., 2002; Wang, 1998; Wang et al., 1998; Wang & Strong, 1996). In the product view, an information artifact is viewed as the output of a well-defined manufacturing process performed by an information system, where data are the input to this process (Lee et al., 2006; Wang, 1998; Wang et al., 1998). Furthermore, Kahn et al. (2002) argued that the process of converting data into information has characteristics of a service, and incorporates

service quality in their IQ benchmark model. Thus, product quality relates to the features of the information artifact, whereas service quality relates to features of the service delivery process of the information artifact. This view of IQ relates closely to the concepts of content quality (product) and media quality (service) proposed by Eppler (2006).

According to Ge and Helfert (2007), the most adopted definition of IQ in existing literature is "fitness for use" (Ge & Helfert, 2007, p. 1) or "fit for purpose" (Liaw et al., 2012, p. 57), implying that information considered as appropriate for one user may be insufficient for another. Thus, IQ is contingent upon information users' subjective perceptions of the usefulness of information within its use context. In their seminal article, Kahn et al. (2002) proposed a two-fold, yet complementing definition of IQ: (1) information "conforming to specifications", and (2) information "meeting or exceeding consumer expectations" (p. 185). Whereas the former definition denotes an objective quality assessment of how closely information conforms to predefined specifications, the latter takes an information user's viewpoint by encompassing their subjective assessments of the quality of information. The rationale behind advancing the fit for use definition was the overly broad notion of "fitness," leading to challenges in measuring such a concept (Kahn et al., 2002, p. 185).

An alternative approach of the manufacturing view is to understand information as a value-adding life-cycle process. While value-adding processes are not new to information systems (IS) research (Knight, 2011), connecting the information life cycle to IQ is a novel idea presented by Liu and Chi (2002). The idea of IQ as a life-cycle concept is that value-judgements of IQ dimensions depend heavily on where in the life cycle the user-information interaction takes place (Knight, 2011). The different stages of the life cycle are collection, organization, presentation, and application, as illustrated in Figure 2-2.

Knight (2011) grouped the processes into the two overarching processes of "information generation" and "information use" (see Figure 2-2). The information generation process comprises the data collection and data organization subprocesses, whereas the information use process comprises the data presentation and data application subprocesses. In the life cycle, data collection relates to the

capturing of organizational data, organization relates to how the collected data is structured or organized in an IS, presentation relates to how the organized data are visualized, and application relates to the actual use of the visualized data (Liu & Chi, 2002). The basic idea of IQ as a life-cycle concept is that IQ changes through these value-adding processes before being applied by the user (Knight, 2011), and that DQ/IQ issues can be introduced independently in the different stages of the life cycle (Liu & Chi, 2002).

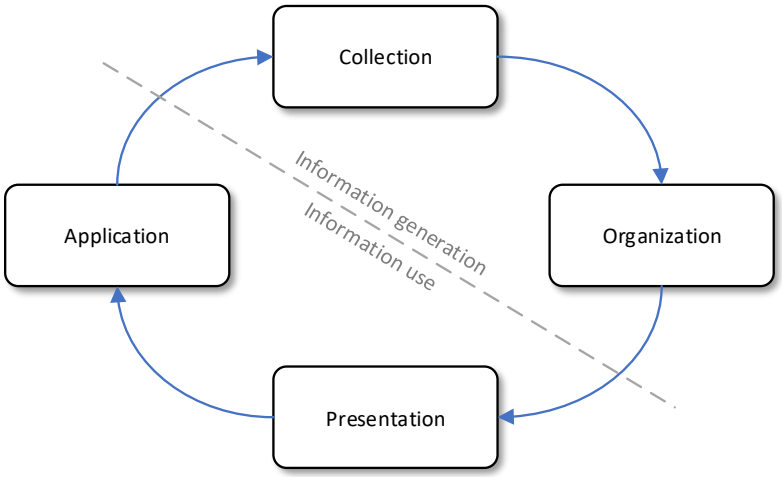


Figure 2-2: IQ as a life cycle, adapted from Knight (2011).

2.2.3 IQ Dimensions

It is generally acknowledged that IQ is a multidimensional concept (Ge & Helfert, 2007; Illari & Floridi, 2014). IQ dimensions can be defined as a set of attributes (Miller, 1996) or characteristics (Ge & Helfert, 2007) that represents a single aspect or construct of IQ (Wang & Strong, 1996). Examples of IQ dimensions include accuracy, relevancy, completeness, reliability, and timeliness of information. There is, however, no general agreement on the exact meaning of each dimension (Batini et al., 2009). Table 2-4 provides some examples of variations in definitions of the completeness dimension in existing literature.

One reason for the existing discrepancies in definitions of IQ dimensions can be attributed to the contextual nature of quality (Batini et al., 2009), and another reason is that researchers tend to select IQ dimensions intuitively, based on their experience (Ge & Helfert, 2007; Wang & Strong, 1996).

Table 2-4: *Examples of Variations in Definitions of the Completeness Dimension*

Definitions of "completeness"	**Reference**
"The extent to which data are of sufficient breadth, depth, and scope for the task at hand."	Wang and Strong (1996, p. 32)
"All values that are supposed to be collected as per a collection theory are collected."	Liu and Chi (2002, p. 302)
"The extent to which information is not missing and is of sufficient breadth and depth for the task at hand."	Kahn et al. (2002, p. 187)
"The degree to which all possible states relevant to the user population are represented in the stored information."	Nelson, Todd, and Wixom (2005, p. 204)

2.2.4 IQ Classifications

Because of the contextual nature of quality, there is no general consensus about which set of dimensions defines IQ (Batini et al., 2009). Thus, numerous classifications of IQ dimensions exist in the literature, where researchers employ an intuitive approach (Ge & Helfert, 2007; Wang & Strong, 1996). Table 2-5 presents examples of such classifications.

One of the most common classifications used in research originates from the highly cited article by Wang and Strong (1996). Their classification distinguishes between the following aspects of quality: (1) intrinsic quality, which refers to "the extent to which data values are in conformance with the actual or true values" (Wang & Strong, 1996, p. 18), including believability, accuracy, objectivity, and reputation; (2) contextual quality, which refers to "the extent to which data are applicable (pertinent) to the task of the data user" (Wang & Strong, 1996, p. 18), and includes value-added, relevancy, timeliness, completeness, and appropriate amount of data; (3) representational quality, referring to "the extent to which data are presented in an intelligible manner" (Wang & Strong, 1996, p. 18), including interpretability, ease of understanding, representational consistency, and concise representation; and (4) accessibility quality, which refers to "the extent to which data are available or obtainable" (Wang & Strong, 1996, p. 18), including accessibility and access security.

Table 2-5: *Examples of Classifications of IQ Dimensions*

Perspective	Classification	Dimensions
Hierarchical (Wang & Strong, 1996)	Intrinsic quality	Believability, accuracy, objectivity, reputation
	Contextual quality	Value-added, relevancy, timeliness, completeness, appropriate amount of data
	Representational quality	Interpretability, ease of understanding, representational consistency, concise representation
	Accessibility	Accessibility, access security
Product and service performance (Kahn et al., 2002)	Sound	Free-of-error, concise representation, completeness, consistent representation
	Dependable	Timeliness, security
	Useful	Appropriate amount, relevancy, understandability, interpretability, objectivity
	Usable	Believability, accessibility, ease of manipulations, reputation, value-added
Producers and users (Seppänen & Virrantaus, 2015)	Internal product quality	Conciseness, consistency, accuracy, currency
	External product quality	Comprehensiveness, clarity, applicability, value-added, reputation
	Internal service quality	Convenience, timeliness, traceability, interactivity
	External service quality	Accessibility, security, speed

2.2.5 Actor Roles Involved in Data and Information Processing

The literature refers to three distinct data processes in the life cycle of information: data collection (referred to as *data extraction*), data storage and maintenance, and data utilization (Cao & Zhu, 2013). Three distinct roles of human actors are involved in these processes, often referred to as the three Cs: data collectors, data custodians, and data consumers (Lee, 2003; Lee et al., 2006; Osesina, Carton-Mizeracki, & Talburt, 2011). Data collectors are actors that provide the initial input of organizational data to the IS (Cao & Zhu, 2013; Lee, 2003). In primary use of EHR data, data collectors include clinical staff (e.g., doctors and nurses) and

administrative staff (Cruz-Correia et al., 2009). In the secondary use of data, however, existing data are being extracted from the EHR system (Lindquist, 2004) by administrative personnel (e.g., secretaries and analysts). To avoid confusion between data collectors of primary data and collectors of already existing data for secondary use, this dissertation refers to the latter as *data extractors*. *Data custodians* are actors who design, develop, or maintain computing resources for storing, processing, and securing data (Kahn et al., 2002; Wang, 1998). In primary use of EHR data, data custodians typically include actors such as database administrators and computer scientists (Cruz-Correia et al., 2009). Data consumers, or *information users*, are the actors that access and use the information (Kahn et al., 2002). This role is typically held by clinicians, support personnel, researchers, and managers in health care organizations (Cruz-Correia et al., 2009).

In addition to the three Cs, some previous research has included the role of *information producers*, which refers to organizational actors (e.g., administrative personnel) who generate and provide information (Kahn et al., 2002) by utilizing data for further integration, aggregation, presentation, and interpretation (Lee, 2003). In the information manufacturing view, the process of transforming data into information is performed by the IS technology (Wang, 1998), which might be one reason why the human role as information producers is seemingly underplayed in IQ research. One mentionable exception is the role of data output producers who select, extract, and manipulate data to create information artifacts (Lindquist, 2004). Table 2-6 summarizes the roles involved in data and information processing from existing IQ literature.

Existing IQ research hardly addresses the interpersonal communication of the information artifact within the organization. Lillrank (2003) suggested treating information as a deliverable, where the aim is to reach a mutual understanding of the information. However, this was not suggested or formalized as a role in processing information. This study assigns the label *information mediators* to this role.

Table 2-6: *Roles Involved in Data and Information Processing*

Role	Process	Similar roles
Data extractors	Data extraction	Data collectors (e.g., Lee, 2003); Information suppliers (e.g., Batini et al., 2009); Data producers (e.g., Strong, Lee, & Wang, 1997)
Data custodians (e.g., Kahn et al., 2002)	Data organization	Data stewards (e.g., Baškarada & Koronios, 2014); Information manufacturers (e.g., Wang et al., 1998);
Information producers (e.g., Kahn et al., 2002)	Data presentation	Data consumers (Lee & Strong, 2003); Data output producers (Lindquist, 2004)
Information users (e.g., Lee, Strong, Kahn, & Wang, 2002)	Information use	Information consumers (e.g., Kahn et al., 2002); Managers (e.g., Zhu et al., 2014)

More overarching and generic roles, such as information product managers (Kahn et al., 2002) and personal health information managers (Osesina et al., 2011), have received the attention of researchers. Actors holding such roles are often responsible for coordinating activities of IQ management by the IT department and the information producers to ensure they meet the needs of the information users; this involves monitoring the changing needs of information users to be able to target improvement efforts (Kahn et al., 2002). More recently, organizations have increasingly incorporated the role of information product managers into the more executive role of chief data officer (Lee, Madnick, Wang, Wang, & Zhang, 2014).

2.2.6 Challenges and Management of IQ

Poor IQ has been found to be directly related to the quality of health care services provided to patients (Mettler et al., 2008; Pipino & Lee, 2011; Welzer et al., 2005). Pipino and Lee (2011) placed the focus of how poor IQ affects the outcomes of health care services by suggesting the following definition of errors attributable to poor IQ:

> The state of the information such that its measurement, collection, storage, maintenance, retrieval (or lack thereof), its transmittal (or lack thereof), its visualization, or its use, create an environment that enables actions that, in

> turn, contribute directly or indirectly to intermediate or final adverse outcomes. (Pipino & Lee, 2011, p. 6)

As this definition indicates, the sources of errors leading to poor IQ can originate from collection, storage, maintenance, extraction, and visualization of data and communication of information to secondary users, and such issues of IQ can enable actions by secondary users that may lead to adverse outcomes. One of the main challenges of IQ in health care organizations is related to its highly sociotechnical nature (Cabitza & Batini, 2016; Mohammed & Yusof, 2013). Typical problematic technical issues in health care organizations include poor system functionality, lack of system validation, poor database retrieval functionality, and issues related to access control and authentication. Human factors that impact IQ typically include lack of awareness of IQ, lack of education, poor communication of information, user motivation and attitudes toward EHR systems, lack of clarity of IQ requirements, lack of IQ management roles and responsibilities, and inadequate use of EHR systems (Mohammed & Yusof, 2013).

Since health care services can critically impact patients' lives, English (2009) emphasized that health care organizations should demonstrate the highest maturity level of IQ management. However, existing research has concluded that IQ management in health care organizations is still far from desirable (Cabitza & Batini, 2016). For example, Mohammed and Yusof (2013) stated that most health care organizations had still not begun encouraging IQ management and that typically clear responsibilities in data collection and clear definitions of quality requirements were lacking; in addition, they noted that actors were often unable to align the use of information with the task it was supposed to support.

2.3 IQ in Secondary Use of EHR Data

Research on IQ in health care contexts has focused mainly on the primary use of EHR data (Cabitza & Batini, 2016). Equivalent to the fitness for purpose and/or use definition from general IQ literature, IQ in a health care context has been defined as "appropriateness of health interventions and processes", encompassing human, social, and technological elements of the context where information is produced, communicated, and used (Cabitza & Batini, 2016, p. 6). However,

current IQ research in the EHR system context has mainly focused on specific dimensions of IQ, including completeness, accuracy, comprehensiveness, and reliability (Häyrinen et al., 2008), but without integrating the concept of IQ with processes and actors (Mettler et al., 2008). From the existing limited body of knowledge, studies emphasize that high-quality information is critical for effective and efficient management of health care systems (Richards & White, 2013), for example, in terms of organizational planning and quality and safety of care (Liaw et al., 2013a).

Framing IQ in a health care context has generally been recognized as a challenging endeavor because of the multitude of users, the heterogeneity and ambiguity of the data, and the diversity and multi-level uses of EHR data (Cabitza & Batini, 2016). More specifically, secondary use of EHR data introduces further challenges related to the process of obtaining value from EHR data; in health care, this process is often not well defined, but is rather characterized as ad hoc, without standards in terms of empirical measures of core processes and a lack of understanding of information needs (Botsis et al., 2010; Foshay & Kuziemsky, 2014). Thus, treating information processing as a standardized manufacturing process provides a static view without addressing the dynamics of the process. In addressing this issue, the information production process can be viewed as a value-adding life cycle rather than a manufacturing process. Knight (2011) grouped the processes into the two overarching processes of "information generation" and "information use" (see Figure 2-2). The information generation process comprises the data extraction and data organization subprocesses, whereas the information use process comprises the data presentation and data application subprocesses. I would, however, argue to include data presentation as a subprocess of information generation rather than information application, since designing an information artifact is the final stage in generating information. Moreover, to avoid confusion between collecting data for primary use and extracting existing data for secondary use, I relabel the data collection process as *data extraction*.

The information manufacturing view assumes that quality is achieved when the information meets or exceeds consumer expectations (Kahn et al., 2002). However, Lillrank (2003) questioned this view by arguing that quality is a relational concept where multiple actors may pass judgment on the quality. This

definition leads to a paradox between quality and time by assuming that the consumer is identified and is aware of quality requirements, ex ante information generation (Lillrank, 2003). In reality, however, information is often the subject of interpersonal communication within organizations (Avison & Young, 2007; Rogers & Agarwala-Rogers, 1976), where actual use of information often resides outside of the information designer's control (Mettler et al., 2008). Lillrank (2003) addressed this paradox by distinguishing between quality as artifacts and deliverables. Quality as artifacts refers to the technical quality of the information itself, whereas quality as deliverables refers to the negotiated quality of the information between the producer and receiver. Thus, high quality of information as an artifact is when the receiver captures the intention of the sender, and high quality information as a deliverable is the achievement of a shared understanding (Lillrank, 2003).

Since the output information artifact of the information generation process is subject to interpersonal communication within health care organizations (Avison & Young, 2007; Mettler et al., 2008), viewing information as a technological service provided by the EHR system is insufficient. In a rare exception, Eppler (2006) addressed the quality of interpersonal communication by introducing the concept of communication quality (CQ), defined as "the characteristic of an interaction process among humans (but incl. computers as intermediaries) to meet or exceed their expectation with regard to the exchanged messages and with regard to the process of doing so" (Eppler, 2006, p. 351). Quality dimensions of CQ, include reciprocity, honesty, fairness, authenticity, timeliness, and balance, along with being targeted, having feedback possibilities, and without distortion and interruptions.

The manufacturing view of information treats the output information as a fixed artifact. However, transformation and filtering of the information artifacts is likely to happen in the process of interpersonal communication (Rogers & Agarwala-Rogers, 1976), and thus modifying the information artifact. Hence, we need to take a more balanced view of IQ (Mettler et al., 2008; Neely & Cook, 2011) to understand not only how data evolves in the information generation process but also how IQ changes through communication and information use processes, including the interplay of the technical and social processes involved.

2.4 Chapter Summary

This study adopts a broad understanding of EHR systems as repositories of retrospective, concurrent, and prospective patient data, where the primary purpose of EHR systems is to support quality integrated health care (Häyrinen et al., 2008; ISO, 2005). Examples of EHR data include patient-level clinical and administrative data; the data are often distinguished as being structured, semi-structured, or unstructured (Raghupathi & Raghupathi, 2014).

The processing of EHR data can be categorized into primary and secondary uses (ISO, 2005; Mann & Williams, 2003). Primary use refers to the utilization of data for clinical decision-making at the point-of-care, whereas secondary use of EHR data refers to using the data for a purpose other than originally intended and other than non-direct care (Hripcsak et al., 2014; Safran et al., 2007). Examples of secondary uses include quality management, policy development, and health care management. Several actor roles are involved in the processes related to secondary use of EHR data: (1) data extractors are typically administrative personnel who extract routinely collected data from EHR systems; (2) data custodians are database administrators or computer scientists who design, develop, or maintain computing resources; (3) information producers are typically administrative personnel who utilize data for further integration, aggregation, presentation, and interpretation; (4) information mediators are often managers who communicate the information within an organization; and (5) information users (or secondary users) are actors (e.g., managers and clinicians) who access and use the information for non-direct care purposes.

The quality of health care services provided to patients is found to be directly related to IQ (Mettler et al., 2008; Pipino & Lee, 2011); moreover, the issues leading to inadequate IQ are highly sociotechnical (Cabitza & Batini, 2016; Mohammed & Yusof, 2013). Current research on IQ and EHR systems, however, focuses on the primary use of EHR data (Cabitza & Batini, 2016) and generally examines it from a technological viewpoint (Mohammed & Yusof, 2013).

Arguably, the prevailing view of IQ is challenging in the context of secondary use of EHR data for several reasons: (1) treating information processing as a standardized manufacturing process performed by an IS provides a static view that

fails to address the sociotechnical dynamics in extracting, organizing, generating, communicating, and using the information; (2) viewing IQ as a function of fit between the information and user needs introduces a paradox of time, where the information requirements often are not known ex ante; (3) in secondary use of EHR data, information is often the subject of interpersonal communication; the current manufacturing view does not address how such communication may influence secondary users' perceptions of IQ; and (4) in interpersonal communication, the information is likely to be transformed and filtered. Based on these challenges in secondary use of EHR data, it is insufficient to view IQ as fitness of use between actors and information artifacts produced by EHR systems.

Since EHR data passes through multiple stages of processing before reaching secondary users, a life-cycle view is necessary to fully understand how IQ is transforming in secondary use of EHR data. Thus, in this study the following perspectives are applied: the IQ life-cycle view provided by Knight (2011), the concept of CQ defined by Eppler (2006), and the distinction of IQ as an artifact and as deliverable developed by Lillrank (2003). Figure 2-3 illustrates the interrelations of these concepts.

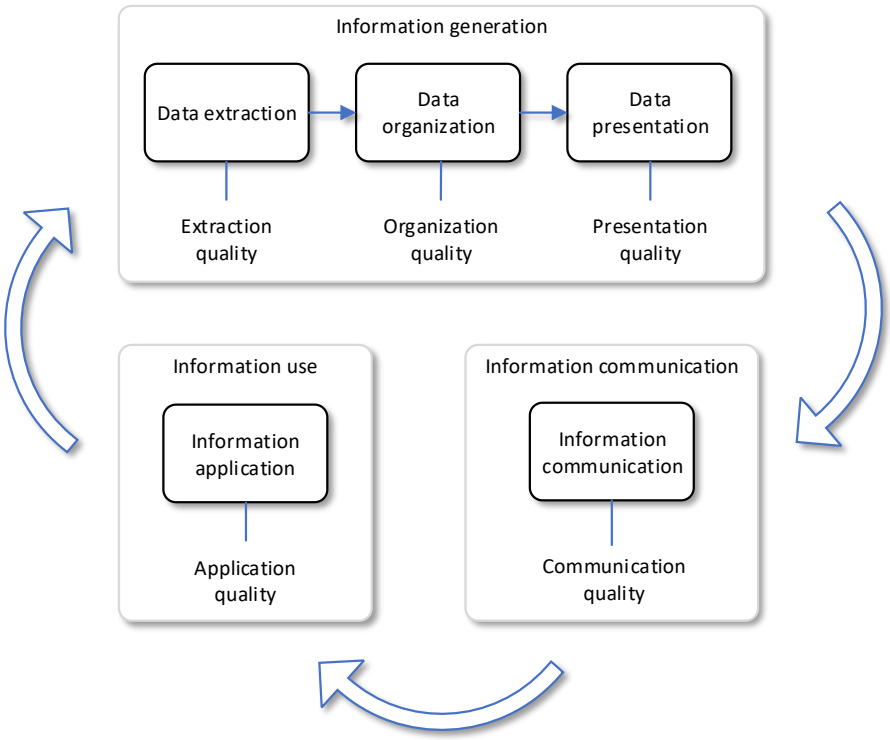


Figure 2-3: Framing of IQ in secondary use of EHR data.

This model will serve as the basis for the focused literature review presented in the following chapter.

3 Systematic Literature Review

To provide a sound basis for understanding the extant literature on IQ in the process of secondary use of EHR data, I conducted a two-staged literature review. The first stage of the review was broad and explorative, where the purpose was to acquire a broad understanding of how IQ impacts health care organizations that use EHR systems. The second stage was more narrowly focused, centering exclusively on the secondary use of EHR data from an IQ life-cycle perspective (see Figure 2-3). The following sections present the two reviews, including the methods, descriptive results, and synthesis of the literature. The description of the review process (in Section 3.2) and the summary of the explorative review (in Section 3.3) build on the published article by Hausvik (2017b).

3.1 Review Method

The method used in this study is primarily based on the work of Okoli (2012, 2015), who distinguished between three kinds of systematic review: theory landscaping reviews (here labelled "explorative review"), theory building reviews (here labelled "focused review"), and theory testing reviews (Okoli, 2012). According to Okoli (2012), studies can apply one, or any combination, of the different reviews.

Explorative reviews are often conducted "at the start of a research program, when a researcher has a general idea of their topic, but has not yet acquired sufficient familiarity with the existing literature to develop precise research questions" (Okoli, 2012, p. 10). At the outset of this study, the purpose of the literature review was to acquire a broad understanding of how the IQ of EHR data is impacting health care organizations. Thus, an explorative review was conducted, with a focus on the documentation of concepts, relationships, and explanations. In such reviews, Okoli (2012) suggested that the search for literature should be exhaustive, without applying quality appraisal criteria. Section 3.3 summarizes the results of the explorative review.

In the process leading to this dissertation, the scope of the study became more focused. New concepts emerged during the process as I acquired more knowledge of the domain and through analyzing data. For example, it became evident that

concepts used in early research papers (i.e., quality improvement and quality assurance—broadly termed quality management) were instantiations of secondary use of EHR data. Thus, a more focused literature review was needed. Focused reviews are appropriate "when a researcher clearly knows their topic of interest but wants to gather support from existing literature to create new theory, or extend or adapt existing theory, that is, offer new explanations for observed phenomena" (Okoli, 2012, pp. 10–11). In focused reviews, Okoli (2012) suggested that the search for literature may draw only from selected sources. Thus, the focused literature review presented in Sections 3.4 and 3.5 is based on articles obtained from the explorative review that include the search term "secondary use," and is updated with the outcomes of all search queries conducted in February 2019.

3.2 Description of the Review Process

The methodology used in this study is primarily based on the work of Okoli (2012, 2015), where the first goal is to identify relevant literature and record the phenomenon observed in a wide area of existing research (i.e., explorative review), and the second goal is to synthesize literature on IQ in the secondary use of EHR data (i.e., focused review). For the explorative review, research on IQ in organizations outside of health care is also valued, since transferability between contexts might exist. The eight-step guide (Okoli, 2015) was used to conduct the literature review, consisting of the following steps: identify the purpose, draft the protocol, apply practical screening, search for literature, extract data, appraise the quality, synthesize the studies (data analysis), and write the review.

A protocol of search strategies, with inclusion and exclusion criteria, was designed prior to the search process to ensure consistency in the process and theoretical rigor (Okoli, 2012, 2015). Practical screening (not to be confused with quality appraisal) sets the practical boundaries of the search process. Following the review methodology, no practical screening criteria were employed concerning journal rankings, field of research (multi-disciplinary approach), outlet (journals, conference proceedings, books, practitioner publications, grey literature), research paradigms (positivist, interpretive), or dates (no date limitations). Only two practical screening criteria were used: language—only English articles—and the limitations inherent to the choice of search words.

Previous research on IQ impact has mostly focused on individuals rather than organizations (Gorla, Somers, & Wong, 2010). However, in secondary use of EHR data, organizations may be impacted in several different ways, where researchers likely use different terminology (e.g., organizational performance, process performance, and organizational impact). Thus, a heuristic approach to defining the search words was employed. Several search words synonymous with "impact" were used in initial test searches. Some relevant articles were already identified, and new search words were added to ensure these articles were included in the results. Appendix A presents the search words used in this study. Several search words were included on purpose, expecting that the search would return too many articles. This strategy would increase the possibility of finding all relevant articles, knowing that it would make the screening process more extensive.

Common databases used in IS reviews (Levy & Ellis, 2006), i.e., ProQuest (all databases), IEEE Xplore, and EBSCOhost were selected. Additionally, Scopus and ISI Web of Science were chosen to ensure multi-disciplinary search results. The databases were investigated to ensure indexing of IS journals, and all top-50 journals (AIS, 2016) were covered except one (MISQ Discovery). All searches were done in conjunction using the search terms "information quality" OR "data quality". Appendix A presents the results of the search.

The initial search returned 4,324 articles. Of these, 1,912 duplicates were removed, 37 were inaccessible, 70 were non-English, 93 were too general (typically summaries of journals or conferences), and 1,988 lacked relevance. This large number of non-relevant articles was expected and part of the strategy. These articles were judged non-relevant to this study based on screening of titles, abstracts, and a full-text review when necessary. Table 3-1 presents the exclusion criteria.

After applying exclusion criteria 1–5, 224 articles remained. Through careful full-text assessment, these 224 articles were reduced further to 57 core articles. A forward citation search of these 57 articles returned 2,045 articles for further examination. The same procedure (described above) was conducted, adding 20 new articles to the core collection. A second round of forward citation search was

performed on these 20 articles, resulting in two more core articles (n = 79 in sum). These 79 articles were used for the explorative review.

Table 3-1: *Exclusion Criteria*

	Exclusion criteria	**Explanation**
1	Not discussing the concept of IQ or DQ	Articles only briefly mentioning DQ or IQ, without defining or operationalizing the concept.
2	Not discussing organizational impact of IQ (e.g., on processes, services, operations, performance, improvement)	Articles not putting IQ in a meaningful organizational context and thus treating IQ as the end rather than means. See also criterion 5.
3	Focus is outside the focal organization (e.g., inter-organizational, regional, national, and international)	Articles discussing how IQ in one organization is impacting other organizations, or how IQ affects data aggregation outside an organization.
4	Focus is on IQ in research/clinical trials	Articles discussing how IQ in an organization affects clinical trials and research.
5	Impact is on data/information management itself	Articles discussing how IQ influences data management. See also criterion 2.
6*	Not discussing secondary use of data	Articles focusing on IQ in the primary use of data at the point-of-care.
7*	Focus is on systems other than EHR systems	Articles discussing IQ outside of a health care context.

* criteria only applied to the focused review

For the focused review, exclusion criteria six (articles not discussing secondary use of data, n = 17) and seven (articles focusing on other systems than EHR systems, n = 38), as presented in Table 3-1, were applied. The rationale for applying these additional exclusion criteria was because of the focused scope of this dissertation compared to the explorative review. Applying exclusion criteria seven was not straightforward since several articles did not use the term ‘EHR’ explicitly but used other terms or even failed to specify the underlying system for the secondary use. Thus, a certain extent of interpretation was needed, using a

broad understanding of the EHR system concept, as defined in Subsection 2.2.1. Section 10.2 presents the limitations of the literature review.

A backward search of the core articles was intended; however, this search returned 2,608 articles. Thus, a full backward search was not feasible within the scope of this study. To partially address this limitation, all citations from the core articles used in this study were investigated and assessed, but none were found relevant for inclusion in the core collection. Figure 3-1 illustrates the data reduction procedure.

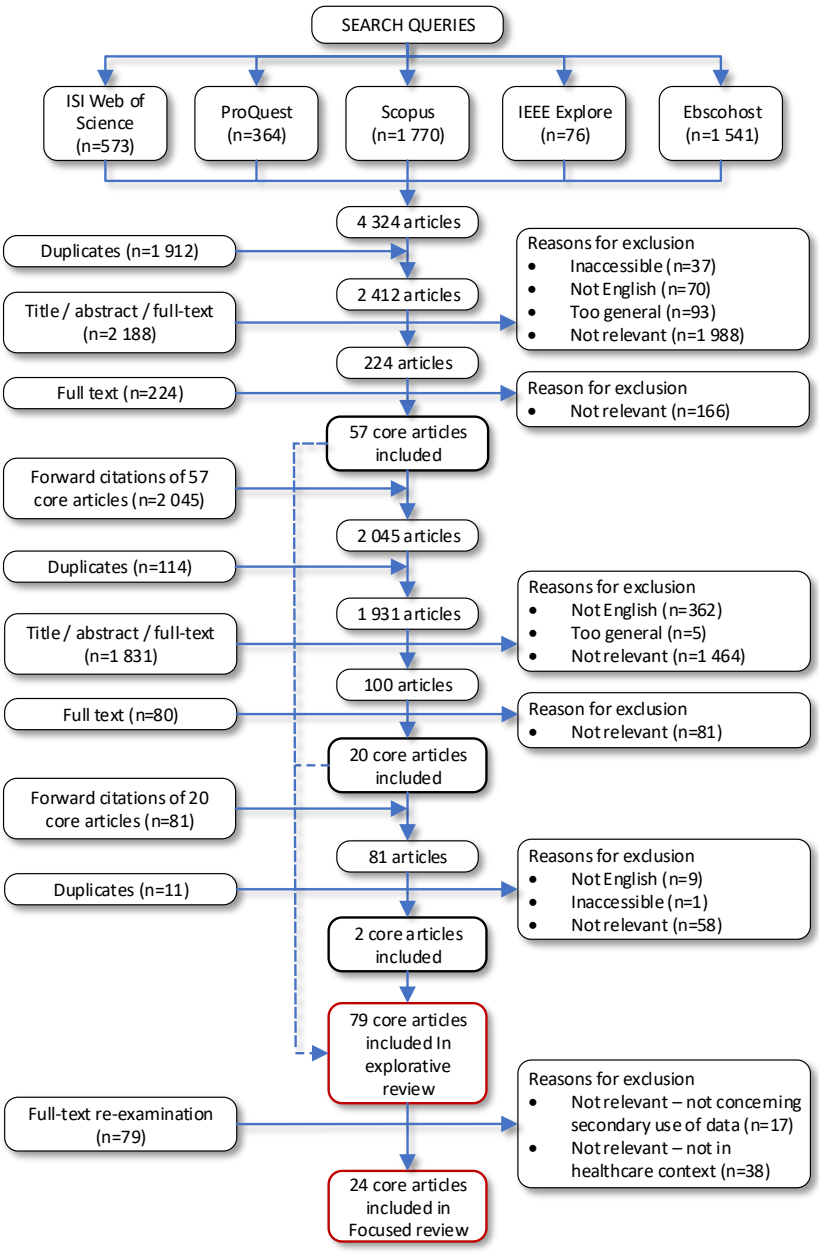


Figure 3-1: Data reduction procedure.

A quality appraisal of the core articles was not conducted primarily because of the epistemological assumptions of critical realism[1], where the review is exploratory and all new ideas, however unorthodox, are welcomed as long as they are supported by theoretical arguments (Okoli, 2012).

In the explorative review, the extracted articles were analyzed using NVivo 11. The core articles addressed a range of research questions. To make sense, the articles were classified inductively by identifying all the dependent variables (what the articles tried to explain), and by carefully investigating the reasoning presented. Data were analyzed from different angles, including an analysis of article metadata (year of publishing, research methods, and outlet target discipline). Central to the analysis was a concept-centric analysis to synthesize concepts, rather than summarizing relevant articles (Webster & Watson, 2002). By applying exclusion criteria 6 and 7 in the focused review, data were reanalyzed by using the IQ life cycle (see Figure 2-3) as a reference framework.

After ending the first search ended in January 2016, updates were made in May 2016, April 2018, and February 2019.

3.3 Summary of Explorative Review

The purpose of the explorative review was to acquire a broad understanding of how IQ impacts health care organizations when using EHR systems. The following paragraphs provide a brief summary of the findings. A full description of this review is available as a published research paper (Hausvik, 2017b).

The analysis revealed a complex and fragmented body of research, where IQ was found to impact organizations in four domains: organizational performance, process performance, process improvement, and decision-making processes. No consensus was found regarding how IQ related to any of the domains, where such relations included (1) a direct relation, where IQ was either the only variable or in conjunction with other variables; (2) IQ moderating or mediating the effect of other

[1] Like this study, the methodology by Okoli (2012, 2015) is based on critical realism (see Section 5.1)

variables; (3) IQ as an antecedent variable and, thus, indirectly related through other variables; and (4) IQ as a part of a process with inputs and outputs.

One of the main findings was the lack of an existing body of knowledge within the IS field pertaining to how IQ relates to improvements in organizational processes. For example, process improvement is a broad term, incorporating concepts such as business process improvement, quality improvement, quality assurance, and operational improvement. Notably, almost half of the studies identified within this domain was published outside IS research. Most of the research was concerning the health care context, but it was rarely supported by any theoretical frameworks. These studies found IQ to directly influence improvements to health care processes, e.g., by attending to IQ for improving clinical handover processes (e.g., Gogan, Baxter, Boss, & Chircu, 2013), and by enabling line managers to disseminate information that facilitates health care quality improvement interventions (e.g., Ginsburg, 2003; Needham et al., 2009).

Since IQ should be perceived as a means to achieve favorable ends, this review concludes that future research within this domain needs to shift the focus from defining, measuring, and managing information to achieve IQ excellence (Neely & Cook, 2011) to increasing the knowledge of "how to truly use performance data for bringing about improvements in health care delivery" (Ginsburg, 2003, p. 281). Specifically, there is a need for more research on how IQ facilitates quality management processes of health care services delivered to patients.

3.4 Descriptive Results of Focused Review

This focused review included 24 articles, where the majority were published in journal outlets (n = 18). Of the articles, 18 were published in outlets from different disciplines than IS/IT, and medicine/health care outlets were most frequent, with 13 articles (see Figure 3-2 for distribution of articles per outlet type and discipline).

The included articles were published between 1999 and 2018, with a peak in 2013 (see Figure 3-3 for a timeline of publication dates). By counting the affiliations of the first authors, 10 articles were published in North America, six in Europe, five in Oceania, and three in Asia.

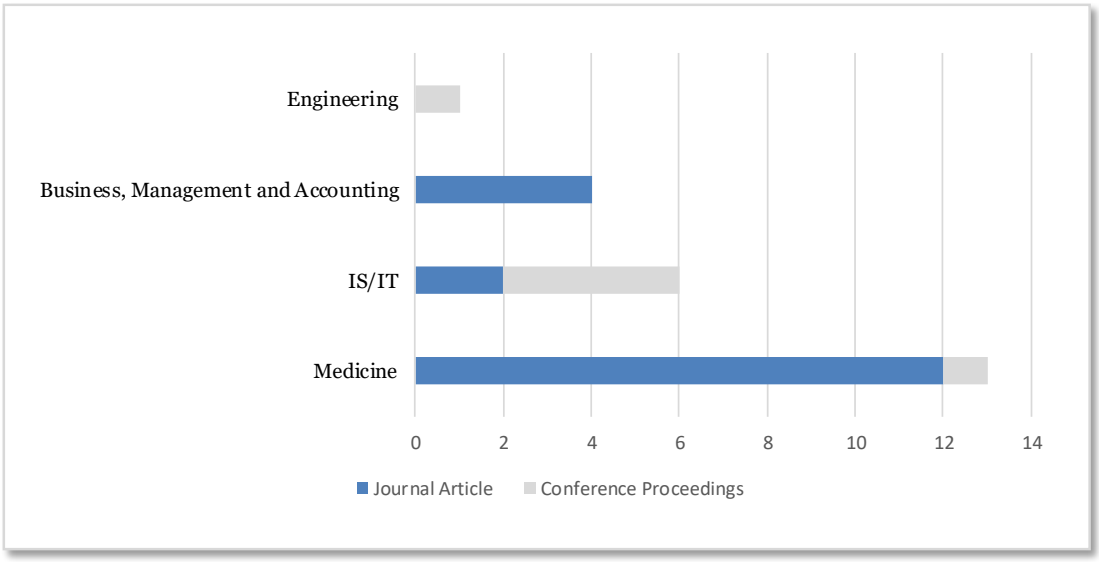


Figure 3-2: Outlet types and disciplines.

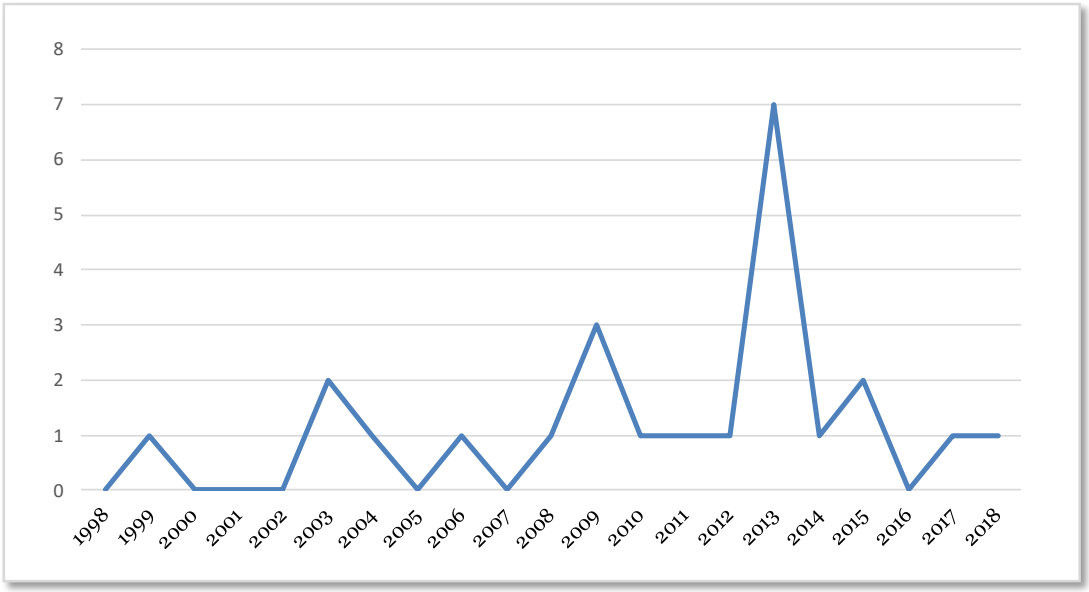


Figure 3-3: Articles by year.

The research methods used in the articles were case study (n = 6), conceptual research (n = 6), content analysis (n = 4), literature review (n = 3), action research (n = 2), and secondary use of survey data (n = 1). No theoretical frameworks were identified in 17 articles. In the remaining articles, the following theories/frameworks were found to underpin the research: accounting control theory (n = 2), quality frameworks (ISO 9000 and Baylor quality practices, n = 2), co-agency theory (n = 1), diffusion of innovation (n = 1), high-performance work

systems (n = 1), institutional theory (n = 1), organizational information processing theory (OIPT; n = 1), and socio-technical theory (n = 1).

3.5 Synthesis of the Literature from Focused Review

The purpose of the focused review was to synthesize existing literature on how IQ is impacting health care organizations' secondary use of EHR data. The analysis of the 24 core articles identified four themes describing the ways in which IQ influences the processes (see Figure 2-3) in the secondary use of EHR data. These themes are (1) the usability of source data for secondary use, (2) the process of information generation (transformation of data into information), (3) the process of communicating information, and (3) the actual use of information to achieve the organizational goals. Even though several papers addressed more than one of these themes, the following subsections summarize each theme separately. In summary, the relatively few articles included in this review resonate with a literature review by Vuokko et al. (2015), which concluded that limited research exists on IQ and EHR data for secondary purposes, and only a handful of the articles were concerned with the "impact on care processes, productivity and costs, patient safety, care quality, or health impacts" (p. 293).

3.5.1 DQ and Usability of EHR Source Data in Secondary Use

Papers within this theme discuss the usability of EHR data as a source for secondary use. Structured, valid, and relevant data are required to support the secondary use of EHR data; however, limited evidence indicates that this leads to increased benefits. Though EHR data is considered to be a potential goldmine for secondary use (Verheij et al., 2018), routinely collected EHR data is argued to be an underused resource (de Lusignan, Hague, van Vlymen, & Kumarapeli, 2006). Insufficient quality of EHR data is suggested as one of the major reasons for the limited impact of the secondary use of EHR data (Byrd et al., 2013; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999). For example, Liaw et al. (2012) extracted structured diagnosis data on patients and compared the data with audited patient discharge summaries. They found that discharge summaries were missing in 12%–15% of the cases, and coded the diagnosis accuracy at 61%, a result that confirmed the results of other comparable studies (Liaw et al., 2012). Other studies report

similar findings, including significant variability in completeness, validity, granularity, and timeliness of EHR data (Byrd et al., 2013). Administrative data are generally found to have better quality than clinical data, and prescribing data are more complete than diagnostics or lifestyle data (Liaw et al., 2013a).

The variations of DQ of EHR data have raised some concerns about the "fitness for purpose" of the information for secondary use, leading to the conclusion that "we are only as good as the information we have!" (Liaw et al., 2012, p. 62). However, the quality of routinely collected data and its fitness for purpose is determined by more than the "garbage in, garbage out" principle (Liaw et al., 2013a). The following paragraphs present the literature on issues of DQ in EHR data and the suggested responses to the issues.

Organizational issues. The quality of EHR data is found to depend on the data entry process (Clark, Delgado, Demorsky, Dunagan, & Eichelmann, 2013), where poor DQ can be attributed to incomplete, incorrect, inaccurate, and/or imprecise data entry (Clark et al., 2013; Liaw et al., 2013a; Lindquist, 2004; Verheij et al., 2018). Several antecedent factors lead to low quality data entry, including the complexity of the health care services delivered to patients. There is an inherent uncertainty in the clinical processes, where the clinical picture of patient disorders may be unclear and evolving over time, leading to inaccurate data entry (Liaw et al., 2012). Furthermore, such uncertainty requires discretionary judgement, resulting in a direct relation between quality of data and the clinical qualification and skills of the person entering the data (Lindquist, 2004; Verheij et al., 2018).

Health care organizations are often described as intrinsically complex organizations, where internal documentation practices and workflows can vary profoundly, and thus lead to variations and inconsistencies of DQ between organizational units (Liaw, Taggart, Yu, & de Lusignan, 2013b). It is stated that there is no single way of organizing clinical data, leading to idiosyncratic data-entry practices within and across organizations (Kerr & Norris, 2008). This idiosyncratic data entry can be attributed to variations of professional and data-entry guidelines (Verheij et al., 2018) and/or mal-compliance with such guidelines and protocols (Liaw et al., 2013a). Variations in data-entry practices and quality are also evident between patient groups (de Lusignan et al., 2006). Owing to

incentivizing specific patient groups or mitigating risks of lawsuits, selective and strategic data entry can lead to such DQ variations (Verheij et al., 2018).

In addition to the large amount of data being routinely collected, there is an increasing pressure to collect more potentially relevant data (Liaw et al., 2013a). The existing (high) workload of clinicians is found to affect the quality of data entered into the EHR system (Verheij et al., 2018). Furthermore, training and support for collecting high quality data is often disregarded in environments lacking time and resources (Liaw et al., 2012).

Addressing organizational issues. To amend DQ issues, existing research suggests that organizations need to develop clinical documentation policies and data-entry guidelines that facilitate accurate data capture in the data entry process. These policies and guidelines should address the challenge of terminology interoperability (Clark et al., 2013; Liaw et al., 2013a; Perimal-Lewis et al., 2015) and provide clear data definitions to ensure data fields are interpreted correctly (Kerr & Norris, 2008). To reduce organizational variations of DQ, greater standardization between practices is also needed (de Lusignan et al., 2006).

To achieve a more concerted effort of ensuring quality in the data entry process, it is suggested that organizations should foster a quality culture by championing quality improvement and raising staff awareness of the consequences of poor DQ (Kerr & Norris, 2008; Liaw et al., 2012; Perimal-Lewis et al., 2015). This culture should include training, documentation, and assisting clinicians in the data entry process (Chircu, Gogan, Boss, & Baxter, 2013; Liaw et al., 2012; Verheij et al., 2018). Increased knowledge and experience in data entry tend to improve data validity (Liaw et al., 2012).

Active DQ management, which involves establishing roles and responsibilities within organizations, is proposed as an important initiative to improve and sustain DQ (Liaw et al., 2013a). Health information managers are increasingly acting as data stewards (Clark et al., 2013), a role that includes protection and development of data, by ensuring that data are managed in the interests of relevant stakeholders (Kerr & Norris, 2008).

An important part of DQ management is the implementation of governance strategies to ensure the data entry process is complete, correct, and consistent (Clark et al., 2013; Liaw et al., 2013b). Such strategies can be either data-driven or process-driven (Perimal-Lewis et al., 2015) and include quality and risk management assessment initiatives such as continuous data-driven quality assessment (e.g, Foshay & Kuziemsky, 2014; Liaw et al., 2013b; Verheij et al., 2018), traditional auditing procedures (Clark et al., 2013; Liaw et al., 2012), and self-assessment of DQ practices (Prybutok & Spink, 1999). In addition to assessing DQ, the strategies also need to incorporate standardized policies of prevention, exception handling when poor quality is identified, and continuous improvement of DQ (Chircu et al., 2013; Clark et al., 2013; de Lusignan et al., 2006; Verheij et al., 2018). The policies can be incorporated into already existing management strategies, such as total quality management (Kerr & Norris, 2008; Prybutok & Spink, 1999), and in the clinical workflow, such as clinical pathways and checklists (Chircu et al., 2013; Liaw et al., 2012).

Clinician involvement in the validation of DQ, by continuous monitoring and comparative performance feedback to clinicians, is found to increase DQ (Kerr & Norris, 2008; Liaw et al., 2012; Verheij et al., 2018). By comparing outcomes, peer pressure can have a positive effect on the quality (Perimal-Lewis et al., 2015). However, personal feedback on quality can result in ego-defensive reaction mechanisms of clinicians, leading clinicians to question the usefulness of the data (Ginsburg, 2003). Visual representations of DQ issues make it possible to engage in a dialogue with clinicians and to raise awareness of the consequences of poor quality (Perimal-Lewis et al., 2015). Moreover, incentive strategies are found to have a positive effect on DQ by incentivizing high quality data entry (de Lusignan et al., 2006; Perimal-Lewis et al., 2015; Verheij et al., 2018). As mentioned above, such strategies introduce a risk of selective data entry practices, potentially biasing the quality of data (Verheij et al., 2018).

The governance strategies and methods are suggested to be transparent by providing documentation to stakeholders, and ensuring that such strategies are optimal by continually reviewing alternative strategies, consulting with experts and users, and notifying stakeholders of any changes in management practices (Kerr & Norris, 2008).

Furthermore, existing literature suggests to take an end-to-end approach to DQ control (Chircu et al., 2013) and use methods such as the hospital patient journey, process mining of historical process data to assess information flow abnormalities (Perimal-Lewis et al., 2015), and simulation methods to identify specific parts of the process that needs improvement (Peng, Su, Peng, & Zhao, 2009; Su & Shen, 2010). Such efforts may lead to the need of participative (Perimal-Lewis et al., 2015) redesign of business processes (Liaw et al., 2012; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999).

Technological issues. Vocabularies and classifications, representing clinical terms in a standard way, are found to be difficult to develop because patient conditions are often complex, probabilistic, and highly nuanced (Kerr & Norris, 2008; Liaw et al., 2012). Furthermore, decomposition of key components of the patient record into coded concepts is constantly evolving (Kerr & Norris, 2008). Thus, failure to maintain adequate terminologies and unambiguous data-entry definitions in the EHR system (Kerr & Norris, 2008; Liaw et al., 2012) may result in inter-practice variations and overall biased data-entry practices (de Lusignan et al., 2006; Kerr & Norris, 2008).

Other technological issues reported to affect DQ include unavailability of workstations for data entry (Liaw et al., 2012), unfriendly or unusable interfaces and variations in system design factors (Liaw et al., 2012; Liaw et al., 2013b; Lindquist, 2004), variability of EHR system functionalities available within organizations (Verheij et al., 2018), and corruption of the database architecture (Liaw et al., 2013a).

Addressing technological issues. To ensure DQ, researchers suggest implementing standard classifications, codes, and terminology in the EHR system (Clark et al., 2013; Kerr & Norris, 2008; Verheij et al., 2018) to achieve standardized data definitions and consistent structure of data models (Chircu et al., 2013; Clark et al., 2013; Lindquist, 2004). Clark et al. (2013) suggested that it is imperative that those standards are designed into decision-making interfaces, including templates, data fields, and other tools for documentation. Classifications, codes, and terminology should furthermore be maintained, for example, by

removing codes and classifications that are no longer in use (de Lusignan et al., 2006).

Software engineering is proposed as a necessity to ensure reliability and validity of the user interface and database architecture (Liaw et al., 2012), through interface coherency and validity checks (Lindquist, 2004), using mandatory versus optional data fields (Clark et al., 2013; Perimal-Lewis et al., 2015), designing logical rules to avoid inconsistencies (Clark et al., 2013), and by designing documentation grading in the user interface (markers) to indicate completeness (Clark et al., 2013). Supplementary tools for ensuring DQ can also be implemented, such as natural language processing, computer-assisted data entry, intelligent software agents for automated quality assessment (Clark et al., 2013; Liaw et al., 2013a), and auto-encoders (Lindquist, 2004).

Information sharing has also shown to increase DQ, since actors entering the data are aware of its usefulness for other actors (Kerr & Norris, 2008; Verheij et al., 2018). However, giving patients access to own data can paradoxically lead to incomplete, incorrect, or imprecise data, particularly when sharing is enforced (Verheij et al., 2018), because of clinicians' reluctancy to sharing clinical data with patients (de Lusignan, Ross, Shifrin, Hercigonja-Szekeres, & Seroussi, 2013).

Other technological initiatives for increasing DQ include standardizing the technical infrastructure to remove barriers of data aggregation by consolidating and reducing the number of different systems used by clinicians (de Lusignan et al., 2006), strengthening the DQ infrastructure and capacity, and increasing the use of mobile technology to capture data when they are observed (Kerr & Norris, 2008).

Summary and discussion. Most of the articles identified in this literature review are concerned with the DQ of EHR data and thus, its usability for secondary use. That is, poor DQ is viewed as the primary barrier to secondary use, and the main source of poor DQ is related to errors made in the data entry process (e.g., Byrd et al., 2013; Perimal-Lewis et al., 2015). Furthermore, administrative data are found to be of higher quality than clinical data (Liaw et al., 2013a). Hence, a core assumption based on the existing literature is that the main challenge impairing

secondary use of EHR data is related to the DQ of clinical data for which data entry is conducted by clinicians. The review identified several organizational and technological issues leading to errors in the data entry processes, as summarized in Table 3-2.

Table 3-2: Summary of DQ and Usability of EHR Source Data

Source	Issues	Addressing the issues
Data entry	Organizational issues: Complexity of health care services; evolving patient disorders; use of discretion; variations of guidelines, practices, and workflows; strategic data entry; heavy workload; lack of training and support	Clinical documentation policies and data-entry policies (interoperability and clear definitions); standardization between practices; fostering quality culture; increasing staff awareness; training, documentation, and support; establishing roles and responsibilities; governance strategies (prevention, exception handling, and improvement); clinician involvement; clinician feedback (can lead to ego-defensive mechanisms); incentives (can lead to selective data entry); governance transparency
	Technical issues: Difficult to standardize and maintain vocabularies and classifications in EHR systems; unavailability of workstations; non-user-friendly interfaces; variations in designs; variability of EHR system functionalities; corruption of database architecture	Implementation and maintenance of standard classifications, codes and terminologies; design standards in interfaces (templates, data fields, etc.); software engineering; patient access (can lead to biased data entry); standardizing and strengthening technical architecture and systems; mobile solutions

The analysis of articles that addressed this theme revealed several unaddressed challenges and tensions in existing literature that are discussed next. First, some research suggests that the data entry process needs to be standardized throughout an organization (Clark et al., 2013; de Lusignan et al., 2006; Liaw et al., 2013a; Perimal-Lewis et al., 2015). Such standardization involves redesign of workflows and implementation of standard documentation policies and data-entry guidelines

/ protocols to reduce organizational variations in DQ. Other studies, however, point to the challenges of disrupting existing workflows by emphasizing the need to account for the contextual complexities inherent to health care organizations, such as process uncertainty, patient disorder evolvement, discretionary judgment, lack of time and resources, and other factors (e.g., Liaw et al., 2012). Thus, there is an unaddressed tension in the literature on secondary use of EHR data of how to increase standardization of the data entry process to maintain DQ for secondary use without disrupting existing workflows that already account for the contextual complexities inherent to health care processes.

Second, there is a tension between involving clinicians in validating DQ and an expectation that this will result in clinicians resolving DQ issues in the data entry process. For example, some research has revealed that continuous monitoring and validation of DQ by providing feedback to clinicians increases DQ (Kerr & Norris, 2008; Verheij et al., 2018). Thus, providing individual and comparative feedback to clinicians consequently leads to peer pressure to improve the DQ through data entry practices (Perimal-Lewis et al., 2015). However, other studies have demonstrated that clinicians who receive poor performance feedback rate the usefulness of the feedback significantly lower than clinicians who receive average and strong performance ratings. Such poor ratings indicate that poor performance feedback can lead to ego-defensive reactions by clinicians impairing DQ improvement (Ginsburg, 2003). This tension can be further fueled by an increased pressure on clinicians to collect more data in an environment where clinicians are already struggling with heavy workloads and lack of time and resources (Liaw et al., 2012; Verheij et al., 2018). This tension is not currently discussed in existing literature on secondary use of EHR data.

Third, the literature review revealed tension between implementing DQ improvement interventions and the risk of such interventions resulting in biased data entry. For example, some research suggests that incentivizing quality in the data entry process leads to improved DQ (de Lusignan et al., 2006; Perimal-Lewis et al., 2015). Others warns that such incentivization of quality will lead to selective data entry practices, potentially biasing DQ (Verheij et al., 2018). Similarly, information sharing is found to improve DQ by making data more transparent to other relevant actors (Kerr & Norris, 2008). Other studies, however, emphasize

that information sharing, particularly sharing information with patients, may lead to biased data entry because of reluctancy to share information (de Lusignan et al., 2013; Verheij et al., 2018). Existing research on secondary use of EHR data does not address these conflicting evidences of improvement initiatives that may result in biased data entry; thus, this can be considered a gap in the literature.

3.5.2 IQ and Information Generation

Papers within this theme discuss the challenges of the information generation process, and how IQ is related. In this process, EHR data is manipulated in such a way to make the outcome information useful for a specific purpose (Foshay & Kuziemsky, 2014). In the secondary use of EHR data, this process involves defining and selecting a subset to extract, extracting EHR data into data repositories for analysis and/or data mining to infer meaning from the data, and presenting the information artifact in a useful format (Liaw et al., 2013b; Lindquist, 2004), which is actionable for information consumers (Jeffs et al., 2015).

After more than two decades of extracting data from EHR systems, we still know little about the quality of such data extracts (Liaw et al., 2013b), or the wide range of factors that need to be accounted for when inferring meaning from EHR data (de Lusignan et al., 2006). Thus, data extracted from EHR systems may be unreliable and potentially unsafe to use (Liaw et al., 2013b). The following section presents literature examining the issues of DQ in the generation of information based on EHR data, followed by suggested responses to the issues.

Information generation issues. EHR systems are often not designed to support secondary use of data directly. In fact, one study found that only one of three quality metrics for quality management was readily accessible from the EHR system (Byrd et al., 2013). Thus, data need to be extracted from the EHR system, and are often flowing through multiple data-processing systems (Verheij et al., 2018). Extracting data from the EHR system is found to be a challenging affair (Verheij et al., 2018), partly because of inaccessibility of data for extraction (Foshay & Kuziemsky, 2014), and partly because of a mixture of narratives and structured data entered into the EHR system (de Lusignan et al., 2006). Since

structured data are easier to extract and process than narratives, actors tend to only extract structured data for secondary use (de Lusignan et al., 2006).

Moreover, the extracted data can be manually imported (Foshay & Kuziemsky, 2014), batch imported (Lindquist, 2004), or directly integrated with data-processing systems (Foshay & Kuziemsky, 2014). Such systems include business intelligence or analytics systems (Chae, Yang, Olson, & Sheu, 2014; Foshay & Kuziemsky, 2014), performance management systems (Ginsburg, 2003), process management systems (Michelberger, Mutschler, & Reichert, 2011), and other management and decision-support systems. However, the information generation process can often be immature in health care organizations, with ad hoc handling of requests and execution of extractions; a lack of skillful and knowledgeable actors executing data extraction, manipulation, and analysis; and a lack of sophisticated data-processing tools (Foshay & Kuziemsky, 2014). This immaturity often leads to using manual processes to run EHR system reports and manually importing the results into basic data-processing tools, such as spreadsheet applications (Foshay & Kuziemsky, 2014). Such manual processes for manipulating EHR data into a useful form is found to be marginally effective, labor intensive, and time consuming (Foshay & Kuziemsky, 2014). Lack of time-efficient data processing can furthermore create problematic delays for information consumers (Clark et al., 2013; Foshay & Kuziemsky, 2014).

The effect of the extraction procedures and tools on the quality of data has been discussed to a limited extent in existing literature, with inconclusive results. For example, one study found up to 10% variation in the completeness dimension of the extracted data compared to the source data of the EHR system (Liaw et al., 2013b). The conclusion of this study was that data-extraction tools were unsafe and potentially harmful, whereas another study reported excellent correspondence of quality between the data-extraction tool and the EHR system (Byrd et al., 2013). Errors in the extraction process can affect DQ (Liaw et al., 2013a) because of inconsistencies between the data-extraction tools and the EHR system, mismatch between data models (Liaw et al., 2013b), and due to a lack of semantic interoperability (Liaw et al., 2012; Liaw et al., 2013a).

After data are extracted from the EHR system, the quality can also be affected by the data analysis and the format of presentation. For example, even though the data extracted from the EHR system are of excellent quality, analyzing the data in conjunction with data from other sources (e.g., population denominator for interpreting data for a population) can lead to incorrect conclusions (de Lusignan et al., 2006). Furthermore, information artifacts displaying a level of precision that cannot be supported by the data can lead to misinterpretations such as over-interpretations of small differences (Clark et al., 2013).

Addressing information generation issues. Previous research has emphasized the importance of actors having a deep understanding of the processes underlying data entry (Clark et al., 2013) and the complexity of the context, and having detailed knowledge of the extracted data, including its strengths and weaknesses (e.g., Clark et al., 2013; Perimal-Lewis et al., 2015; Verheij et al., 2018). It is thus crucial to develop the appropriate IS skills, allocate relevant resources to facilitate this process (Foshay & Kuziemsky, 2014), and develop effective management practices for the information generation process (Foshay & Kuziemsky, 2014) that account for the contextual complexities (de Lusignan et al., 2006). Consumers of the information artifact should be involved in the process, and the methods of extraction should be transparent (de Lusignan et al., 2006). For example, the producers of information should engage in dialogue with the consumers to fully understand the information needs to support core health care processes (Foshay & Kuziemsky, 2014) and to ensure a proper definition of the data extraction process (Needham et al., 2009). This collaboration could furthermore be streamlined by ensuring formal documentation of extraction requests and fulfillments (Foshay & Kuziemsky, 2014).

Information generation management involves both management of technology and the information generation processes. On the technological side, the extraction tools need to be maintained and constantly adapted to the changes in the structure and content of the EHR system (Verheij et al., 2018). On the process side, the information generation process can benefit from standardization (Foshay & Kuziemsky, 2014), which consequently makes it possible to optimize data extraction, cleansing, storage, transformation, and curation of extracted EHR data (Liaw et al., 2013a; Liaw et al., 2013b). For example, traceability and consistency

of the extracted data could be improved by standardizing extraction queries and managing look-up tables, identifiers of all entities, and metadata (de Lusignan et al., 2006). Process management also involves quality control throughout the data life cycle (Needham et al., 2009; Verheij et al., 2018), and includes DQ control of the relevant data before the data extraction, during cleansing, and after the extraction (de Lusignan et al., 2006; Lindquist, 2004; Needham et al., 2009). After the extraction, the quality should be verified prudently by human actors (Lindquist, 2004; Verheij et al., 2018), using statistical methods (Needham et al., 2009), where accuracy and completeness of the output should be controlled against the actual content of the EHR system (Clark et al., 2013).

It is important for analysts to have a deep understanding of the extracted dataset and know the potential biases since data analysis may lead to different conclusions between analysts (Verheij et al., 2018). Thus, organizations need to prioritize the development of IS skills with analytic capabilities (Foshay & Kuziemsky, 2014). The information artifact based on the analysis is judged by its quality dimensions. Whereas objective quality dimensions, such as accuracy, precision, completeness, and timeliness, are influenced by the extraction process (Lindquist, 2004; Michelberger et al., 2011), subjective dimensions, such as relevancy, should also be considered in the design process (Lindquist, 2004). Thus, information should be designed judiciously by making it relevant for the information consumer (Liaw et al., 2013a). Perceived relevance is important for actions to be taken in response to the information (Ginsburg, 2003) and is determined by its ability to provide adequate information to address a particular problem (Lindquist, 2004). Relevance is also related to the level of specificity of the information artifact (Ginsburg, 2003; Lindquist, 2004; Michelberger et al., 2011), where different levels of specificity allow for both in-depth analysis and a broader overview (Lindquist, 2004). Different consumer groups also tend to prefer different levels of specificity, where senior managers tend to prefer high-level summaries, and line managers tend to prefer detailed and unit-specific information (Ginsburg, 2003). Thus, Ginsburg (2003) suggested that the stakeholder audience of the information must be identified to be able to tailor the information accordingly. Moreover, information producers should consider benchmarking the information against meaningful standards or comparison groups to increase the actionability of the information (de Vos et al., 2013). Finally, by providing metadata of the DQ, consumers will be

able to evaluate the robustness of the information before application (Needham et al., 2009).

Summary and discussion. The articles identified that focused on this theme were concerned with quality issues in data extraction, data analysis and presentation of information in secondary use of EHR data. Core assumptions derived from the literature are as follows: (1) EHR systems are often not designed to support secondary use (Byrd et al., 2013), and additional data-processing tools are needed to extract data from EHR systems to generate information for secondary use (Verheij et al., 2018); (2) the process of generating information from EHR data is often immature and ad hoc in health care organizations, and, thus, often performed manually (Foshay & Kuziemsky, 2014); and (3) actors tend to only extract structured data since structured data are easier to extract than unstructured data (de Lusignan et al., 2006). The review identified several issues leading to errors in extraction, analysis, and presentation of data, as summarized in Table 3-3.

Table 3-3: Summary of IQ and Information Generation

Sources	Issues	Addressing the issues
Data extraction	Inaccessibility of data for extraction; mixture of structured and unstructured data; immature process; manual process of data extraction; lack of skills and knowledge; lack of data-processing tools; mismatch between data models; lack of semantic interoperability	Develop IT skills for understanding the data entry process, the context, and the detailed knowledge of the data extract; develop management practices; involve users in data extraction; standardize and formalize the extraction process; adapt and maintain extraction tools; improve extraction processes; verify extraction processes
Analysis and presentation of data	Incorrect conclusions of analysis; misinterpretations	Develop analytic capabilities (including for knowledge of the data entry process, the context, and the data extract); identify stakeholders; tailor information to fit stakeholders' needs; benchmark information; provide quality metadata

The analysis of articles within this theme identified unaddressed controversies and tensions in existing literature, as discussed in the following section. First, there is

conflicting evidences on the quality of data extracts from EHR systems in existing literature. Whereas one study reported excellent correspondence between the EHR source data and the extracted data (Byrd et al., 2013), another study found significant variations (Liaw et al., 2013b). The latter study concluded that data-processing tools for extracting EHR data are unsafe and potentially harmful. This conflicting evidence suggests the existence of variations between the tools used for data processing that affect the DQ of data extracts. Current research has, to some extent, addressed such variations in data-processing tools from technological and semantic points of view. Examples include a mismatch in data models and lack of semantic interoperability between the EHR system and the data-processing tool (Liaw et al., 2013a; Liaw et al., 2013b). However, while data extraction is often performed manually, the existing literature fails to address how human actors' use of data-processing tools influences the quality of information generated for secondary use of EHR data (i.e., quality of data extraction, data organization, data analysis, and information production). This can, therefore, be considered a gap in the literature.

Another example is an unaddressed challenge related to generating information according to user needs. Since one core assumption from the existing literature suggests that the process of information generation based on EHR data is often immature and ad hoc in health care organizations, it makes sense to address this issue by promoting process standardization (Foshay & Kuziemsky, 2014), quality governance (Needham et al., 2009), and user involvement (Foshay & Kuziemsky, 2014; Needham et al., 2009). However, de Lusignan et al. (2006) stated that the process should account for contextual complexities inherent to health care organizations, as discussed in Subsection 3.5.1, including process uncertainty, patient disorder evolvement, discretionary judgment, lack of time and resources and other issues (Liaw et al., 2012). As discussed in Section 2.4, these contextual complexities make both standardization of the information generation process and user involvement challenging in the process of secondary use of EHR data. For example, in health care organizations, information is the subject of interpersonal communication (Avison & Young, 2007), where the actual use of information often resides outside the control of the actors generating the information (Mettler et al., 2008). Consequently, information needs in secondary use of EHR data are often difficult to fully articulate ex ante (Lillrank, 2003). This challenge of

addressing information needs when generating information is not addressed in the existing literature on secondary use of EHR data, and can, therefore, be considered a gap in the literature.

3.5.3 IQ and Information Communication

Papers within this theme discuss how information based on secondary use of EHR data is being communicated. Through techniques and tools, such as email, shared drives, Web 2.0 applications, and various ISs, an extensive amount of information is being communicated within health care organizations, consequently risking information overload (Michelberger et al., 2011). Thus, when an information artifact has been produced for the secondary use of EHR data, it is important to achieve relevant, reliable, and timely information communication to consumers (Jeffs et al., 2015) for action to be taken in response to the information (Ginsburg, 2003). Dissemination intensity and modes of communication are found to relate significantly to consumers' perceptions of usefulness (Ginsburg, 2003).

Only a few articles identified in this review addressed how communication impacted the consumers' perceptions of IQ. These articles are summarized subsequently.

Communication issues. With an increasing information overload in health care organizations, delivering the right information, in the right way, in the right format, with the right level of specificity, at the right place, at the right time, and to the right actors is challenging (Michelberger et al., 2011). In one study, 76% of the respondents reported that access to EHR data for secondary use was a major barrier to the effective use of the information (Foshay & Kuziemsky, 2014). Similarly, another study found that 35% of the respondents involved in a process using secondary EHR data never received the output information artifact of the information generation process (Ginsburg, 2003). These findings confirm other studies demonstrating that information outcomes based on EHR data are only received by a small group of frontline managers (Ginsburg, 2003). This lack of information access furthermore hampers action taken by frontline staff (de Vos et al., 2013). The most significant challenge of communicating information within health care organizations is found to be the lack of communication strategies

(Foshay & Kuziemsky, 2014). The lack of such strategies can lead to manual circumventions, where actors spend time increasingly on manual information extraction to meet local information needs (Foshay & Kuziemsky, 2014), which often leads to inefficient data processing (Lindquist, 2004).

Moreover, communication of high-quality information alone is often insufficient to engage frontline staff in action (Ginsburg, 2003), since information might not be understood or interpreted correctly (Jeffs et al., 2015).

Addressing communication issues. Providing high-quality information to relevant consumers is found to be critical in enabling action in response to the secondary use of EHR data (de Vos et al., 2013; Foshay & Kuziemsky, 2014). To assure that relevant, reliable, and timely information is being communicated effectively and efficiently to consumers (Jeffs et al., 2015), health care organizations must establish communication strategies (Foshay & Kuziemsky, 2014; Ginsburg, 2003). Establishment of roles, responsibilities, policies, and procedures for the information generation process should include the communication of the information artifact (Liaw et al., 2013a). For example, all data should be reviewed and quality should be assessed before being communicated to consumers (Kerr & Norris, 2008). Prior to establishing a communication strategy, existing processes should be analyzed (Liaw et al., 2013b) as an initial step for establishing process-oriented information logistics (Michelberger et al., 2011).

Communication strategies include policies about whether information is pushed to or pulled by consumers. One study found that all information was pulled by consumers, but ideally, a mixture was found to be more useful (Foshay & Kuziemsky, 2014). By using push strategies, organizations must find the most effective combination of rich versus lean communication (Ginsburg, 2003), through information sharing, displaying information, and discussing information artifacts with consumers (Jeffs et al., 2015). Important factors for successful communication include using multiple modes and channels for communication and having a redundancy of key messages (Ginsburg, 2003). Furthermore, clinicians are not always able to understand, interpret, or see the relevance of the data, which is a prerequisite for being accountable and to engage in action

(Hausvik, 2017a; Jeffs et al., 2015). Here, frontline managers are strategically positioned to make sense of and translate the data for clinicians to see clear links to their daily practice and to provide a shared accountability of actions (Hausvik, 2017a; Jeffs et al., 2015). Thus, frontline managers should act as catalysts for information dissemination by aligning the information with corporate priorities and standards so that clinicians can perceive the relevancy of the information (Jeffs et al., 2015). Translation of data can be done by 'people-izing' the information, meaning that information is presented using patient stories by conveying the information in meetings and face-to-face (Jeffs et al., 2015) and by using additional tools such as cause-and-effect diagrams and action plans (de Vos et al., 2013).

Summary and discussion. The few articles identified that relate to this theme were concerned with quality issues in communication of the information generated for secondary use of EHR data. A core assumption derived from the literature is that information users' perceptions of IQ are not only determined by the quality of the information itself, but also by the communication of the information (Ginsburg, 2003). The review identified several issues leading to challenges in information communication process, as summarized in Table 3-4.

Table 3-4: Summary of IQ and Information Communication

Source	Issues	Addressing the issues
Communication of information	Information overload; access to information; lack of communication strategies; inefficient data processing; mode of communication	Analyzing existing communication processes and establishing communication strategies; balance push and pull; balance rich versus lean; establish roles and responsibilities for communication; engage frontline managers as catalysts of information; 'people-izing' information to clinicians

Existing literature emphasizes the importance of delivering high quality information to the right users at the right time (Michelberger et al., 2011), where the lack of access to information is the major barrier to the effective use of information in secondary use of EHR data (Foshay & Kuziemsky, 2014). Furthermore, the mode of communication is suggested to impact users'

perceptions of the information usefulness (Ginsburg, 2003), thus influencing action taken by frontline staff (de Vos et al., 2013). There is, however, an important aspect of the users involved in the communication process that is unaddressed: is the information user actively retrieving the information from the data-processing tool, or is the information provided to users through interpersonal communication? The former can be characterized as a pull strategy, whereas the latter can be considered a push strategy (Foshay & Kuziemsky, 2014). As discussed in Section 2.4, information in health care organizations is often the subject of interpersonal communication (Avison & Young, 2007). Thus, one would expect to find evidences that conflicts with the findings of Foshay and Kuziemsky (2014), who only observed pull strategies in secondary use of EHR data. Furthermore, push strategies are associated with modes of communication, such as lean (e.g., sharing information) versus rich (e.g., discussing information) communication. The mode of communication is minimally addressed in the existing literature on secondary use of EHR data. One exception is Ginsburg (2003), who suggested that health care organizations needed to find an effective combination of lean and rich communication. How such choices impact IQ was not addressed.

In summary, existing literature on secondary use of EHR data has not sufficiently addressed how human interactions, through different modes of communication, impact information users' perceptions of IQ. Thus, this can be considered a gap in the literature.

3.5.4 IQ and Information Use

Papers within this theme discuss the role of IQ in the use process of information. By translating EHR data into information and through proper communication, organizations can leverage the information to understand clinical and operational processes and make appropriate changes in those processes resulting in improved outcomes (Jeffs et al., 2015). From the information consumers' perspective, IQ influences the action potential (de Vos et al., 2013; Jeffs et al., 2015; Lillrank, 2003), where consumers failing to see the relevance will disregard the information, and thus not take appropriate action (Ginsburg, 2003). Action taken on poor quality information may further result in adverse outcomes (Foshay & Kuziemsky, 2014). Despite increased efforts to extract EHR data, outcome information often fails to

enable action in health care organization (Ginsburg, 2003), possibly because of the lack of research focus among frontline and midlevel hospital managers' perceptions of the usefulness of information (Ginsburg, 2003).

Use issues. In one study, 70% of the hospital managers reported that accuracy, interpretability, and perceived usefulness created a barrier to actual use of the information (Ginsburg, 2003). More recently, 42% of the respondents cited poor quality of format, currency, and timeliness as major barriers to effective decision-making based on secondary use of EHR data (Foshay & Kuziemsky, 2014). Specifically, high quality information for decision-making may exist, but it is inaccessible or not communicated to relevant actors when needed (Foshay & Kuziemsky, 2014). Furthermore, poor IQ may lead to a lack of trust in the information (Lindquist, 2004) and consequently to a lack of decision confidence (Foshay & Kuziemsky, 2014), thus hampering the use of the information (de Vos et al., 2013).

Consumers evaluate IQ on several quality dimensions, which originate from the data entry process, the information generation process, and the communication process (Clark et al., 2013; Jeffs et al., 2015; Perimal-Lewis et al., 2015), and they perceive information to have high IQ when it is fit for the intended use (de Lusignan et al., 2006). However, simply generating and providing high quality information based on secondary use of EHR data to consumers will not in itself lead to use (Ginsburg, 2003). Additionally, the information must be perceived as relevant and urgent by the information consumer (Jeffs et al., 2015; Liaw et al., 2013a; Lindquist, 2004), in an environment where time and resource constraints challenge consumers' perception of relevancy (de Vos et al., 2013). IQ may be perceived as high for one consumer and low for another (Ikram, Zhao, & Su, 2009). This discrepancy might be because information in health care can be equivocal, and interpreted in several, often conflicting ways (Preuss, 2003). Translating equivocal information into effective action is difficult (de Vos et al., 2013; Hausvik, 2017a) and depends on the interpretive skills and knowledge of consumers exposed to the information (Preuss, 2003). Such skills and knowledge are often missing in health care organizations, which hampers action (Foshay & Kuziemsky, 2014; Preuss, 2003).

Like the information generation and communication processes, the information consumption process is found to be ad hoc, where a lack of defining information needs from a consumer perspective is a significant issue (Foshay & Kuziemsky, 2014). Poor understanding of core processes (Foshay & Kuziemsky, 2014) and lack of normative standards and benchmarks are persistent challenges that decrease the interpretability and actionability of information based on secondary use of EHR data (de Vos et al., 2013).

Addressing use issues. Perimal-Lewis et al. (2015) suggested that users of information based on EHR data must be confident with the quality of the dataset, and should be aware of any associated biases in data that may affect the IQ (Verheij et al., 2018). In addition to being reliable, timely, accurate, adequate, appropriately complex, understandable, and with an adequate level of granularity (Ginsburg, 2003; Kerr & Norris, 2008; Michelberger et al., 2011), information needs to be provided to the right people at the right place and time (Michelberger et al., 2011), and it should be perceived as urgent, useful, and applicable for actions to be taken in response (Hausvik, 2017a; Kerr & Norris, 2008; Preuss, 2003). Thus, IQ affects information consumers' commitment at various organizational levels to use the information (Hausvik, 2017a). For information to be perceived as relevant and useful, it should be tailored to its audience (Ginsburg, 2003). Whereas senior managers tend to prefer high-level summaries and line managers tend to prefer detailed, unit-specific information (Ginsburg, 2003; Hausvik, 2017a), information to clinicians should be multifaceted (de Vos et al., 2013) and linked directly to patient care, for example, by reflecting patient progress, satisfaction, and experience at the unit-specific level (Jeffs et al., 2015).

Though increased IQ may lead to action (Preuss, 2003), there also needs to be an organizational culture supporting the secondary use of EHR data. Such a culture includes a commitment by key administrators, the presence of an organizational mandate, senior leadership for agenda-setting, and a senior champion that directs managers to the data, informing them about the priority of the data and information (Ginsburg, 2003; Hausvik, 2017a). Furthermore, sufficient time and resources need to be allocated (de Vos et al., 2013), and the required support to use the information needs to be provided (Ginsburg, 2003).

Standardizing the information use process through closer involvement of consumers in the information generation process increases the possibilities of a mutual understanding (Foshay & Kuziemsky, 2014) and facilitates use (de Vos et al., 2013; Hausvik, 2017a). Since the use of equivocal information depends largely on the interpretive skills of the consumer exposed to the information, it is important to provide consumers with extensive relevant knowledge to enable them to use their skills (Preuss, 2003). Consumer involvement may lead to increased sharing of information and knowledge, which further leads to increased interpretive skills and increased IQ perceived by consumers (Preuss, 2003).

Summary and discussion. The articles identified that focus on this theme present the role of IQ in the utilization of information in the process of secondary use of EHR data. From this literature, two core assumptions can be derived: (1) information needs to be tailored to specific user groups (de Vos et al., 2013; Ginsburg, 2003) to fit the needs for intended use (de Lusignan et al., 2006); and (2) the information must be perceived as relevant by the information users to enable appropriate actions in response to the information (Ginsburg, 2003; Jeffs et al., 2015). The review identified several issues leading to challenges in employing the information for the secondary use of EHR data, as summarized in Table 3-5.

Table 3-5: Summary of IQ and Information Use

Source	Issues	Addressing the issues
Use of information	Inaccessible to users; not communicated to relevant users; poor DQ, IQ, or CQ; lack of relevancy, urgency; difficult to translate equivocal information to action possibilities; lack of user knowledge and interpretive skills; ad hoc use process; unclear information needs; poor understanding of core processes; lack of normative standards and benchmarks	Transparency of data biases; tailor information with correct level of specification; build an organizational culture supporting secondary use; management commitment; organizational mandate; champions; sufficient time and resources; standardization of the use process; clinician involvement; increase knowledge

The assumptions derived from existing literature related to this theme raise contradictions when considering the literature discussed in Subsections 3.5.2 and 3.5.3. First, making information fit for use by tailoring the information is challenging since the information needs may not be fully articulated ex ante prior to information generation (Lillrank, 2003). Stated differently, when designing information for the secondary use of EHR data, it can be difficult to understand for what and whom the information should be fit. Existing literature does not address how this possible misalignment of information needs and actual information provided affects information use.

Second, organizational research suggests that information is likely to be modified and adapted when communicated between actors within organizations (Rogers & Agarwala-Rogers, 1976). Since information is communicated between human actors and groups of human actors, it is likely that multiple levels of both users and information needs exists within the scope of secondary use of EHR data. Moreover, the information generated from EHR data can be equivocal and interpreted in different and conflicting ways (Preuss, 2003), thus influencing the information users' perceptions of its relevancy. Consequently, several suggestions from the existing literature to address the issues of IQ in the information use process can be questioned. For example, is it possible to formalize the information needs and fully standardize the use process? Also, are the fit of information for use and the perceptions of the relevancy of information both determinants for whether actors will use the information? These issues are not addressed in existing literature on secondary use of EHR data.

3.6 Chapter Summary

In this chapter, I presented the findings from a two-staged literature review. The explorative review aimed at acquiring a broad understanding of how IQ impacts health care organizations. The review concluded with a determination of the need for more research on how IQ influences the process of secondary use of EHR data.

By conducting the focused review from a life-cycle perspective on IQ, I synthesized and discussed existing literature focused on the different processes applied for secondary use of EHR data: DQ and usability of EHR data for

secondary use, IQ in information generation, IQ in information communication, and IQ in information use. In discussing the literature, I identified the following gaps in the existing literature, presented as propositions:

- Since existing workflows account for the contextual complexities inherent to health care processes, a full standardization of the data entry process can disrupt the workflow and negatively affect DQ.
- Expecting clinicians to resolve DQ issues in the data entry process by involving them in DQ validation may be counterproductive and can result in ego-defensive mechanisms being deployed by the clinicians.
- Some DQ improvement interventions in the data entry process (e.g., quality incentivizing and information sharing) can be counterproductive and can introduce additional biases into the data entry process.
- Human actors' use of data-processing tools in the information generation process influence IQ of the output information artifact.
- Actors involved in generating information artifacts cannot fully understand the information needs since information needs are not fully articulated ex ante; consequently, information artifacts may be modified and adapted before being communicated between different levels of users, which also result in a change in the IQ of the artifacts.
- Differences in modes of communication influence information users' perceptions of IQ in interpersonal communication.
- Alignment between user needs and actual information (fit for use) is insufficient to determine whether actors will engage in action based on the information.

The first three propositions are related to the data entry process of routinely collected EHR data. Since this dissertation mainly focuses on the process of secondary use of EHR data, those propositions will not be addressed from this point forward.

From the discussion of the literature, it becomes apparent that the different processes in secondary use of EHR data are interconnected. For example, choices made by actors in the information generation process and communication process influence users' perceptions of IQ in the use process. In order to be sensitive to

these interconnections, the research data for this study are analyzed from a life-cycle perspective of IQ. The propositions illustrate that there is a general gap in the literature on how IQ is transforming in the process of secondary use, from generation and modification to communication and use.

Moreover, the propositions suggest that IQ in the process of secondary use of EHR data is part of a complex interplay of human actors, technology, and information. In order to acquire a deeper understanding of how this interplay impacts human actors in generating, communicating, and using information, the underlying mechanisms involved in transforming the IQ in the process of secondary use of EHR data are explored in this study.

The following two chapters present first, the theoretical lenses that are applied, and second, how the propositions derived from the literature guided the research design for this study.

4 Theoretical Lenses

The research framework presented in Figure 1-1 suggests that (1) IQ is transforming through the processes of information generation, communication, and use, and (2) that sociotechnical mechanisms exist that underpin the processes. As discussed in the previous chapter, the different processes in secondary use of EHR data are interconnected, where choices made by actors in the information generation process and communication process influence users' perceptions of IQ in the use process. In order to be sensitive to these interconnections, while seeking to understand how IQ is transforming, this study is conducted from a life-cycle perspective (see Figure 2-3). To understand the underpinning mechanisms, however, an appropriate theoretical lens is needed to address the sociotechnical aspects of the process. The identified gaps, as summarized in Section 3.6, highlight the need to investigate the underlying sociotechnical interplay between human actors, technology, and information to understand generation, communication, and use of information. This chapter presents the theoretical lenses used to address the gaps in the literature. First, the process of theory selection is described, followed by a presentation of the theory of affordances and the concept of mediators.

4.1 Theory Selection

Through theoretical concepts, I will be able to re-describe the empirical data and increase the theoretical level of engagement beyond thick descriptions of empirical entities (Fletcher, 2016). The role of theory is discussed in detail in Subsection 5.4.2. Thus, selecting an appropriate theory as the basis for the research is important, and several considerations need to be made. Walsham (2006) offered some general principles guiding the process of theory selection in qualitative research:

- To convince others, you must be convinced that the selected theory is the most appropriate. Thus, you must perceive the theory to provide insights relevant to the research topic and the field data.
- Do not fix on one theory without evaluating alternative theories, but rather investigate widely to increase the likelihood of making a good and informed choice.
- Do not dismiss a theory without evaluating it in some depth.

- Listen to others as a source of inspiration. However, the choice must be your own, and not because of other peoples' opinions or based on fashion.

In the process of selecting the theory for this study, I evaluated several theoretical lenses. Taking the general principles of Walsham (2006) as a starting point, I developed a set of criteria for selecting the appropriate theory from candidate theories. The criteria presented in Table 4-1 are based on my philosophical positioning (see Section 5.1) and include both general criteria and criteria derived from existing EHR systems and IQ literature. Although I evaluated many theories, such as the organizational information processing theory (OIPT), the contingency theory, media synchronicity theory, technology acceptance model, and IS success model, I exemplify the process by discussing two of the discarded candidate theories.

At an early stage of the project, and before the data collection, OIPT, introduced by Galbraith (1974), was a candidate theory for this study. The rationale for using OIPT was the combination of the overall research agenda of how IQ influences organizations, and the ability of OIPT to connect technology and information to organizational outcomes. More specifically, OIPT suggests that an ideal fit between information-processing capability (technology) and information-processing needs (information) leads to increased organizational performance (Premkumar, Ramamurthy, & Saunders, 2005). This idea of fitness between processing capabilities and needs seemingly translates well to the most adopted definition of IQ (see Subsection 2.2.2), where high quality is achieved when information is fit for use (Neely & Cook, 2011). Furthermore, OIPT is rooted in the contingency theory (Haußmann, Dwivedi, Venkitachalam, & Williams, 2012), which relates closely to the prevailing view of information. For example, information has most often been viewed as a product (Kahn et al., 2002; Wang, 1998; Wang et al., 1998; Wang & Strong, 1996), where an information artifact is viewed as the output of a well-defined manufacturing process (Lee et al., 2006; Wang, 1998; Wang et al., 1998). This manufacturing view is often adopted by contingency theorists, where technology is perceived as the production system that manufactures information based on data (Leonardi, 2010).

Table 4-1: *Criteria for Choosing Theoretical Lens*

Criteria	**Explanation**
Relevant to data	The selected theory should be relevant to the data and provide the researcher with insights from the field data (Walsham, 2006).
Relevant to research topic	The theory should be relevant to the research gaps identified in Chapter 3, and should thus provide insights to the research questions or research agenda under investigation (Houston, 2001).
Addressing human agency, social processes, and technology	The theory should be non-deterministic (see ontological positioning in Section 5.1) and account for both structure and human agency (Dobson, 2001), since IQ in an EHR system context encompasses human, social, and technological elements, where information is generated, communicated, and used (Cabitza & Batini, 2016). However, most research is based on a technological view of IQ (Mettler et al., 2008), and more attention should thus be given to sociotechnical factors (Mohammed & Yusof, 2013). Thus, the selected theory should be able to explain the complex interplay between human actors, technology, and information, as discussed in Section 3.3.
Addressing contextual complexity	As discussed in Section 3.5, there exists several controversies related to contextual complexity in current literature. An EHR system context is highly complex and comprises several tensions and paradoxes (Greenhalgh et al., 2009). The selected theory should not overlook such contextual complexity.

By applying the selection criteria and assessing the usefulness of the theory, some challenges arise. While OIPT would be able to address aspects of the overall research agenda based on the relation between information-processing needs, capabilities, and organizational outcome, and it would also be applicable to the collected data to gain insights into contingencies influencing this relation, OIPT becomes challenging when it comes to the role of technology because it has been criticized for its technological imperative, leaving individual and social issues unaddressed (Haußmann et al., 2012). According to Leonardi (2010), contingency theories posit a strong deterministic view, where technology acts as a causal agent

of organizational change. This view is also reflected in OIPT, where increased fit between information needs and processing capabilities leads to increased performance by (1) reducing environmental uncertainty in which actors process the information or (2) increasing the processing capabilities of the technology (Premkumar et al., 2005). This deterministic view of technology from the contingency theory and OIPT translates poorly to research on IQ in an EHR system context that encompasses human, social, and technological elements wherein information is generated, communicated, and used (Cabitza & Batini, 2016). Thus, the processes of generating and providing information fit for use cannot alone explain whether information is actually applied by information users (Ginsburg, 2003), which is a major shortcoming of the contingency theory, OIPT, and the current definition of IQ.

As discussed in Subsection 3.5.1, the health care context is often described as inherently complex (Avison & Young, 2007), and several tensions and paradoxes exist in current EHR systems research (Greenhalgh et al., 2009). Such tensions include treating (1) the EHR system as either a "container" or an "itinerary"; (2) the EHR system user as an information processer or as a member of a sociotechnical network; and (3) the organizational context as the setting within which the EHR system is implemented, or as the EHR-in-use (Greenhalgh et al., 2009, p. 729). The contingency theory, for example, has been criticized for being too static, for failing to address the complexity within organizations and the variations of structures and technology between organizations, and for not addressing human agency (By, 2005). OIPT has been criticized for not recognizing that users of technology may have different frames of reference and for failing to address the multifaceted nature of technology (Haußmann et al., 2012).

As found in the literature review (see Section 3.2), most research articles addressing IQ in the context of secondary use of EHR data were not underpinned by any specific theoretical frameworks. With the above discussion in mind, and through calls for more attention to sociotechnical factors (Mohammed & Yusof, 2013), this study needs to be approached with a solid theoretical foundation that (1) diverges from the mainstream contingency-driven IQ research, by (2) incorporating human, social, and technological elements for generating, communicating, and using information (Cabitza & Batini, 2016).

The following section presents the selected theory for this study: the theory of affordances.

4.2 Theory of Affordances

In contrast to contingency theory and the OIPT, the theory of affordances addresses the complexity of EHR systems in organizations (Mettler, Sprenger, & Winter, 2017). A relational view of technology and human actors in a social context is the essential core of the theory (Chemero, 2003), thus avoiding technological determinism. By distinguishing between what actors can potentially accomplish with the technology and the actual outcome of using the technology, the theory of affordances can address the shortcomings of both OIPT and the prevailing views of IQ.

The following section presents the origins of the theory of affordances and its application in the IS field. As with other theories, the theory of affordances also has some limitations. Thus, the challenges in the context of secondary use of EHR data are discussed in Subsection 4.2.3.

4.2.1 Origin

The theory of affordances was coined by Gibson (1979) in his seminal book, *The Ecological Approach to Visual Perception* – a book challenging the contemporary research on perception within the fields of physics, optics, anatomy, and visual physiology. Gibson's (1979) ecological approach differentiates between the animal environment (the perceptions of animals) and the physical world (the world described by physics), and considers "affordances" as follows:

> [T]he affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment. (p. 127)

This definition implies that an affordance is a property of the environment relative to animals with capabilities of perceiving and using the affordance (Chemero, 2003). However, Chemero (2003) argued that affordances cannot be features or properties of the environment alone, but features of a whole situation, or relations between the environment and animals. More specifically, he suggests affordances to be the "relations between abilities of organisms and features of the environment" (Chemero, 2003, p. 189).

While Gibson (1979) was concerned with the relation between animals and the environment from an ecological psychology view, several researchers adapted the theory to understand the relationship between human actors and technology. For example, in the late 1980s, Norman (2013) first published the book *The Design of Everyday Things* in which he connected the theory of affordances to the practice of designing objects. He suggested that affordances can be designed into objects, and make them perceivable for human actors through designing "signifiers," such as words or graphical illustrations (Norman, 2013, p. 19). Subsection 4.2.2 briefly summarizes the use of the theory in IS research.

4.2.2 Theory of Affordances in IS Research

The concept of affordances has been applied in many fields of research (Şahin, Cakmak, Doğar, Uğur, & Üçoluk, 2007). In the IS context, affordances are often defined as "the possibilities for goal-oriented action afforded to specified user groups by technical objects" (Markus & Silver, 2008, p. 622). Many views on types of affordances exist; Lanamäki, Thapa, and Stendal (2016) distinguished between four major stances of affordances: canonical affordances, designed affordances, potential affordances, and affordances as completed actions. In this study, the potential affordance position is adopted, where an affordance is viewed as a relation between actual human actors and the materiality of IS (Fayard & Weeks, 2014; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). In this view, individuals interact with an object based on perceptions of what the object can be used for (Seidel, Recker, & Vom Brocke, 2013). Thus, affordances arise when individuals interpret technology through their goals for action (Zammuto et al., 2007).

Recent studies advocate that it is not enough to understand how human actors perceive the IS affordances, but also understand how the affordances are actualized by human actors (Anderson & Robey, 2017; Bernhard, Recker, & Burton-Jones, 2013). Figure 4-1 illustrates the existing view on the relationships between affordances as action possibilities, actualization, and outcome.

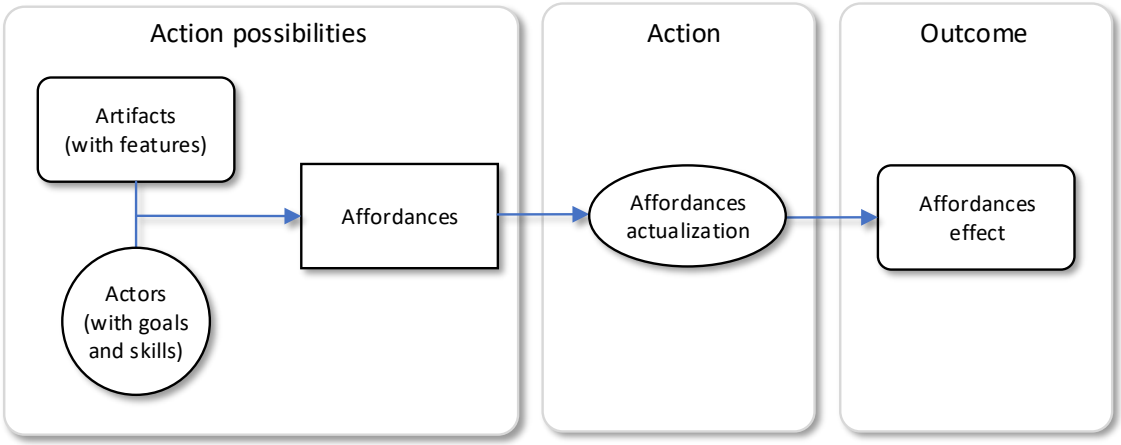


Figure 4-1: Relationships between affordances, actualization, and outcome.

Bernhard et al. (2013) argued that actualization is influenced by users' perceptions of the effort that needs to be invested for enactment. Anderson and Robey (2017) supported this view by introducing the concept of "affordance potency" as "the strength of the relationship between the abilities of the individual and the features of the system at the time of actualization, conditioned by the characteristics of the work environment" (p. 103). They argued that the level of ease (i.e., mental and/or physical energy) needed to actualize the affordance that influences users' decisions of actualization (Anderson and Robey (2017). Strong et al. (2014) also identified characteristics of the environment as factors facilitating and/or inhibiting actualization of affordances.

4.2.3 Relevance of Affordances in Secondary Use of EHR Data

EHR systems have been viewed as technologically capable of transforming health care systems and assuring a higher quality of care to patients (DesRoches et al., 2008; Meidani, Sadoughi, Malieki, Tofighi, & Marani, 2012; Menachemi & Collum, 2011). However, previous studies show that such transformations are complex and challenging, arguing that the adoption of EHR systems alone is not

sufficient to assure quality of care and that such adoption needs to be coupled with IS artifacts, actors, and context (Greenhalgh et al., 2009; Zhou et al., 2009). This can be illustrated by the following propositions derived from the literature review (see Section 3.6):

- Human actors' use of data-processing tools in the information generation process influences IQ of the output information artifact.
- Alignment between user needs and actual information (fit for use) is insufficient to determine whether actors will engage in action based on the information.

The first proposition indicates that the IQ of information artifacts produced for secondary use of EHR data is the result of a complex sociotechnical process. The second proposition expresses that alignment between information user needs and the actual information (fit for use) is insufficient to determine whether actors will engage in action based on the information. This illustrates an important point: even though actors perceive an action possibility that they are capable of actualizing, it does not mean that it will be actualized. The theory of affordances addresses this point by distinguishing between the processes of affordance perception and actualization by human agency (Pozzi et al., 2014).

Studies show that the theory of affordances can capture the complexity of EHR systems in organizations (Mettler et al., 2017). For example, Strong et al. (2014) developed a mid-range theory of EHR system-associated organizational change by applying the theory of affordances. Their theory helps us to understand the complex relations between technological artifacts (e.g., EHR systems), the actors (EHR system users and other actors in health care), and the context (organization, social structures), and how these relations lead to action possibilities. Their extension of the theory includes the process of actualizing the potential of affordances by theorizing about higher-order affordances and how the affordances of EHR systems are bundled and interrelated. However, actualization of the affordances depends on the relationship between the system and the actors, in the context in which the IS are used (Leonardi, 2011), resulting in a wide range of potential outcomes (Volkoff & Strong, 2013). For the purpose of this dissertation,

and by building on the work of Strong et al. (2014), the following three unresolved issues need to be addressed:

First, actualizing IS affordances can be highly complex, since actualization happens in an open system that is beyond human ability to control directly (Wynn & Williams, 2012). Strong et al. (2014) identified three key factors leading individuals to actualize EHR system affordances: (1) individual abilities and preferences, (2) the EHR system's features, and (3) the work environment's characteristics. They found that factors 1 and 2 not only form the affordances, but they also affect actualization (Strong et al., 2014). Furthermore, factor 3 affects the actualization of any affordance, and sometimes the formation of an affordance itself. Similarly, Thapa and Sein (2018) argued that *facilitating conditions* are sociotechnical arrangements that make affordances available in a particular context. They exemplified how a facilitating condition (e.g., a social group in a village) made an affordance (e.g., virtual co-localizability) available to actualize (Thapa & Sein, 2018). However, in the existing research, the factors that make affordances available and the factors that influence the actualization processes are not clearly differentiated. For example, the empirical evidence of such factors only includes variations of resources (Strong et al., 2014), effort, and time constraints (Anderson & Robey, 2017). These examples illustrate two distinct ways factors can affect the actualization process: (1) factors that make affordances available for action in a specific context (e.g., a social group in a village), and (2) factors that either facilitate or constrain the actualization process, and thus influence the human agency to enact (e.g., variations of resources, time constraints, and effort). For the former, this dissertation adopts the idea of Thapa and Sein's (2018) facilitating conditions that condition the actualization process and are mainly focused towards making affordances available for action, whereas the latter is conceptualized in this dissertation as *conversion factors*. Conversion factors are mainly focused towards making human agency act on the available affordances, and can be personal, social, and environmental (Robeyns, 2005). Conversion factors influence not only whether an available affordance is actualized but also the outcome of an actualized affordance. Figure 4-2 illustrates the relation between affordances, facilitating conditions and conversion factors.

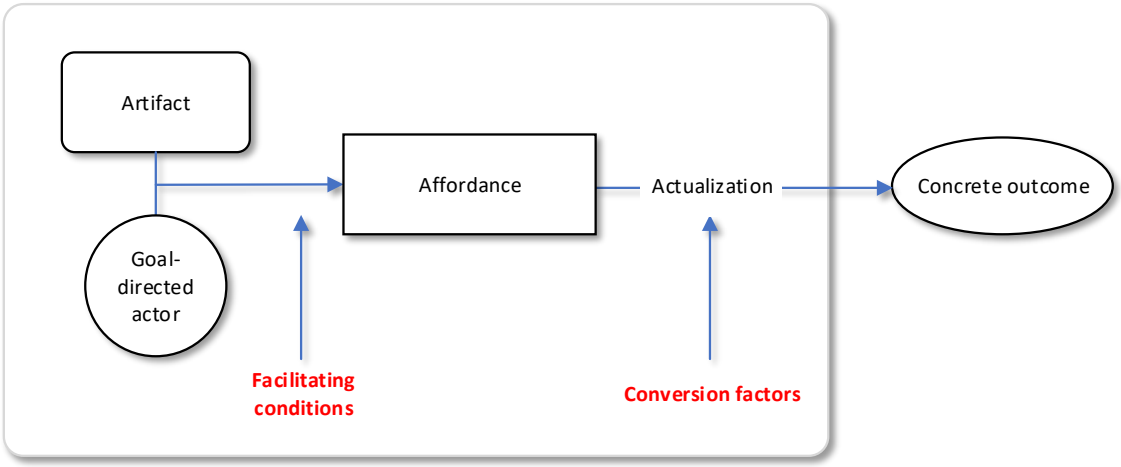


Figure 4-2: Relation between affordances, facilitating conditions, and conversion factors.

Second, Strong et al. (2014) showed how EHR system affordances are interrelated and interdependent, categorizing such dependencies as either strong or weak. In strong dependencies, the actualization of some affordances depends directly on the actualization of other affordances, whereas weak dependencies are not dependent on, but are rather reinforced by the actualization of other affordances. What remains unclear are the dynamics of the interdependencies and how these interdependencies relate to the overall goal of the actors. I argue that the outcome of actualized affordances plays an important role in understanding how affordances are interdependent—a topic hardly debated in IS research. For example, in their framework of affordance constructs, Bernhard et al. (2013) presented the outcome, or effect, as either positive or negative, but without any further elaboration. One notable exception is the work of Strong et al. (2014), which introduced the term "immediate concrete outcome" (p. 70). However, Volkoff and Strong (2017) reduced the urgency of immediate concrete outcome in one of their six principles of using affordances theory in IS research: principle three emphasized that research should "focus on the action, not the state or condition reached after taking the action" (p. 5). The rationale for this suggestion was that focusing on the immediate concrete outcome results in a conflation of affordances research and IS impacts research. This principle, however, can be argued. More recently, for example, Thapa and Sein (2018) introduced the concept of "trajectory of affordances," where actualization of affordances may follow certain trajectories. They found that actualization of certain affordances may lead to the emergence of other affordances, indicating that some affordances might be related by the outcome of actualizing another (Thapa & Sein, 2018). Other

researchers support this connection between affordances (e.g., Pozzi et al., 2014; Strong et al., 2014). Since actors can actualize the same affordance differently, the outcome of actualization is indeterminate (Volkoff & Strong, 2013), potentially resulting in a spectrum of significantly different outcomes (Strong et al., 2014). Thus, I argue that a gap exists in the literature on how the outcome of the actualization process can help us understand how affordances are interrelated.

Third, the work of Strong et al. (2014) focuses on the affordances of EHR system implementations, and thus on some core features of EHR systems. However, the use and utilization of EHR systems introduce a more complex picture where affordances of supplementary technologies (e.g., data-processing tools), including their interrelations, also need to be considered. For example, some EHR system implementations have bundled extensive features into the EHR system (Mandl & Kohane, 2012), while others have more basic features that need to be supplemented with other systems. Such use of supplementing systems, such as databases and spreadsheet applications, can be critical in the day-to-day work in organizations (Handel & Poltrock, 2011) and for reaching organizational goals such as quality management of health care organizations (Foshay & Kuziemsky, 2014). From an affordance perspective, Lindberg, Gaskin, Berente, and Lyytinen (2014) recently argued that affordances are constituted and reconstituted across bundles of technologies. Hence, we need to explore the affordances of all involved technologies, and their interrelations. Following Lindberg et al. (2014), I argue that by focusing solely on the EHR system, a complete map of affordances in the process of secondary use of EHR data cannot be provided.

4.2.4 Distinction between IS and Information Affordances

As described in Subsection 4.2.1, most IS studies adopt the functional view where affordances of technology exist between human actors and the materiality of IS (Fayard & Weeks, 2014; Zammuto et al., 2007). In this study, such functional affordances are referred to as *IS affordances*. However, what the information artifact from IS can afford users is, to my knowledge, not discussed previously in research applying the theory of affordance. Such affordances of information are discussed next.

Without connecting it to the theory of affordance, some existing IQ research refers to information as "actionable." For example, Lillrank (2003) defined actionable information as "meaning derived from data and context with a knowledge function" (p. 691), where "only meaningful information can enable purposeful action" (p. 694). By treating the output information artifact of the information generation process as an artifact, as suggested by Lillrank (2003), I argue that information artifacts can enable action possibilities by human actors. For example, Jeffs et al. (2015) discussed how the process of translating EHR data to actionable information enables health care organizations to "make appropriate changes in those processes resulting in improved outcome" (p. 269). Moreover, de Vos et al. (2013) found that "difficulties to translate feedback into effective actions… hampered the impact of the [quality improvement] intervention" (p. 233). Thus, this dissertation makes the following distinction of affordances: IS affordances are action possibilities between goal-oriented actors and the properties of IS, whereas *information affordances* are action possibilities between goal-oriented actors and properties of information artifacts.

The theory of affordances introduced through the concept of information affordances helps to address the following unaddressed proposition derived from the existing literature (see Section 3.6): alignment between user needs and actual information (fit for use) is insufficient to determine whether actors will engage in action. In additions to the quality of the information artifact needed to perceive the affordances of the information, the facilitating conditions and conversion factors of the affordance are needed in order to understand whether users can and will engage in action.

4.2.5 The Role of Mediators in Affordances

The common characteristics of information as the product of a manufacturing process from existing IQ literature (see Subsection 2.2.2), where the sole actor involved in transforming data inputs into information artifacts is considered to be the IS, provide a limited understanding of the secondary use of EHR data. In practice, human actors are also involved in transforming data into information artifacts. Furthermore, information artifacts from the EHR systems are not always used directly; they may be communicated to other users. According to Avison and

Young (2007), such interpersonal communications are evident in both primary use of data (e.g., collaborative diagnosis and treatment assessment) and secondary use of data (e.g., organizational planning and decision-making). Thus, viewing the EHR system as the single most important actor involved in generating and communicating the information artifact is insufficient; the human actors involved in generating information artifacts and communicating them to other humans are also important actors.

In Section 3.6, I proposed two unresolved propositions related to interpersonal communication of information artifacts based on existing literature on secondary use of EHR data:

- Actors involved in generating information artifacts cannot fully understand the information needs since information needs are not fully articulated ex ante; consequently, information artifacts may be modified and adapted before being communicated between different levels of users, which also result in a change in the IQ of the artifacts.
- Differences in modes of communication influences information users' perceptions of IQ in interpersonal communication.

The propositions show that involvement of human actors can influence information users' perceptions of action possibilities. In other words, certain actors play an important role in appropriation and actualization of information affordances. For example, the first proposition assumes that human actors may actively modify information before it is communicated between multiple levels of users, and the second proposition assumes that information users' perceptions of IQ are influenced by how actors perform the communication process. Since theory of affordances mainly addresses how individuals perceive and enact action possibilities of artifacts, it does not explain how some actors can influence other actors' perceptions and engagement in action. To better understand the human practices involved in communicating the information artifact in secondary use of EHR data, complementary concepts to the affordance theory are needed. Thus, I apply the concepts of mediators and intermediaries. Intermediaries can be defined as human or technological actors "transporting meaning or force without transformation" (Latour, 2005, p. 39), where defining the inputs of the actor is

enough to define its outputs. *Mediators*, by contrast, are human or technological actors that "transform, translate, distort, and modify the meaning or the elements they are supposed to carry" (Latour, 2005, p. 39). Hence, by transportation, information users may not be able to perceive the affordances of the information (or information affordances, as discussed in Subsection 4.2.2). Through translation, however, mediators can translate the information to make the information affordances perceivable to information users. This distinction between transportation and translation is similar to the modes of communication, as discussed in Subsection 3.5.3. For example, whereas transportation resembles the lean mode of communication, where information is simply shared between actors, translation resembles the rich mode of communication, where information is discussed between actors to reach a shared understanding (i.e., translation). Thus, the concept of mediators is appropriate to address the unresolved issue of how interpersonal communication impacts information users' perceptions of IQ (see Section 3.6).

From an affordance perspective, there exists action possibilities between a mediator and the information artifact (see information affordances in Subsection 4.2.4). One such affordance can be the possibility to communicate information to other actors. Communicating the information artifact can be done with technological intermediaries (e.g., email or presentation software) and without technology (e.g., oral communication). Thus, affordances related to communication are relations between goal-oriented mediators and the information artifact, where the goal of the mediator may be to reach a shared understanding. As discussed in Subsection 4.2.3, the outcome of an actualization process (e.g., level of shared understanding) is influenced by conversion factors. Since the mediator can use different modes of communication (i.e., transportation and translation), the level of shared understanding may vary. Thus, the mode of communication can be viewed as a conversion factor. The output of the affordance (level of shared understanding) will further influence information users' abilities to perceive other information affordances. Thus, the output of the actualization process acts as a facilitating condition for information users. The role of mediators in affordances related to communication is illustrated in Figure 4-3.

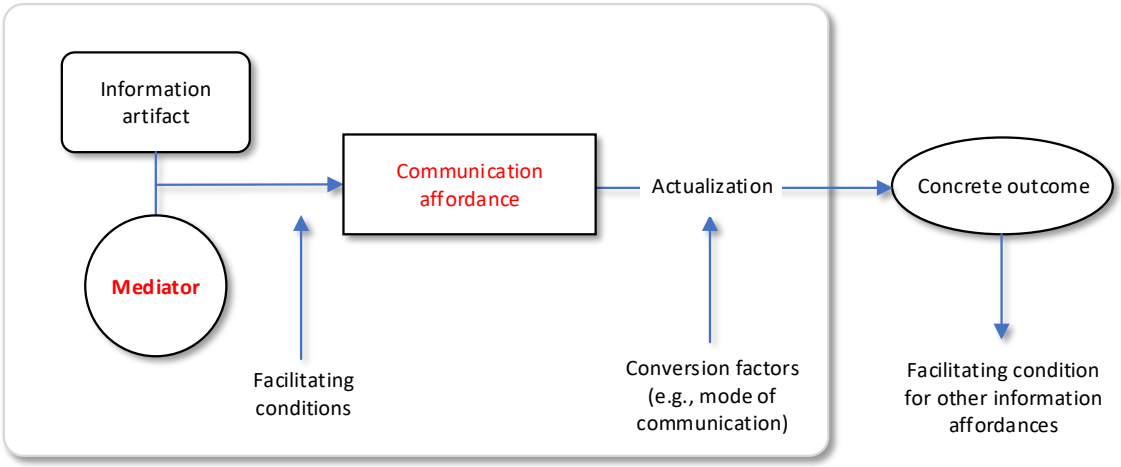


Figure 4-3: The role of mediators in affordances.

In this dissertation, I will document how such human mediators influence IQ as perceived by information users, through transformation, translation, distortion, and through modifications of the meaning of information.

4.3 Chapter Summary

In this chapter, I discussed how the theory of affordances can help to gain insights into the underlying sociotechnical mechanisms underpinning the IQ life cycle, as presented in the research framework (see Figure 1-1). I first described the process leading to the selection of the theory of affordance as a theoretical lens for this study. Then, I presented the origin of the theory and its application in IS research. Finally, I discussed how the theory is appropriate in addressing the unresolved propositions derived from the literature review on secondary use of EHR data in Section 3.6.

I have chosen to address the overall research objective of this study, to understand the role of IQ in secondary use of EHR data, through two research questions. The first research question aims to understand how IQ is changing in the process of secondary use of EHR data, where human agency influences users' perceptions of IQ in the use process. In order to be sensitive to these interconnections, this study is conducted through a life-cycle perspective of IQ (as illustrated in Figure 2-3). The aim is to understand the views on IQ of the various actors involved in generation, communication, and use of information artifacts. Thus, the first

research question is: How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data?

The second research question seeks to understand the sociotechnical mechanisms underpinning IQ transformation in the process of secondary use of EHR data. Thus, the second research question is: What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data? This research question is addressed by applying the theory of affordances. As discussed in this section, this theory is appropriate to address the unresolved propositions from the existing literature (see Section 3.6.). There are, however, some unresolved challenges in the current literature on affordances that relate to secondary use of EHR data. In this section I have discussed how to address these challenges and their relevance in answering the second research question. The challenges are briefly summarized as follows:

- Existing literature on affordances does not distinguish between the factors that make an affordance available for users in a specific setting, and the factors influencing the actualization process and, thus, its outcome. This dissertation research approach conceptualizes the former as facilitating conditions and the latter as conversion factors.
- The outcome of actualizing an affordance is indeterminate, since actors can actualize the same affordance differently. Thus, interdependencies between affordances are more dynamic than the existing literature suggests (i.e., strong and weak dependencies).
- Affordances in the process of secondary use of EHR data involve multiple IS artifacts, not just the EHR system.
- The information artifact generated in the process of secondary use of EHR data enables actors to engage in action. Thus, both ISs and information artifacts provide actors with action possibilities. This dissertation conceptualizes the former as IS affordances and the latter as information affordances.
- The choices actors make when actualizing affordances (i.e., in interpersonal communication of information artifacts) influence information users' perceptions of action possibilities of information affordances. In this study

such actors are conceptualized as mediators that can transport, transform, translate, and distort information.

In the next chapter, I describe the research design used in this study to answer the research questions.

5 Research Design

In this chapter, after identifying the research gaps (see Section 3.6) and positioning the gaps from the affordance perspective (see Section 4.3), I discuss how the research questions are addressed. To investigate the research questions of this study, an appropriate research design is needed. Creswell (2009) argued that research designs are "plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis" (p. 3). The research design can be qualitative, quantitative, or mixed methods that involves the intersection of philosophy, strategy of inquiry, and methods (see Figure 5-1).

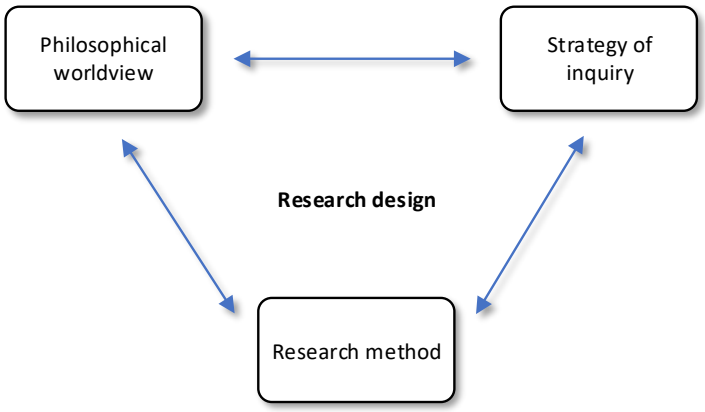


Figure 5-1: Research design, adapted from Creswell (2009).

This chapter describes the research design employed in this study. The components of the research design are (1) the philosophical worldview underpinning this dissertation, (2) the strategy of inquiry, (3) the research methods, (4) the limitations of the research approach, and (5) the ethical considerations of this study.

5.1 Philosophical Worldview

The philosophical premise for this study is critical realism, which assumes a realist ontology and interpretivist epistemology. In his seminal book *A Realist Theory of Science* from 1975, Roy Bhaskar introduced a philosophical alternative to science from a realist perspective (Bhaskar, 2008). Bhaskar's (2008) aim was to develop an alternative to the positivistic science that had dominated Western research for most of the twentieth century. One reason for this positivistic dominance related

to the impact of Humean empiricism that was advocated by the Vienna circle in the 1920s and 1930s (Archer, Bhaskar, Collier, Lawson, & Norrie, 1998). Humean empiricism postulates that knowledge entirely arises from cause and effects of constant conjunctions of events, as originally stated by David Hume in 1748:

> If we would satisfy ourselves … concerning the nature of that evidence, which assures us of matters of fact, we must enquire how we arrive at the knowledge of cause and effect. I shall venture to affirm, as a general proposition, which admits of no exceptions, that the knowledge of this relation is not, in any instance, attained by reasoning a priori; but arises entirely from experience, when we find that any particular objects are constantly conjoined with each other. (Hume, 2007, p. 19)

Bhaskar (2008) refuted the Humean notion of constant conjunctions of events as a necessity for establishing a scientific law. Rather, he argued that it is only through establishing a theory that we can provide adequate explanations of the observed events (Bhaskar, 2008). Put in other words, he asked, "what properties do societies and people possess that might make them possible objects of knowledge for us?" (Bhaskar, 1998, p. 15). This question is a transcendental argument, and the essence of scientific realism—to understand what the world must be like to generate a certain phenomenon (Smith, 2006), and Bhaskar's main question in his book from 1979, *The Possibility of Naturalism*, in developing critical naturalism for social sciences (Bhaskar, 1998). By asking this question, Bhaskar (2008) criticized the Humean statement that knowledge entirely arises from experience and described it as an "epistemic fallacy" (p. 5), meaning that ontological statements (statements of being) are often and mistakenly being reduced to epistemological statements (statements of knowledge or experience of being). Smith (2006) illustrated the epistemic fallacy by showing how logical positivists are committing this fallacy in claiming that a proposition is meaningless unless it is tested and verified empirically.

The solution to the epistemic fallacy in critical realism are the ontological concepts of *intransitivity*, *transfactuality*, and *stratification* (Archer et al., 1998). Intransitivity means that the world consists of both transitive and intransitive dimensions, where the transitive dimension comprises knowledgeable objects, and the intransitive dimension constitutes objects that are not dependent upon our

knowledge. Whereas empiricism only accepts the transitive dimension, i.e., "which cannot be perceived cannot be" (Mingers, Mutch, & Willcocks, 2013, p. 796), critical realism emphasizes this distinction and the existence of intransitive objects and structures independent of human knowledge. By transfactuality, Bhaskar (1998) argued that the laws of nature operate independently of the systems in which they occur and independently of human perception. Consequently, the laws of nature can (1) produce (actualize) phenomena that are observable for humans, (2) produce (actualize) phenomena that are unobservable for humans, and (3) inhibit (not actualize) phenomena from occurring. Failure to recognize transfactuality results in a homogenous and collapsed reality, and is defined as the "fallacy of actualism" (Archer et al., 1998, p. xii). By assuming that the world consists of intransitive objects and structures, i.e., beyond our knowledge, and that laws of nature operate independently of human perception, critical realists argue for the existence of stratification in nature, claiming that it should thus be reflected in science (Archer et al., 1998). Fundamental to this assumption is the existence of a reality independent of human knowledge. In critical realism, this stratification is three-fold; namely, the domains of the real, actual, and empirical. The domain of the real is the "whole" of reality, including deep structures, experiences, mechanisms, and events. Further, these structures in the domain of real have the capacity of behaving in certain ways, namely as "generative mechanisms" (Bhaskar & Lawson, 1998, p. 6). The outcomes of the mechanisms are actions or events (or they constrain actions or events from happening) in the stratified subset of real, called the domain of actual. In other words, if a phenomenon in the real is actualized, it belongs to the domain of the actual. Finally, if a phenomenon actualized in the domain of actual is being observed, it belongs to the domain of the empirical, which means that the structures and generative mechanisms are ontologically decoupled from the events they produce (Smith, 2006).

Thus, the aim of research in critical realism is more than just investigating the observed events; it involves building theoretical foundations to understand the conditions of how the observed events could be produced. The aim of research includes identifying the mechanism and its structure (vertically) and the other relevant structures (horizontally) in the system under investigation. Figure 5-2 illustrates the research strategies in critical realism, which is adopted from Bygstad, Munkvold, and Volkoff (2015).

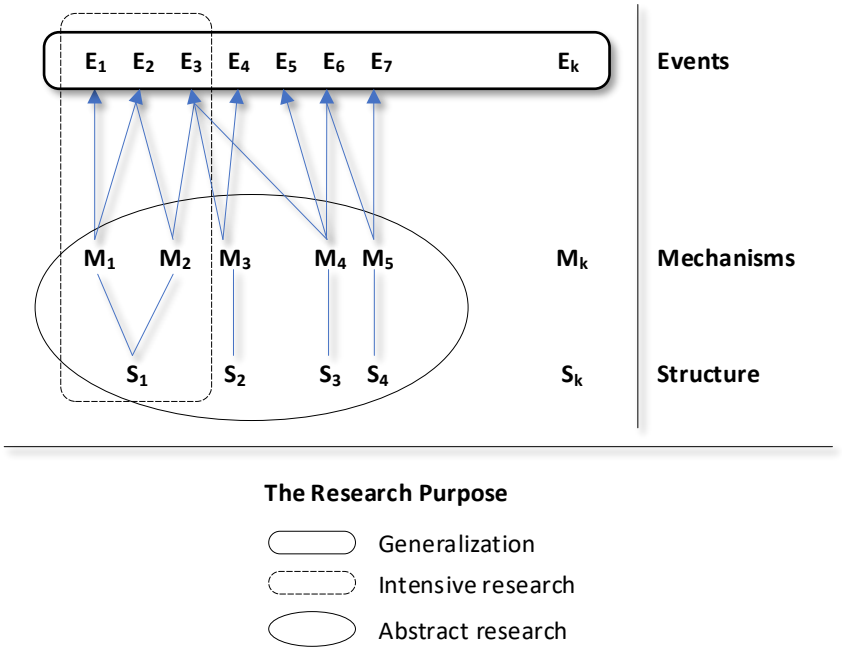


Figure 5-2: Layered ontology and research strategies in critical realism, adopted from Bygstad et al. (2015).

This stratification and its following logic in scientific discovery has implications not only for the natural sciences, which was Bhaskar's (2008) focus in *A Realist Theory of Science*, but also for the social sciences. In his book *The Possibility of Naturalism*, Bhaskar (1998) critiqued the contemporary philosophies underpinning social (human) sciences, particularly the existing dichotomies and dualities between positivism and hermeneutics, individualism and collectivism, voluntarism and reification, facts and values, reason and causes, and mind and body (Archer et al., 1998). His response to these dichotomies was called critical (or social) naturalism, where social structures are also ascribed as structures belonging to the domain of the real (Smith, 2006). Thus, the structure of society is constantly reproducing itself, and always preexists human agency and simultaneously the outcome of intentional human agency (Archer et al., 1998).

The notion of critical in critical realism is to be understood in a Kantian sense; critical realism accepts epistemic relativity, i.e., knowledge is always local and historical, but it rejects judgmental relativity, i.e., all viewpoints are equally valid (Mingers et al., 2013). This view makes it possible to favor a new and improved theory over established theoretical assumptions, if the new theory proves to explain reality better.

5.2 Affordances and Mechanisms

On the one hand, generative mechanisms are structures in the domain of the real that have the capacity to behave in certain ways (Bhaskar & Lawson, 1998). The outcomes of the mechanisms are actions or events (or constraining action or events from happening) in the stratified subset of the actual, and sometimes observed in the subset of the empirical. On the other hand, affordances are described as action possibilities between a goal-oriented actor and an object that may lead to a concrete outcome (Strong et al., 2014). Mechanisms and affordances are apparently closely related, since both refer to the potentiality of events to occur, rather than the event itself. Volkoff and Strong (2013) proposed that affordances are one subset of generative mechanisms; they distinguished between generative mechanisms that are triggered by human agency (affordances) and generative mechanisms that are triggered without human involvement.

Equating affordances and mechanisms is, however, a challenging assumption for several reasons. First, affordances cannot be actualized by themselves, and they require human agency in a given context. In addition to user capabilities and features of the IS artifact, the affordance needs to be available and perceivable for actors in the given context for actualization to occur (Bernhard et al., 2013; Pozzi et al., 2014). Once an affordance is perceived and is available for an actor to actualize, existing literature often refers to factors that affect the actualization of affordance as characteristics of the work environment (Anderson & Robey, 2017; Strong et al., 2014). Empirical evidence of such factors is limited, however, and includes variations of resources (Strong et al., 2014), perception of the effort that needs to be invested (Anderson & Robey, 2017; Bernhard et al., 2013), and time constraints (Anderson & Robey, 2017). As discussed in Subsection 4.2.3, we thus need to make a clear distinction between the factors making affordances available in a given context (i.e., facilitating conditions) and the factors that facilitate or constrain the actualization process (i.e., conversion factors). In a critical realism view, conversion factors can be viewed as causal structures that impact the actualization process, including its outcome.

Second, it is likely that there are multiple affordances interacting at any specific moment (Bygstad et al., 2015). As discussed in Section 4.3, affordances are interdependent, where the outcome of actualizing one affordance can influence

human perceptions of action possibilities of other affordances. Consequently, this points towards the conclusion that mechanisms can consist of one or multiple interdependent affordance(s).

Thus, I do not fully agree with Volkoff and Strong (2013) in equating affordances and mechanisms, but rather view affordances as a subset of mechanisms (Lanamäki et al., 2016). Since affordances cannot be actualized by themselves, and actualization does not happen in a vacuum, we can only understand how events occur if we include the facilitating conditions and the conversion factors as part of the mechanism. Figure 5-3 illustrates the relation between an affordance and a mechanism. In the following, affordances relate only to the action possibility between actors and objects, whereas the mechanism consists of affordances, their interdependencies, facilitating conditions, and conversion factors facilitating or constraining actualization.

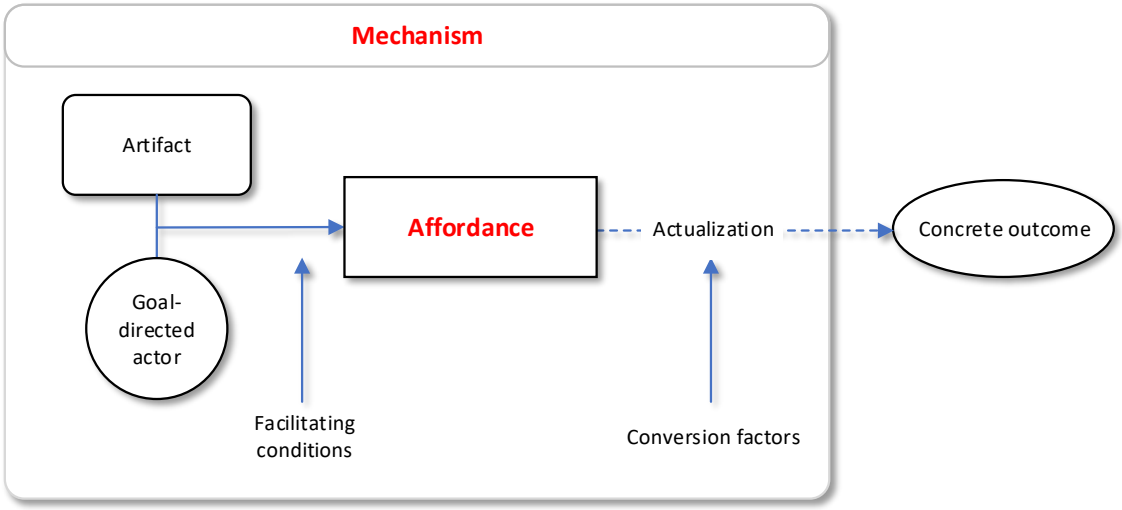


Figure 5-3: Affordance as part of a mechanism.

5.3 Strategy of Inquiry

Critical realism assumes a realist ontology and an interpretivist epistemology (Easton, 2010), meaning that although a real world exists, our knowledge of reality is socially constructed and is thus fallible (Bygstad, 2010). By endorsing a wide range of research methods, research following the critical realism paradigm is often distinguished by being either intensive or extensive (Sayer, 2000). Extensive research investigates regularities by using quantitative strategies, whereas

intensive research focuses on individual actors to explain how particular events occur by applying qualitative strategies (Easton, 2010). Choosing between a qualitative or a quantitative strategy should depend on the objective of the study and what the researcher wants to learn from the research (Sayer, 2000).

Since the role of IQ in the secondary use of EHR data is a relatively unexplored field of research, where the extant research is often conducted without using theoretical frameworks (see Section 3.2), this study is explorative and explanatory in nature. The intention of this study is to provide an in-depth understanding of the phenomenon, which calls for an intensive approach. Thus, for this study, a qualitative strategy is appropriate.

Case studies are found to be particularly suited for phenomena that are complex and relatively clearly bounded, such as organizations or interorganizational relationships (Easton, 2010). Case studies can have different epistemological underpinnings; for example, Easton (2010) argued that a positivistic epistemology of case studies, as suggested by Eisenhardt (1989), is problematic for critical realists because researchers adopting a positivistic epistemology would often favor an ideal number of cases to increase the possibility of generalizing to a population. Based on several cases, regularities or law-like generalizations allow positivists to make statements of explanations and prediction. From a critical realist view, such a constant conjunction of events is deemed to be atheoretical truth claims, and fails to explain why events occur (Easton, 2010). Furthermore, increasing the number of cases to improve the generalizability to a population is not a logic that follows critical realism. On the contrary, the goal of case studies in critical realism is depth rather than breadth, where a single case must be able to stand on its own (Easton, 2010).

Several researchers have argued that using a case study is the best approach for critical realists to explore the interactions of structure, entities, events, actions, and context to identify causal mechanisms (e.g., Wynn & Williams, 2012). It is argued that "for the purpose of studying contemporary socio-technical phenomenon to uncover the causal mechanisms and contextual factors that combined to generate them, case study research is well-suited to conduct critical realist research" (Wynn

& Williams, 2012, p. 795). Therefore, this study applies a critical realist case study approach.

The design of case studies can involve either single or multiple cases. Evidence from multiple case studies, where the study is organized around two or more cases, have, particularly from a positivist view, been considered more compelling and robust than has evidence from single-case studies (Yin, 2014). However, in situations of unusual access to informants (Eisenhardt & Graebner, 2007), or in cases with unusual, extreme, critical, or revelatory aspects, a single-case design is justifiable (Yin, 2014). From a critical realist view, the focus of a case study is different from the positivist view:

> The emphasis is on the detailed and precisely focused study of a limited number of cases, often a single case, in a specific setting in an attempt to build an explanatory theory that matches the empirical facts as closely as possible …. As a result, such idiographic case studies are the dominant approach to CR researchers because this methodology enables researchers to develop detailed context-sensitive causal explanations of specific phenomena. (Wynn & Williams, 2012, p. 804)

Since this study is both explorative and explanatory in nature, and it takes an intense approach, the goal is to obtain an in-depth understanding of the role of IQ in secondary use of EHR data. Following the tradition of critical realism, this study, therefore, applies a single-case design. The rationale for choosing this particular design (presented in Chapter 6) is primarily because I have unusual access to informants (Eisenhardt & Graebner, 2007) by being employed in the focal organization. Since I probably would not have been granted such level of access to informants elsewhere, the case can also be viewed as revelatory (Yin, 2014). In the following section, the research method applied to this case study is presented.

5.4 Research Method

This section presents the data collection of this case study, followed by the data analysis. Finally, issues of validation and how these were addressed are described.

5.4.1 Data Collection

The primary sources of data for this study included interviews with employees, and the secondary sources included audit reports, templates used in data extraction, and meeting minutes. The aim of the interviews was to gain an in-depth understanding of IQ in the secondary use of EHR data from informants involved in this process. Unlike the interview data, the secondary sources of data were not coded directly, but rather, they were used to gain a better understanding of the processes, and to obtain real examples of information that the informants were discussing. Furthermore, the audit reports and data extraction templates were useful contextual illustrations for discussing the study with peer (outsider) researchers that lacked the contextual knowledge.

The purpose of interviewing is to obtain an in-depth understanding of "the lived experience of other people and the meaning they make of that experience" (Seidman, 2006, p. 9). Interviews are viewed as the most common method for collecting qualitative data, and they are usually classified as structured, unstructured, semi-structured, and group interviews (Myers & Newman, 2007). This study employed a semi-structured design of interview, which is well suited to in-depth exploration of perceptions and opinions of heterogenous groups of informants regarding a complex issue (Barriball & While, 1994), such as IQ. In the following paragraphs, I describe the interviewing process used in this study, including the preparations, the interview situation, and the processing of the collected data.

Preparations. Prior to conducting the interviews, an interview guide was developed, and the sampling strategy was planned carefully. The purpose of using an interview guide was to structure the interview and assure that the topics of interest are covered (Kvale & Brinkmann, 2009). Since the interviews were semi-structured, most questions were open-ended, thus allowing me to deviate from the interview guide if necessary, and allowing the informants to elaborate on relevant topics that were not part of the guide (Kvale & Brinkmann, 2009; Myers & Newman, 2007). The interview guide is presented in Appendix C.

As summarized in Section 4.3, human agency influences information users' perceptions in the IQ life cycle of secondary use of EHR data. Thus, the research

design needs to be sensitive to the interconnections between different processes in the IQ life cycle (as illustrated in Figure 2-3). Consequently, all stakeholder groups in the process of secondary use of EHR data are included in the sampling strategy of this research. Such purposeful sampling strategy, with maximum variation, has been found to be an effective strategy for selecting informants (Seidman, 2006). Since information in the process of secondary use of EHR data is the subject of interpersonal communication (see Section 3.6), I chose to include informants by following the information from its generation, through communication, to use. In practice, I followed the information through the line of management, where data were collected from all organizational levels of three different departments within the division, including top management, division staff, department management and staff, unit management, and operational-level staff members. To assure insight from key informants, the first informants being interviewed were "highly knowledgeable informants who view the focal phenomenon from diverse perspectives" (Eisenhardt & Graebner, 2007, p. 28). Further selection of informants was done by snowballing, where the initial informants helped to identify knowledgeable persons that could add understanding and richness to the research (Creswell, 2007). Such knowledgeable persons included stakeholders such as administrative personnel, managers, and clinicians (e.g., psychologists, psychiatrists, and nurses). In addition to obtaining an in-depth understanding, this strategy provides a holistic view of this process.

Interviews. In total, 31 interviews were conducted in two phases: 11 interviews in September–October 2016, and 20 interviews in April–June 2017. The average length of the interviews was 60 minutes and ranged between 38 and 79 minutes. Table 5-1 presents an overview of the informants from the 31 interviews (more details on the informants are presented in Appendix D). All interviews were tape-recorded, and additional notes were taken during the interviews.

Data processing. Transcribing the data is the process of converting recorded audio into text in preparation for analysis (Kvale & Brinkmann, 2009). All 31 interviews were transcribed using the NVivo 11 software suite for qualitative analysis. The transcripts included verbatim verbal speech and nonverbal signals, such as coughs, laughs, sighs, pauses, and interruptions. Such detailed and careful transcripts are suggested to be of great benefit when transcripts are studied months after the

interviews occurred (Seidman, 2006). Even though a recording procedure was used, the quality of one interview was so poor that I was unable to transcribe it. This was realized immediately after the interview and I was thus able to complement the notes taken during the interview with a thick description of the conversation.

Table 5-1: *Overview of Informants*

Background	**Top mgmt.**	**Division staff**	**Dept. mgmt.**	**Unit mgmt.**	**Operation-al level**
Administrative*	0	0	3	3	0
Nurses**	0	1	3	4	4
Psychiatrists	1	0	0	0	1
Psychologists	1	1	0	0	3
Other clinicians***	0	0	2	2	3
Total****	**2**	**2**	**8**	**9**	**11**

* includes secretary, sociologist, and IT professional

** includes nurse, registered nurse, and psychiatric nurse

*** includes child welfare officer, clinical social worker, physiotherapist, and social educator

**** two informants participated in one interview, thus 32 informants in 31 interviews

5.4.2 Data Analysis

In analyzing the data, I followed the critical realist framework of identifying generative mechanisms through affordances (Bygstad et al., 2015). Since this framework does not focus on coding techniques, I complemented this framework with thematic analysis, which provides more detailed guidelines of the coding process (Braun & Clarke, 2006). Table 5-2 presents the phases of the thematic analysis, including the actions taken in each phase. Since the research questions each had a different focus, the coding process was performed several times during the study. Thus, Table 5-2 presents an overall summary of the coding process. The following paragraphs describe the steps of identifying the generative mechanisms in detail (Bygstad et al., 2015; Thapa & Omland, 2018).

Step 1: Description of events. In a critical realist context, events are the object of inquiry (Thapa & Omland, 2018), and they consist of clusters of observations made by the researcher or informants (Bygstad et al., 2015). Identification of events in this case was done by applying the logic of thematic analysis (as described above). The events are presented in Subsection 7.2.1, and the coding process is described in Appendix E.

Step 2: Identification of key entities. Key entities are the real objects of the case, including persons, organizations, and systems (Bygstad & Munkvold, 2011b). The objects are interconnected and constitute structures with causal powers (Bygstad et al., 2015) that interact to generate events (Thapa & Omland, 2018). After identifying the events in Step 1, I reinvestigated the data and searched for the human and technological entities that were involved in the various events. These entities are presented in Subsection 7.2.1 and summarized in the first column in Appendix F.

Step 3: Abduction (theoretical re-description). To identify candidate mechanisms, this step abstracts the case by exploring different theoretical perspectives and explanations (Bygstad & Munkvold, 2011b). More specifically, the empirical data are re-described using existing theoretical concepts (Fletcher, 2016). Through abduction, the theoretical level of engagement is increased beyond thick descriptions of the empirical entities, while acknowledging that any chosen theory is fallible (Fletcher, 2016).

In this study, the abduction process was as an iterative process of discovering the theory that could best explain the data. As described in Section 4.1, OIPT was my initial candidate theory, but after the first batch of interviews was conducted, I realized that I was unable to re-describe the data using this theory. Thus, I investigated several other theories before concluding that the theory of affordances was the most suitable for re-describing the data and for addressing the research questions.

Additional theoretical frameworks applied as a result of the abduction process included (1) the concept of mediators, which helped understand how actors where involved in the communication process; and (2) the IQ life-cycle view, which

helped understanding how IQ transformed through the process of secondary use of EHR data.

Table 5-2: *Phases of Thematic Analysis*

Phase	Actions taken
1. Becoming familiar with the data	Familiarization with the data started during the interview and the transcription process. After all interviews were transcribed, transcripts were read and reread multiple times. Initial ideas were noted down during the interviews, during transcription, and when reading the transcripts.
2. Generating initial codes	Initial open-ended coding of the data was performed systematically across the entire dataset. For example, when coding the events of the case, all events of interactions between actors and data/information were coded (see the first column in Appendix E).
3. Searching for themes	Through collating/clustering codes, potential themes emerged. For example, several events coded in Phase 2 were similar, and thus clustered (see second column in Appendix E).
4. Reviewing the themes	The themes were reviewed by checking if they worked in relation to the coded extracts and the entire dataset. For example, the coded events were checked to see whether they fitted into the theme, and to ensure the theme was consistent throughout the dataset.
5. Defining and naming themes	The themes were refined iteratively throughout the process. For example, further clustering and naming/renaming of the events was an iterative and ongoing process (see third column in Appendix E for the final clustering and naming of the events in the case).
6. Producing the report	As stated in Phase 5, the analysis was an ongoing process that continued during the process of writing research articles and this dissertation. For example, while writing the articles, representative extracts that could illustrate the findings were selected.

Step 4: Retroduction (identification of candidate affordances). Retroduction means "moving backwards" and is a "mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them" (Sayer, 1992, p. 107). Retroduction is the most crucial step in critical realism analysis (Bygstad & Munkvold, 2011b), yet it is not straightforward and involves several iterations of steps 1–3 (Thapa & Omland,

2018). Bygstad et al. (2015) proposed a four sub-step approach of the retroduction process: (a) identification of immediate concrete outcomes, (b) analysis of the interplay of human and technical entities, (c) identification of candidate affordances, and (d) identification of stimulating and releasing conditions.

By starting with the events identified in Step 1, I analyzed the interplay of human and technological entities, as identified in Step 2, that produced the event. The key entities and their associations in producing the various events from Step 1 are presented in Appendix F. Since affordances arise from the relations between human and technological entities, the candidate affordances emerged in the analysis by applying this theoretical lens. The identified affordances in this case, including example statements from informants, are presented in Appendix I. As stated above, this process of identifying affordances through retroduction was iterative in nature. For example, after conducting the first 11 interviews, an inductive analysis of the events and entities led to a theoretical re-description of the data (abduction) using the affordances lens. By analyzing the data deductively, I identified six candidate affordances: auditability, systematizability, visualizability, communicability, prioritizability, and accountability. The findings from this analysis are published in Hausvik and Thapa (2017). Before collecting the rest of the data (20 interviews), the interview guide was somewhat modified to include aspects from the theory of affordances (e.g., the goals of actors in the process). With the more comprehensive dataset, I re-examined the events, entities, and interconnection of entities. Through this analysis, one new affordance emerged (analyzability), and one affordance was modified (e.g., analysis of the entire dataset identified data extraction of both unstructured and structured data—auditability was thus renamed extractability).

Finally, the stimulating and releasing conditions for actualizing each affordance needed to be identified (Bygstad et al., 2015) by analyzing (1) the conditions making the affordances available (defined here as facilitating conditions), and (2) the factors affecting the actualization process of the affordances (here defined as conversion factors). The facilitating conditions for each affordance are presented in Appendix K, and the conversion factors are presented in Appendix L.

This openness to the field data, through iteratively expanding, revising, or abandoning initial theoretical assumptions using both inductive and deductive approaches, is not only required in the abduction and retroduction processes, but it is also desirable in interpretive studies in general (Walsham, 1995).

Step 5: Analysis of the set of affordances and associated mechanisms. To understand how affordances form parts of the mechanisms, the interactions between affordances need to be analyzed (Bygstad et al., 2015). The interactions were identified by analyzing the sequences of how the affordances were actualized in this case. By investigating the non-linear relations between the outcome of one affordance and the facilitating conditions of sequential affordances, patterns of mechanisms emerged.

Step 6: Assessment of explanatory power. The goal is not to identify all mechanisms in an open system, but the key mechanisms, i.e., the mechanisms with the strongest explanatory power (Bygstad & Munkvold, 2011b). Furthermore, any proposed mechanism should be treated as a candidate explanation, where data collection and analysis should be repeated until closure is reached (Bygstad et al., 2015). Since our knowledge of reality is socially constructed and thus fallible (Bygstad, 2010), reaching such closure is, however, not possible. In this case, assessment of the explanatory power of the mechanisms can be done by comparing the mechanism identified by analyzing data from the first 11 interviews[2], and the mechanisms identified by analyzing the whole dataset (31 interviews in total). Here, we can see that the initial mechanism (commitment mechanism) only provided a coarse-grained explanation of how mediation of information could lead to commitment (accountability) of actors and furthermore enactment. However, through an exploratory approach, the initial analysis documented the importance of accountability to achieve action in response to the information. By collecting more data, and analyzing these through the affordance lens, I was able to identify a more detailed map of the constituent parts of the mechanisms, and thus provide a better explanation.

[2] Findings from the analysis of the first 11 interviews were published in Hausvik (2017a)

5.4.3 Validation

From the interpretive epistemology, researchers are not claiming to report facts, but rather socially constructed interpretations of facts (Bygstad, 2010). Thus, process validation of the case study is required. In the following, I present validity issues related to data collection and analysis, and I describe how I addressed these issues in this study. First, I discuss my role as the researcher and my relations to the focal organization, since the level of involvement influences the outcome of the research (Walsham, 2006).

Role of the researcher. Since the interview is a social encounter and collected data are idiographic, the researchers should situate themselves (Myers & Newman, 2007). The role of the researcher can be understood from two different perspectives: as the researcher-subject distance (Gonzalez & Bharosa, 2009) and the researcher being an outsider or insider (Brannick & Coghlan, 2007). The former denotes the level of researcher engagement in data collection and refers to the research methodology. For example, in action research, researchers are considered to be highly engaged, whereas an analysis of published data is considered to be highly distanced (Gonzalez & Bharosa, 2009). The chosen methodology of semi-structured interviewing, as described Subsection 5.4.1, is located somewhere in the middle of this continuum.

Researchers as outsiders versus insiders is not a question of methodology, but of whether the researcher is a member of the organization or culture being researched (Brannick & Coghlan, 2007). Insider research distinguishes from outsider research because the researcher is already immersed in the organization and brings preexisting knowledge of the organization into the research situation. This could be described as "a journey from nearness to distance—and back" (Brannick & Coghlan, 2007, p. 66). Personally, I have been employed in the focal organization for more than 19 years and had an in-depth understanding of the processes, culture, and people of the organization in advance of this study. Though there has been criticism about being insiders, such as duality of role that may place the researcher in an untenable position (Brannick & Coghlan, 2007), there are also several advantages. For example, Riemer (1977) argued that researchers should take full advantage of being insiders by turning familiar situations, timely events, or special expertise into objects of study, rather than neglecting at-hand knowledge. This

notion is supported by Creswell (2009), stating that "the more experience that a researcher has with participants in their actual setting, the more accurate or valid will be the findings" (p. 192).

Being an insider, most informants were acquaintances. Thus, I needed to critically reflect on my two different roles before conducting the interviews—being a researcher in the interview setting and being a management representative outside the interview setting. In all interviews, I spent the introductory part clarifying the distinction between these roles. Moreover, I disclose my different roles, so readers can take them into consideration when assessing the validity of the findings (Myers & Newman, 2007).

Validity issues related to data collection. Techniques were used to reduce biases and increase the validity of the data collection process in this study. The guidelines of Myers and Newman (2007) were helpful for understanding my influence on the interview situation, and they offered techniques to avoid pitfalls. Table 5-3 summarizes the validity issues and how they were addressed.

Validity issues related to data analysis. In validating studies based on an interpretive epistemology, a common mistake is to apply positivist validation criteria (Munkvold & Bygstad, 2016). In this study, I have applied the seven principles for evaluating interpretive research provided by Klein and Myers (1999). Principle 1, the fundamental principle of the hermeneutic circle, is the fundamental meta-principle underpinning the other six principles (Klein & Myers, 1999). In my study, I consider the hermeneutic circle as the underlying analytical process starting from the moment when I decided to research this subject matter, until writing this dissertation; i.e., as a longitudinal and iterative analytical process of making sense of the phenomenon, through collecting data, looking at the data through different theoretical lenses, moving the perspective back and forth between individual statements to a holistic view, etc. All the principles, including examples from this study, are presented in Table 5-4.

Table 5-3: *Validity Issues in Data Collection*

Issue	**Addressed**
Represent various "voices" To understand a phenomenon, various people in various roles need to be heard (Myers & Newman, 2007), and biases from specific groups should be avoided (Miles, Huberman, & Saldaña, 2014).	This issue was addressed by selecting informants with various backgrounds and from various organizational levels.
Gaining access Level of entry can facilitate or inhibit the ability to reach key informants (Myers & Newman, 2007), thus potentially leaving important aspects of the case undisclosed.	I was allowed to contact any informant at any level within the division.
Time management Lack of time can lead to incomplete data collection and to interviewees creating opinions under time pressure (Myers & Newman, 2007).	When making appointments with interviewees, I estimated approximately one-hour sessions. I experienced that in almost all interviews, I was the one initiating closure since all topics were covered exhaustively. In some instances, the interview exceeded the allotted time, but this was expressed as unproblematic by the interviewees. Thus, lack of time was not experienced as constraining the interviews.
Establishing trust A lack of trust may lead interviewees not to divulge information (Myers & Newman, 2007).	By being an insider, most informants were acquaintances, and trust was already established. I experienced that informants were open, and sometimes brutally honest, even though I represent the management in my daily role. Thus, I concluded that trust was established, and that separation of roles was achieved.
Minimize social dissonance For the interviewees to feel comfortable, and to reduce biases, it is important to minimize social dissonance (Myers & Newman, 2007).	By being an insider, dress code and internal jargon were unproblematic. The interviews were furthermore conducted at the interviewees' offices in an undisturbed and familiar environment for the interviewee (Creswell, 2007).

Table 5-3 continued

Issue	Addressed
Use mirroring in questions and answers Mirroring allows the researcher to focus on the interviewees' understanding rather than that of the researcher (Myers & Newman, 2007).	Mirroring was done actively to avoid imposing my understanding of reality on the interviewee; it involved listening, encouraging, prompting, and directing the conversation.
Flexibility Flexibility, improvisation, and openness are required to capture surprises and explore interesting subjects emerging (Myers & Newman, 2007).	In practice, it was sometimes difficult to achieve the balance between allowing informants to tell anecdotal stories that could potentially bring new elements into the research and directing the conversation to assure that all topics were covered. However, flexibility was achieved by making minor refinements of the interview guide between the first 11 and the last 20 interviews. This allowed me to explore findings from the first batch of interviews.
Member validation of collected data Distributing interview transcripts to interviewees for verification can increase the validity (Bygstad & Munkvold, 2011a).	Most informants were invited to receive interview transcripts for verification. Only one informant wanted the transcript. Thus, such validation was difficult, and being appreciative of their time spent in interview, I would not put additional work on the interviewees.

In addition to the validation principles by Klein and Myers (1999), I applied other techniques to validate the data analysis. For example, a member validation of the analysis (Bygstad & Munkvold, 2011a) involved sending the manuscripts to members of the organization who were involved in the quality management process for verification of the analysis and findings. All the feedback I received supported my analysis and findings. During the analysis, several of the informants were contacted to clarify or elaborate certain aspects per email. Furthermore, co-authors and supervisors operated as external auditors to validate the analysis and findings from an academic peer perspective situated outside of the focal organization (Creswell, 2009).

Table 5-4: *Validity Issues in Data Analysis*

Principle	Goal	Examples
1. The fundamental principle of the hermeneutic circle	Iterative considerations of the meaning of parts and the whole they form	Iterative analysis during data collection and analysis. Tacking back and forth between analyzing individual statements and determining how these relate to the overall case.
2. The principle of contextualization	Critical reflection of the social and historical background of the context	Being an insider, the social and historical background was already known and actively reflected upon during analysis.
3. The principle of interaction between the researchers and the subject	Critical reflection of how data are socially constructed between researcher and participant	Through interactions with informants, an understanding of the phenomenon was developed. By knowing the organization, I was able to challenge informants' understandings, and at the same time be challenged by informants.
4. The principle of abstraction and generalization	Relating idiographic details to theoretical concepts	For abstraction, see Step 3 (abduction) in Subsection 5.4.2. For generalization, see the own paragraph within this subsection.
5. The principle of dialogical reasoning	Sensitivity to contradictions between theoretical preconceptions and actual findings	In the analysis, I was concerned with not force-fitting data into theoretical frameworks. Contradictions were valued as important findings and reported as theoretical contributions.
6. The principle of multiple interpretations	Sensitivity to different interpretations among participants	Different interpretations were valued and facilitated by selecting informants from various roles and positions.
7. The principle of suspicion	Sensitivity to possible biases and distortions	An example of reducing biases in data analysis includes corroborating data (e.g., meeting minutes and interview notes).

Generalizability. In case studies, the goal is not to extrapolate probabilities and make knowledge claims to any population (statistical generalization), but rather to provide analytical generalization by expanding and generalizing theories (Yin,

2014). More specifically, and from a critical realist perspective, expanding and generalizing theories are the result of identifying the underlying structures working under contingent conditions through particular mechanisms (Easton, 2010), where the intent is "to utilize the detailed causal explanations of the mechanisms at work in a given setting to obtain insights as to how and why a similar mechanism could lead to different, or perhaps similar, outcomes in a different setting" (Wynn & Williams, 2012, p. 804). Thus, generalizability provides a means to utilize any statements of causal mechanisms to explain the observed events, rather than predicting outcomes to a given population (Wynn & Williams, 2012).

In this study, generalization is thus to be understood as "theoretical generalization," where identified mechanisms and underlying causal structures can be utilized to improve not only our understanding of IQ, but also the process of actualizing affordances.

5.5 Ethical Issues

In addressing ethical issues, I followed the ethics guidelines for interviewing by Myers and Newman (2007) and Kvale and Brinkmann (2009) to maintain ethical standards in the research. These guidelines involve obtaining permissions, showing respect, and fulfilling commitments, which are described subsequently.

Various approvals were needed before collecting the data, including approval from the research department of SHT, the Research Council of Norway (project number 246646), and from the National Centre for Research Data (NSD). The application was approved by NSD on May 9, 2016 (approval number 49337) and included detailed descriptions of the type of data I proposed to collect, the data collection method, and how data would be stored and managed securely during and after the research. Approval from NSD was granted for collecting data from September 2016 to August 2019. I also consulted the Regional Committee for Medical and Health Research Ethics (REK). Since the subjects of research did not include patients, approval from REK was not needed for this study.

Before approaching the interviewees, the division director sent an email to all department managers urging them to welcome my requests for contacting relevant

informants. Moreover, I always followed the line of management when contacting informants, meaning that all communication was approved by the manager situated closest to the informant. At the beginning of each interview, I presented the form of consent, explaining the implications of participating in the research for the interviewee, and my commitments as a researcher regarding audio recording, managing the data securely, and anonymizing the data when reported. The consent from is presented in Appendix B.

After conducting the interviews, the audio recordings were transferred to a secure server, and the transcripts were fully anonymized. This included anonymization of people, positions, and places. Before August 2019, and according to the approval from NSD, all audio files, including the cipher connecting anonymized data and identification of the informants, will be deleted.

In publishing the research, I have carefully anonymized all participants and organizational entities (e.g., SHT has been presented as Coastline Regional Hospital in all research publications). In dialogue with the research department at SHT, it was decided to disclose the identity of the organization in this dissertation.

5.6 Chapter Summary

In Section 4.3, I summarized how the theory of affordances can address the unresolved propositions from the literature review and how the theory can contribute to understanding the role of IQ in secondary use of EHR systems. In this chapter, I described the research design of this study to address the research questions, including the philosophical worldview, strategy of inquiry, research method, and ethical issues related to the research design.

First, I presented the philosophical worldview of this research, critical realism, which assumes a realist ontology and interpretive epistemology. The aim of critical realist research is to build theoretical foundations to understand the conditions of how observed events are produced (Bygstad et al., 2015). To this end, the identification of generative mechanisms is central in explaining how such observable events are produced. To be able to understand the sociotechnical mechanisms underpinning the process of secondary use of EHR data (see Section

3.6), I discussed the relation between affordances and mechanisms. Specifically, I proposed that affordances relate only to the action possibility between actors and objects, whereas mechanisms consist of affordances, their interdependencies, facilitating conditions, and conversion factors facilitating or constraining actualization (see Figure 5-3).

Second, I discussed strategies of inquiry, justified the selection of a single-case approach, and presented the research method for this research. By drawing on existing literature (Chapter 3) and the theoretical lenses (Chapter 4), I described how data were collected, analyzed, and verified. For example, to be sensitive to the interconnections between different processes in the IQ life cycle (as illustrated in Figure 2-3), I recruited informants to ensure representation from all actor groups in the process of secondary use of EHR data.

Finally, I discussed ethical issues of the research design, such as obtaining permissions, showing respect, and fulfilling commitments. In the next chapter, I present the context of this study.

6 Case Description

In the previous section, I discussed the research method for this study, including the choice of a single-case approach as the strategy of inquiry. The purpose of this chapter is to provide a detailed description of the case organization. The chapter is organized as follows: first, the background of the case organization is presented, including organizational entities and the EHR system; next, the process of secondary use of EHR data for quality management within the case organization is presented, followed by challenges in this process.

6.1 Background

Sørlandet Hospital Trust (SHT) is a large Norwegian public hospital providing medical health services at a specialist level to approximately 300,000 inhabitants. The region consists of urban and rural areas and covers over 16,000 km^2 (see Figure 6-1). More than 7,000 employees, distributed throughout the region, work in different clinical divisions, service departments, and administration.

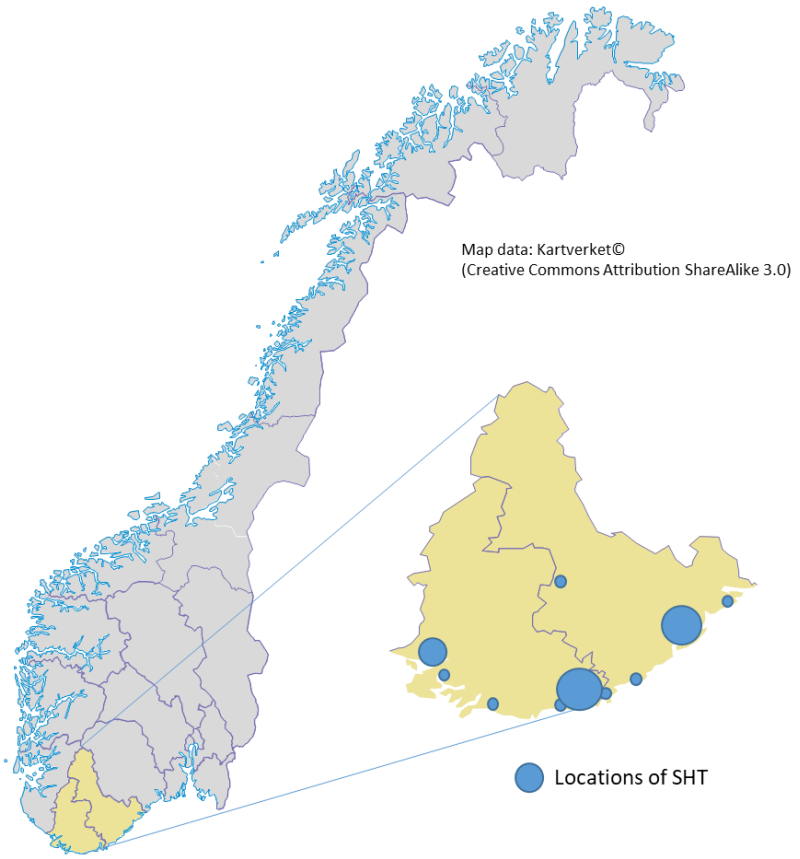


Figure 6-1: Map of SHT locations.

At the topmost level, the formal ownership of all public health institutions in Norway lies with the Ministry of Health. The next level in the chain of command includes the chairs of the four regional hospital trusts. These regional trusts consist of several autonomous hospital trusts, each with its own board. Each CEO runs the hospital trusts on a daily basis in accordance with the instructions provided by the board and imposed by the annual Commissioner's Directive provided by the government.

SHT is organized into four departments: financial, human resources (HR), research and development (R&D), and technological services (see Figure 6-2). The Department of Technology comprises the following units: property unit, medical technology unit, technical unit, archive and documentation unit, clinical ICT unit, and eHealth unit. The clinical ICT and eHealth units were previously organized as a traditional IT department but were relocated to the Department of Technology as the result of a strategic process that aimed to increase the focus on technology by consolidating and organizing all technology-related services under the chief technology officer (CTO). Since the operational IT services (system maintenance, infrastructure, support services, etc.) are outsourced to an external vendor, the eHealth unit deals with managing contracts with service providers, local project management in technology implementation, and innovation support for the clinical divisions. The clinical ICT unit, however, is mainly focused on ensuring that the EHR system supports the clinical and administrative workflows in the hospital. Thus, the clinical ICT unit that is responsible for the use of the EHR system is optimally configured to meet the requirements from the users, the CEO, regulations, and expectations from the public.

SHT is further organized into clinical divisions. As illustrated in Figure 6-2, the hospital trust comprises three somatic divisions, a psychiatric division, a division of prehospital services (e.g., ambulances), and a division of medical services (e.g., imaging diagnostics and laboratories). The somatic divisions used to be organized as individual general hospitals but were merged into SHT in 2004 due to a national health care reform. The division directors of the somatic divisions are responsible for all somatic disciplines (e.g., medicine, surgery, pediatrics), in three different locations.

The Division of Psychiatry and Addiction Treatment (referred to as "the division") is organized across all locations of SHT, unlike the somatic divisions. The division employs over 2,000 people and comprises eight departments supervised by managers, including a department of hospitalized psychiatry, four departments of district psychiatry, a department of addiction treatment, a department of child and adolescent psychiatry, and a department of psychosomatics (see Figure 6-2). All departments are sectioned into units; the number of units varies between departments. Some units are further divided into teams due to division of labor. Formally, the team level is not in the line of management, since unit managers are responsible for human resources at the employee level. The organizational structure of the division is illustrated in Figure 6-2, where the Department of Addiction Treatment is used as an example (highlighted in the figure).

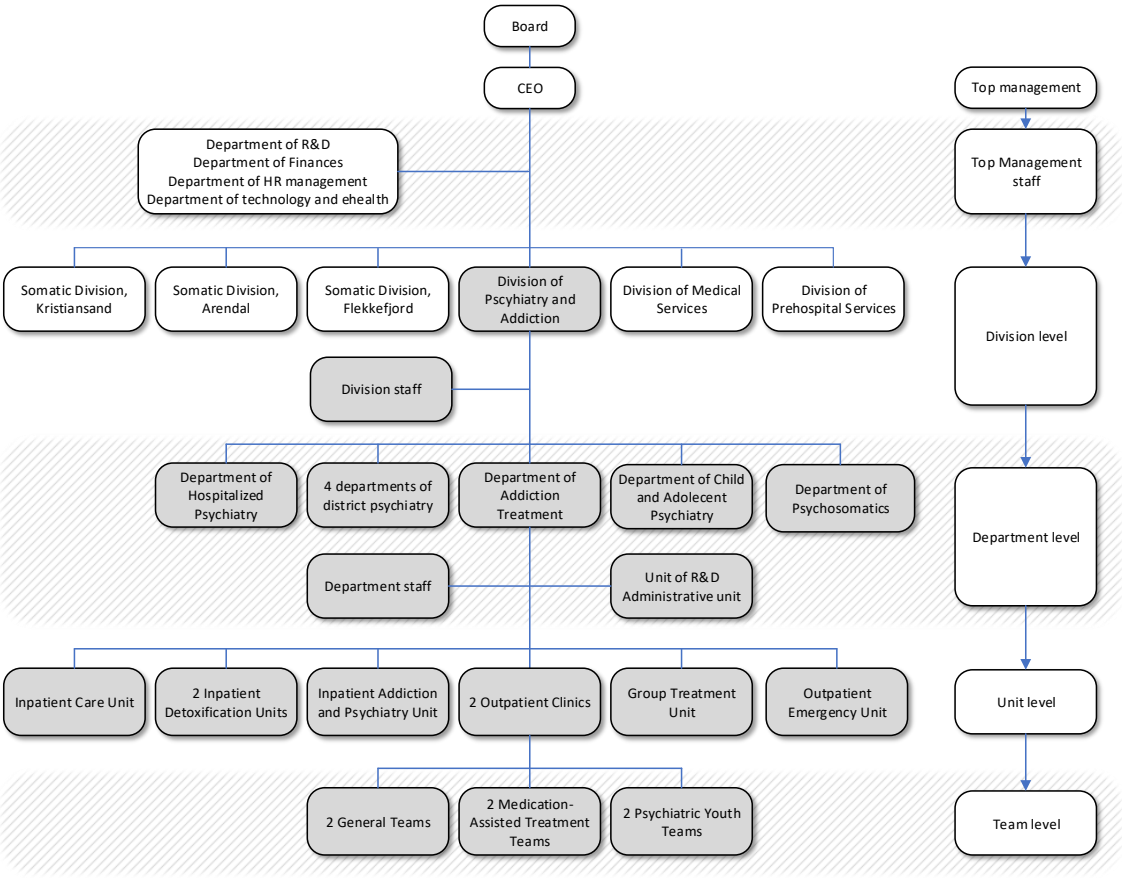


Figure 6-2: The organizational structure of SHT.

Although with 140 years of history as a psychiatric institution, the division in its current form was founded in 2004 as a result of the national health care reform

initiative described in the previous paragraph. In this dissertation, I focus on how secondary use of EHR data facilitates quality management in this division.

After the foundation of the division in 2004, the division director implemented a strategy aimed to improve the quality of all patient- and support-related processes within the division. As a result of this strategy, the division was awarded health care quality accreditation by an international accrediting institution for the health care sector. To maintain the accreditation, an external reevaluation performed by the accrediting institution is required every third year. The division was last reaccredited in 2016. The accreditation enforces a quality system, ensuring that managers at all levels in the division are committed to providing guidelines (strategic, operational, and clinical) for all patient- and administrative-related processes, evaluating and monitoring compliance with the guidelines, and handling discrepancies. Since the accreditation in 2010, there has been an increased focus on the content quality of patient journal documents from the division management group (i.e., the division director and the eight department managers). In this case, secondary use of EHR data for quality management relates to the use of EHR data for monitoring the level of compliance with clinical and administrative guidelines and using the information to handle discrepancies by implementing preventive and corrective interventions.

At an early stage, it was evident that the EHR system lacked the necessary features to monitor quality management data directly. Thus, to monitor compliance with clinical and administrative guidelines, data needed to be extracted from the EHR system by data extractors (i.e., administrative personnel from department staffs). The division implemented a balanced scorecard (BSC) in 2007 for monitoring measurable quality indicators from different systems, including the EHR system. Over the years, the BSC has become internalized in the quality management process. Because of an increased focus on managing the quality of the clinical processes, as enforced by the accreditation system, clinical auditing became a supplementary method to BSC for monitoring compliance with clinical guidelines. For this purpose, the quality advisor in the division management procured a surveying tool. The tool provided the quality advisor with new possibilities for organizing audit assessments and analyzing and visualizing the results. However, owing to software licensing restrictions, this tool can only be used for department-

level audits. Thus, audits performed at unit levels use multiple data-processing tools (e.g., spreadsheets, word processors, and paper) to organize the data from individual patients. Because auditing is a time-consuming and resource-constraining process, it is performed infrequently and with an alternating focus.

The first version of the EHR system was implemented at SHT in 1991, containing electronic patient records for all patients attending the hospital after the date of implementation, including digitized pre-1991 paper records. The EHR system consolidates converted data from several hospital mergers and legacy systems. The system consists of unstructured data (e.g., clinical documents of patients), semi-structured data (e.g., XML-based forms), and structured data (e.g., demographic data, hospital contact data, and diagnostic codes). The clinical documents contain narratives (free-text documents) based on predefined templates. The templates are selected by clinicians based upon the task. There are several templates (e.g., start-up notes, discharge summary, and daily clinical notes) with different headings to guide the documentation of the health care provided. Structured data is entered by clinicians and administrative staff into the EHR system. The values for structured data are predefined coding classifications and include clinical data (e.g., diagnoses, standardized patient assessments, and test results), logistical data (e.g., out-patient appointments, admissions, transfers, referrals, priorities, and waiting lists), and financial data (e.g., government refund rates and patient payment). By March 2017, the EHR system stored 40 million journal documents relating to 665,000 individual patients.

6.2 Secondary Use of EHR Data for Quality Management

The main purpose of quality management in the division is to ensure that the quality of all services (e.g., operational support services and clinical services to the patients) meets predefined standards. As described in the previous section, secondary use of EHR data for quality management in this case relates to the use of EHR data for monitoring the level of compliance with clinical and administrative guidelines and using the information to handle discrepancies by implementing preventive and corrective interventions. The process of secondary use of EHR data for quality management has evolved over several years within the division, since the quality accreditation enforces more rigorous quality

management practices than are required of the other divisions at SHT. Consequently, hospital-wide departments, such as the Department of Technology, are not involved in the process.

Secondary use of EHR data for quality management consists of five key processes: The first three processes involve extracting EHR data, organizing the data in external data-processing tools, and presenting the data. Thereafter, the outcome information of the first three processes is communicated to managers at various levels in the division (i.e., the fourth process). The fifth process concerns the use of the information, which involves discussing the information among managers at different organizational levels and making prioritizations in response to the information. Thus, responsibilities are delegated to unit managers through the line of management, where unit managers delegate tasks to the clinicians at the operational level. The clinicians then take actions accordingly. The quality management process, based on the secondary use of EHR data, presented next is an overall and generic description of the process. The reason for presenting the process generically relates to the continuous use of the EHR system for quality management, unlike for EHR system implementation projects, which are time limited.

Extracting data. The division applies different approaches for extracting EHR data for secondary use in quality management. For unstructured journal documents stored in the EHR system, the only means of assessing quality of care is by performing clinical audits and assessing the discrepancies between documented care in the journal documents and the clinical guidelines available.

Before conducting the audit, the focus of the audit is determined, and patients included in the audit are randomly selected. The EHR data audits at SHT are performed at both the department and unit levels. At the department level, division-quality advisors plan and organize the audit, whereas the audits are performed by clinical specialists. At the unit level, quality advisors at the department level are often involved in the planning, but the audit is most often performed by (clinical) unit managers and clinical specialists. Figure 6-3 illustrates a journal document of unstructured data for one patient. Depending on the topic of the audit, clinical experts investigate if the documentation of the care has followed the clinical

guidelines. This investigation is done on a predefined number of patients to be able to generalize the findings.

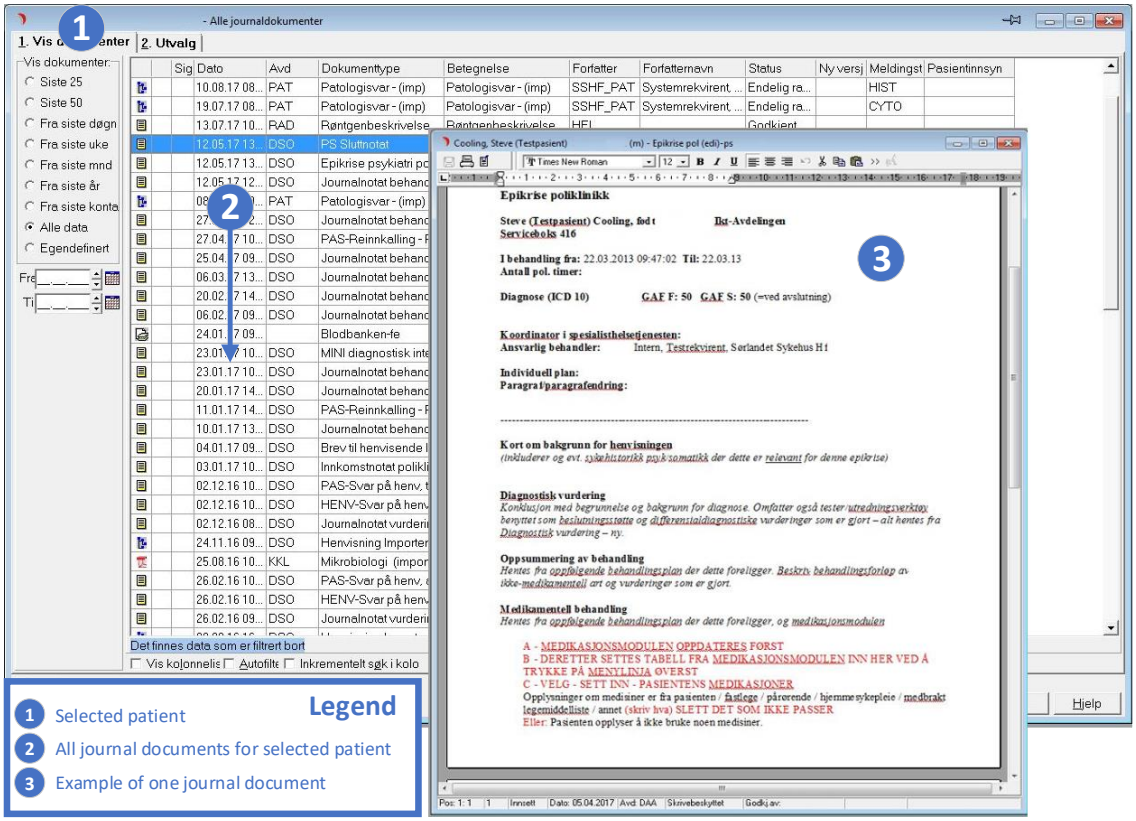


Figure 6-3: Screenshot of journal documents (fictitious data).

If the data are structured, then the second approach of data extraction is to extract data from the EHR system by using the built-in reporting tool. This tool provides basic data manipulation features such as sorting, grouping, and filtering, and basic numerical operators such as average, max, min, and sum. Data for the BSC are extracted by one designated administrative consultant per department. These consultants are knowledgeable of the data input process and the structure of the EHR data, and they are trained in using the reporting tool by peers or personnel from the technology department. Furthermore, the administrative consultants use a detailed guideline of how to extract data accurately. Figure 6-4 shows a screenshot of the tool. In this example, all outpatient consultations performed in a specific period of time are listed. Each row represents a specific patient consultation, and each column represents details of the consultation.

To assure quality of the structured data in the EHR system, administrative personnel run reports regularly, without extracting the results. The division provides a guideline stating which reports should be checked and distributed, and when this should be done. Any discrepancies found in the reports are communicated to the unit manager or directly to the responsible clinician. The division sometimes conducts ad hoc analyses of the structured data to investigate issues that have not been covered by the BSC. Such investigations are often performed by administrative personnel, who use the built-in reporting tool of the EHR system to filter and group the data; however, these personnel often need additional tools to extract, structure, analyze, and visualize the data.

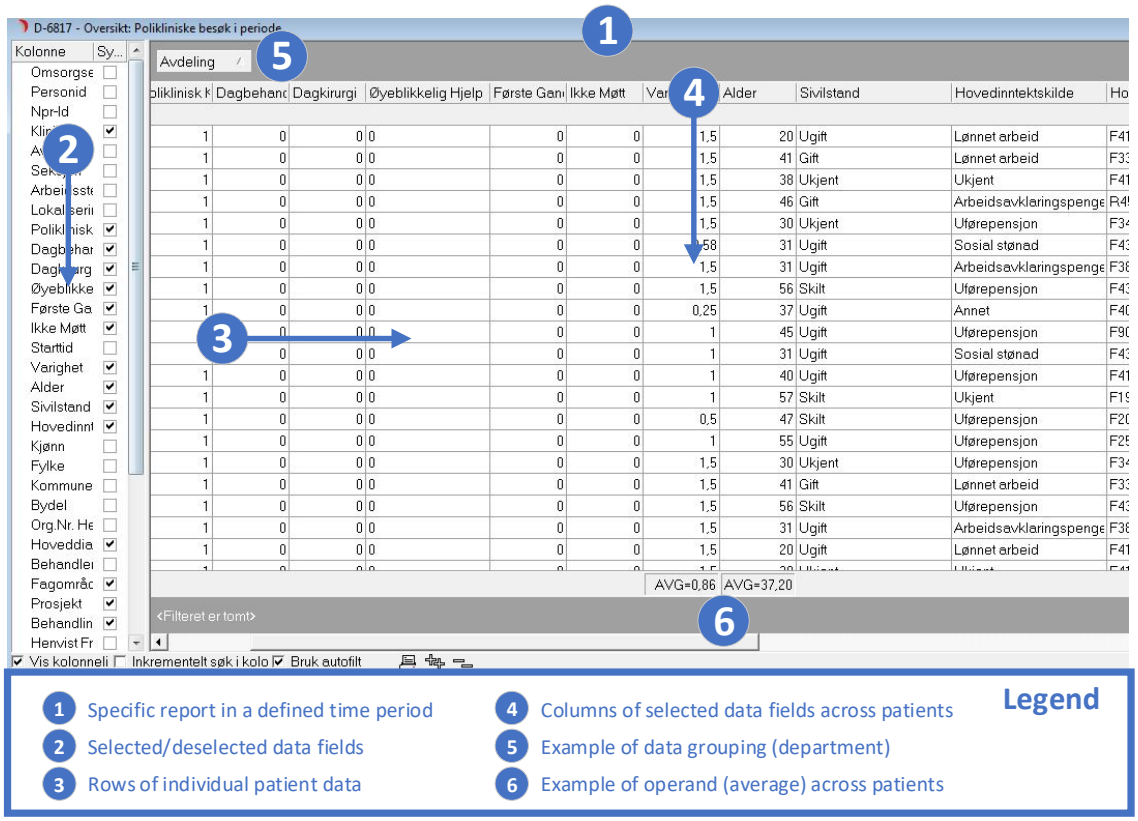


Figure 6-4: Screenshot of the EHR system reporting tool (fictitious data).

Organizing data. Since the EHR system is designed for the primary use of EHR data, functionality for organizing data for secondary use is lacking. Thus, additional data-processing tools are needed. For unstructured data at the department level, each audit assessment is plotted into an external surveying tool by the clinical experts from the division staff. The tool offers features such as the extraction of individual assessments in a standardized form, data aggregation and

comparison, statistical analysis, and visualization of the audit results. Prior to data extraction, the quality advisor at the division staff customize the survey tool by designing questions with structured data fields. The screenshot in Figure 6-5 shows an example as seen from the perspective of the clinical specialists performing the audit. Here, clinical assessments from individual EHR patient documents are entered as structured data.

The department-level audits are often followed by unit-level audits to refine the challenges and pinpoint where each challenge is rooted; thus, improvement interventions can be targeted to those units. However, there is no standard for extracting unit-level audit results. For instance, some unit-level auditors (i.e., managers or quality advisors from department staffs) may use spreadsheets, word processors, or paper-based tools for organizing audit assessments. The unit-level auditors tend to prefer spreadsheets because they offer descriptive statistics and the possibility for visualizing the results. Regardless of the specific tools used, however, the common purpose of the organization process is to structure the findings on individual patients to be able to analyze and generalize the findings across patients.

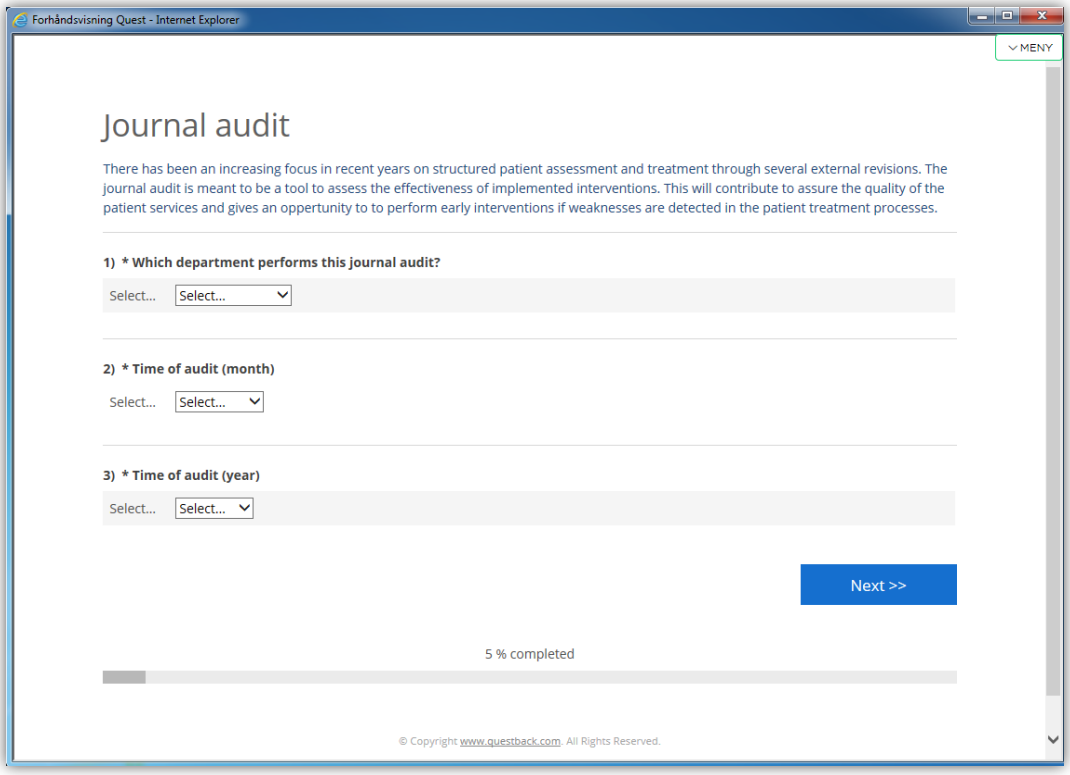


Figure 6-5: Screenshot of audit assessments data input.

After the administrative consultants from each department have extracted the structured data by using the built-in reporting tool of the EHR system (see Figure 6-4), they enter the data into a standardized input file. The data from the input files from each department are automatically consolidated in a BSC. The BSC is a spreadsheet application in which the results for a range of quality indicators are extracted from all departments. Figure 6-6 illustrates an excerpt of the data input file for one of the departments. The administrative consultants enter data for their department each month into the input file. The rows in Figure 6-6 represent several different data needed as basis for computing the quality indicators of the BSC.

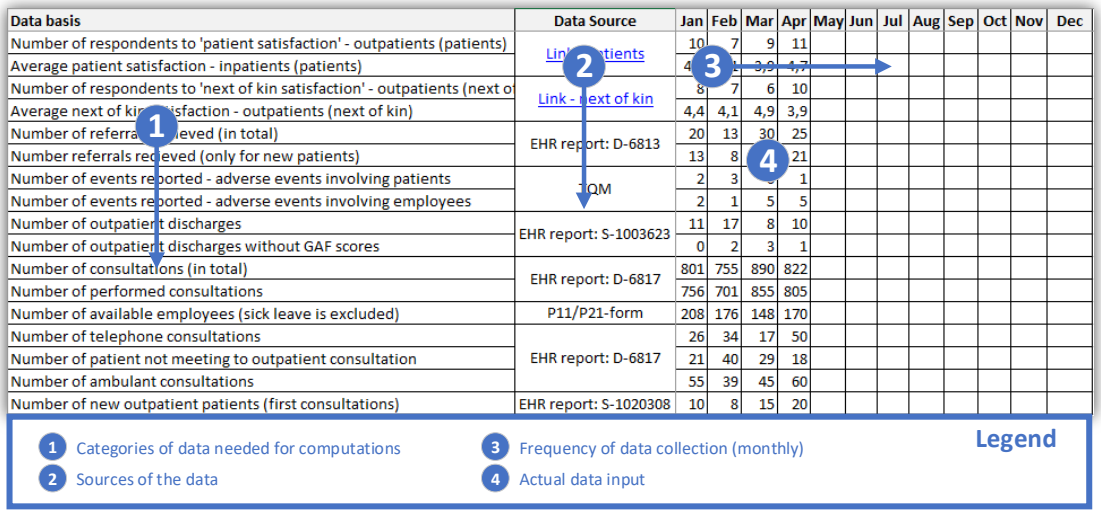


Figure 6-6: Screenshot of BSC data input (fictitious data).

Variants of the BSC exists at the department and unit levels. For example, some department managers have decided that data need to be extracted at the unit level to be able to monitor quality at a more granular level than the division BSC accounts for. Extraction of data at this level is often performed by the same administrative consultants that extract data at the department level. Another example of extracting structured data at the department and unit levels is when there is a local need for monitoring a particular domain of quality, which is not part of the BSC.

Presenting data. After data are extracted and organized in a data-processing tool, the data are assembled and presented visually. After audit data are extracted and organized in the survey tool, the quality advisor at the division staff analyze the data by using built-in analytic functionality. Next, the quality advisor presents

(visualizes) the analyzed data by using a built-in report generator. For unit-level audits, unit-level auditors (i.e., managers or quality advisors from department staffs) use less sophisticated tools for extracting unit-level audit data (e.g., Excel). This often result in a non-standardized way of presenting the results of such audits.

The consolidated input files from the individual departments, including the degree of the goal achievement set by the organization, are automatically presented in the BSC. The quality advisor from the division staff is responsible for maintaining the input files and the consolidated BSC. Figure 6-7 illustrates an excerpt of the BSC used at SHT, where the rows represent various quality indicators, and the columns represent actual values, goals, and goal achievement for a specific quality indicator in a defined time period. The figure further illustrates a detailed view of a specific quality indicator (in this example, percentage of discharge summaries completed within seven days after patient has been discharged). In the detailed view, trends of specific quality indicators can be monitored.

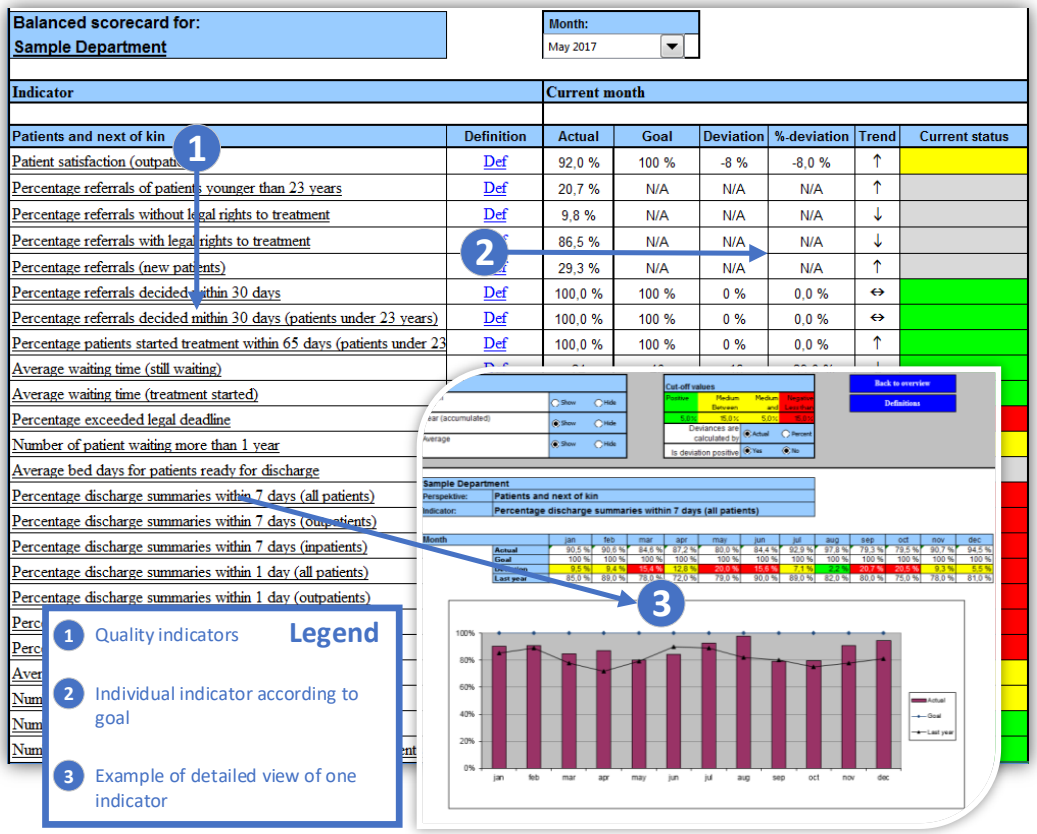


Figure 6-7: Screenshot of BSC data presentation (fictitious data).

Moreover, the quality advisor bundles snapshots of key quality measures from the BSC into a monthly quality report. This report includes information from the secondary use of EHR data and key measures from other systems (human resources system, finance system, quality deviation system, etc.) and is distributed to all department managers every month.

Communicating data. After extracting, organizing, and presenting data from the EHR system, the output information artifact is communicated to managers in the line of management through meetings, workshops, seminars, email, or face-to-face discussions. For example, the quality advisor from the division staff emails the report of bundled quality indicators from the BSC to all department managers once every month. Whereas some managers choose to present the information to the unit managers in meetings, other managers choose to forward the information to the unit managers, using email as the intermediary. Further down the line of management, the unit managers also communicate the information to clinicians in meetings or through email.

The purpose of this communication is not only to disseminate information in the line of management, but also, if needed, to delegate responsibilities for implementing preventive and corrective interventions in response to the information. The main goal of managers when communicating the information is to ensure that the recipients understand the content of the information and know how to respond to it. Since the information flows through the line of management, the recipients can be either subordinate managers or clinicians at the operational level. If no preventive or corrective interventions are needed, the aim of managers when communicating is to compliment the operational-level personnel for their achievements and to encourage those personnel to maintain their high work standards.

Using information. Since the main purpose of quality management is to ensure that the quality of services meets predefined standards, the information generated from the EHR data (Figure 6-7 is an example of such information) is crucial to inform managers of current levels or trends of compliance with guidelines. Thus, one of the main uses of the information is enabling the department managers to decide whether corrective and/or preventive interventions are needed. If needed,

the discussions often involve prioritizing between multiple interventions, based on the information, and prioritizing between new interventions and existing commitments. Such decisions regarding priorities are delegated to department managers, often in mutual understanding with the division director. Interventions in response to the information can range between large projects involving workflow redesign to gently reminding clinicians to adhere to the guidelines.

Once prioritizations are made by the department managers and their unit managers, the unit managers are usually accountable for implementing the interventions at the operational level. This often involves communicating the information to clinicians or administrative personnel with instructions on how to intervene. In cases where information lacks detail, data extraction, organization, and presentation are reiterated to appropriate the information according to unit-level requirements.

Depending on the nature of the prioritized interventions, administrative or clinical personnel in the units act upon the prioritized interventions. Such interventions often involve some change in work processes and can be supported by training sessions. This process is crucial in terms of continuous quality management in the division because the actual benefits of prioritized interventions cannot be realized without operational-level accountability.

6.3 Challenges in Secondary Use of EHR Data

The Division of Psychiatry and Addiction Treatment is a large part of SHT and comprises several departments and units (see Figure 6-2). Thus, the overall description in the previous section does not capture the complex organizational structure, including the challenges and variations between organizational units. For example, whereas some departments have good track records for meeting quality standards, other departments are struggling to achieve their goals. Some of the challenges are presented subsequently.

First, there exists variations in the process of secondary use of EHR data for quality management within the division. For example, extraction of structured data for the BSC by administrative personnel at the department level has been routinized

throughout the division. The communication of information from the BSC from the quality advisor on the division staff to the department managers is also routinized. How the department managers use this information further, however, varies substantially between the departments. As described in Section 6.2, some department managers have invested resources in a unit-level version of the BSC, to be able to monitor quality at the unit level. Thus, the unit managers in those departments have access to more granular information that enables them to target interventions more precisely than unit managers in other departments. This suggests that the IQ of information in the process of secondary use of EHR data varies between departments in the division, and that the information offers different action possibilities for unit managers.

Second, there are differences in how the information is communicated within departments. While some unit managers choose to forward the information based on EHR data and urge clinicians to improve their practices in response to the information, others have fixed meetings to discuss the results and possible interventions with clinicians. This variation in communication often leads to departmental differences in choices of interventions, how interventions are implemented, and the outcomes of the interventions. For example, the following quote illustrates the current practice of communicating the information in the line of management without providing any guidance on how to intervene:

> A problem is not fixed just by stating that you have a problem without addressing it. We recognize that we have a problem, but we [the division management] don't provide solutions, except from stating that we need to improve. Well, how do we improve? (Clinical advisor, division level)

This suggests that communication of information in secondary use of EHR data in SHT leads to variations in intervention outcomes within the division.

Third, there are contextual differences between departments regarding management practices and clinical autonomy exercised by clinicians. For example, the aim for monitoring the level of compliance with clinical and administrative guidelines is primarily to enable managers to manage the quality of the clinical and administrative processes. However, particularly for clinical processes, there exists

a tension between clinical autonomy and quality management practices within the division. For example, clinicians can sometimes be opposed to engaging in interventions, because they are not able to see the relevance of the information that has been communicated. Or, they may see the relevance, but the implication of the information interferes with their clinical autonomy. Here, the management practices vary between unit managers in the division. For example, some unit managers demand clinicians' loyalty to the management decisions, but others may be more lenient in their approaches and encourage clinicians to engage in the interventions. Furthermore, the unit managers have different professional backgrounds, which may affect their management practices. This suggests that management practices by unit managers and clinicians' ability to exercise clinical autonomy influence clinicians' perceptions of relevancy and, thus, their commitment to engage in the interventions.

6.4 Chapter Summary

In this chapter, I presented the case organization of this research. The organization, SHT, is a large Norwegian hospital trust comprising three former general hospitals. The hospital trust is organized into five clinical divisions: three somatic divisions, a prehospital division, and a division for psychiatry and addiction treatment. Unlike the somatic divisions, the Division for Psychiatry and Addiction Treatment is organized across geographical locations and consists of eight departments. As a result of strategic focus on improving the quality of patient- and support-related processes, the division was awarded health care quality accreditation in 2010 by an international accrediting institution for the health care sector. Thus, the process of secondary use of EHR data for quality management has evolved over several years within the division, since the quality accreditation enforces more rigorous quality management practices than are required of other divisions at SHT. The process of secondary use of EHR data for quality management within this division is the focus of this case study.

Secondary use of EHR data for quality management within the division relates to the use of EHR data for monitoring the level of compliance with clinical and administrative guidelines and using the information to handle discrepancies by implementing preventive and corrective interventions. Secondary use of EHR data

consists of five key processes: (1) extracting data, where data extractors extract specific data from the EHR system, which is done either by administrative personnel using built-in reports of the EHR system (for structured data) or by clinical experts performing clinical audits (for unstructured data); (2) organizing data, where data custodians (i.e., administrative personnel and unit managers) prepare data input and organize the extracted data using external data-processing tools; (3) presenting data, where information producers (i.e., administrative personnel and unit managers) analyze and visualize the data; (4) communicating information, where information mediators (i.e., managers at all levels) communicate the information output in the line of management; and (5) using information, where information users (e.g., managers) use the information in decision-making, and operational-level personnel (i.e., administrative personnel and clinicians) enact interventions in response to the information.

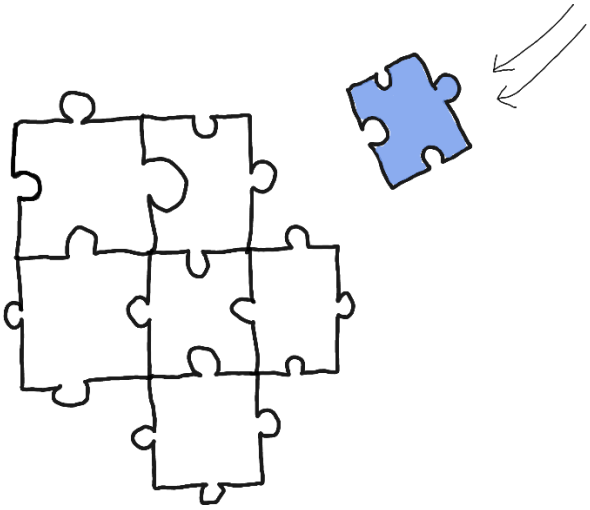
The division experiences variations between departments in meeting the quality standards. Whereas some departments consistently achieve the quality goals, other departments are struggling. These variations are further reflected in the process of secondary use of EHR data. For example, department managers handle information (e.g., BSC and audit information) from the quality advisors on division staff differently. While some departments have invested resources in unit-level BSC to provide the unit managers with more granular information, other departments rely on the department-level information provided by the division staff. Thus, the IQ of quality management information varies between departments, where the information offers unit managers different action possibilities of how to intervene in response to the information.

Furthermore, there are variations in how the information in secondary use of EHR data is communicated within departments. Some departments have a more participative approach, while other departments have a more demanding approach to communication. This variation may lead to departmental differences in choices of interventions, how interventions are implemented, and the outcomes of the interventions. Thus, the communication of information in secondary use of EHR data influences the use of the information.

Finally, the existing contextual differences between departments, for example, management practices and the possibility of exercising clinical autonomy, can influence clinicians' level of commitment to engage in interventions.

In the next two chapters, I first present the findings of the case analysis and then discuss the findings in the context of the existing literature presented in Chapter 3.

Part II
Research Findings



7 Research Findings

As presented in the previous chapter, the process of secondary use of EHR data for quality management in the Division of Psychiatry and Addiction Treatment at SHT involves five key processes: (1) extracting data, (2) organizing data, (3) presenting data, (4) communicating information, and (5) using information. Evident in this case, however, is the existence of variations in how the processes are executed between organizational entities within the division, leading to variations in achievement of the quality goals of the services. The background literature in Chapter 2 indicates that IQ is directly related to the quality of health care services. In secondary use of EHR data, however, I identified a knowledge gap of how IQ is transforming and, furthermore, how the highly sociotechnical interplay between human actors and technology can explain how IQ changes in the process.

Thus, the overall research objective of this study is to understand the role of IQ in the process of secondary use of EHR data through the following research questions:

RQ1. How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data?

RQ2. What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data?

In this chapter I first present the findings addressing RQ1 in Section 7.1. Then, RQ2 is addressed in the following two stages: first, findings are presented in Section 7.2 by applying the theory of affordances as a theoretical lens; second, the underlying mechanisms are proposed and discussed in Section 7.3.

7.1 IQ in a Life-Cycle Perspective

In Chapter 2, I presented the following main challenges of the prevailing manufacturing view of IQ: (1) the failure to address the dynamics in extracting, organizing, generating, communicating, and using information; (2) the paradox of assessing the fit between the information and user needs when information requirements are not known ex ante; (3) the implications of interpersonal

communication; and (4) the transformation and filtering of the information in the communication process.

Since secondary use of EHR data for quality management involves multiple stages of processing before the information reaches secondary users, I apply the IQ life cycle (see Section 2.4) in response to the challenges of the prevailing manufacturing view.

By applying the life-cycle view, the analysis documented how IQ in the secondary use of EHR data is transforming through three distinct processes: information generation, information communication, and information use (see Figure 2-3). In the information generating process, actors heuristically contribute to generate the information artifact by targeting the IQ dimensions they perceive as important. The IQ of the information artifact is further assessed by secondary users, where the communication process influences information users' perceptions of IQ. The following subsections present the findings related to the EHR source data that are the basis for the life cycle. Then, findings on how IQ changes through the three processes, including their interrelations, are presented. Appendix G presents an overview of the IQ dimensions identified in each process.

7.1.1 EHR Source Data

The process of generating, communicating, and using quality management information in SHT ultimately relies on source data from the EHR system. During the interviews, the informants did not express any current challenges related to the quality of the EHR source data for its secondary use for quality management. However, this used to be a problem where managers questioned the correctness of quality management information based on EHR data, as illustrated by an informant:

> [The unit managers] are no longer [making fighting sounds]. They don't make arguments like "the data from the EHR system are incorrect" anymore…. I think we have put this behind us because we've been clear that the EHR data will be used [for quality management], and if they are incorrect, then [the unit managers] are told to straighten up and make the data correct. We don't want to hear any such arguments anymore. (Assistant manager, department level)

As indicated by the informant, continuous management focus has resulted in improved quality of source data in the division over several years. Such focus has initiated the implementation of standardized data entry procedures, regular DQ assurance controls, roles, training, and continuous improvement efforts, as described by a unit manager:

> [It became obvious] that we [entered] data incorrectly. Garbage in, garbage out; that's the way it is. Through data quality improvement efforts, we have investigated this—what's the cause [of poor data], how are other [departments] doing this. So, in order to have comparable data, you need to enter data correctly. Otherwise, it's just garbage in, garbage out…. And we've had several such investigations… so we can amend and prevent this. (Manager, unit level)

7.1.2 Information Generation

The key findings of IQ in the three subprocesses of information generation are presented as follows:

Extraction quality. In the secondary use of EHR data for quality management, data extraction at SHT is two-fold and involves different professionals in the role of data extractors: (1) assessment data of compliance with clinical and administrative guidelines are extracted by clinical experts auditing unstructured journal documents; and (2) structured data as a source of BSC quality indicators are extracted by administrative personnel, by running built-in EHR system reports. After extracting both structured and unstructured data from the EHR system, the data are entered into a data-processing tool for further analysis.

Whereas data extractors of structured data most often stated that accuracy was the single most important dimension of extraction quality, extractors of unstructured data additionally emphasized the importance of completeness, objectivity, and credibility. Accuracy refers to the level of correctness of the data extracted from the EHR system, as described by an administrative consultant who extracted structured data by using built-in EHR system reports and entered the data into the BSC:

> When I work with the balanced scorecard, my goal is that the data I extract must be as correct as possible…. They must represent reality. It has happened that I have punched the wrong numbers [into the balanced scorecard]…, but I can easily see if I have missed terribly. (Administrative consultant, department level)

Unlike the extraction of structured data, where built-in reports in the EHR system summarize data from all patients in a predefined time period, data extractors of unstructured data often emphasized the importance of data completeness. Completeness of data refers to how the sample size of audited patient journals affects the quality of extracted data. This is illustrated by a unit manager's description of the sampling method used in a unit audit:

> I think some of the other [departments] just performed spot sampling. I was the only one sampling [all patients admitted during] the first quarter. It gives a more correct picture than just doing one-day sampling…. For me to find it interesting and thus use it, I found out that I needed to have more data. (Manager, unit level)

However, since audits are time consuming and labor intensive, aiming for data completeness is often not feasible for unstructured data. Thus, actors performed randomized sampling of patient journals to secure objectivity of the data, as described by one of the informants:

> It was a randomized sampling [of patients]… where we evaluated how [clinicians] documented…. You need to read through many journals…, and if you select [patients] that you are familiar with, it might get really biased. So, you need the competence of performing randomized sampling. (Medical advisor, division level)

Since auditing is a process that assesses the level of compliance with guidelines, clinical discretion is needed when interpreting clinical documentation. Informants believed that credibility was included in the data, since such assessments were performed by clinical experts:

> Evaluated by peers…. Yes, you'll probably achieve increased credibility because of that. (Medical advisor, division level)

Organization quality. Organization quality represents the perceptions of actors involved in organizing data, i.e., the data custodians. The process of organizing data for quality management at SHT consists of activities prior to and after the data extraction process. Before data can be extracted, the scope of the quality management is set, and the criteria of how data must be extracted and assessed are determined. After extraction, the data are systematized and maintained in a data-processing tool. While the use of spreadsheet applications in organizing data for the BSC is internalized in SHT, the use of data-processing tools varies when organizing unstructured data. In this case, IT personnel are not involved as custodians in the quality management process at SHT. For division initiatives, such as department-level audits and data extraction for the department-level BSC, the role of data custodians is prominent and held by division-level administrative staff. At unit levels, however, this role is less prominent and often intertwined with other roles. For department- and/or unit-level extraction of structured data, administrative staff often hold the roles of both data extractors and custodians. For unstructured data at unit levels, unit managers often hold the role of data custodian, and sometimes also the role of data extractor:

> When [the audit] was being operationalized, I chiseled out some clear questions. I believe this became some sort of a standard that the other [units] copied. Then I extracted [data] and analyzed it. (Manager, unit level)

The data custodians highlighted the adequacy of scope, granularity, and consistency as important IQ dimensions of organization quality. These actors played an important role in providing clarity of data extraction criteria and by ensuring adequacy of scope—that the extracted data conforms to intended specifications. The process of ensuring adequacy of scope when extracting unstructured audit data was illustrated by one of the informants:

> We are also involved in figuring out what [the auditors] are looking for—the indicators that could provide evidence of discrepancies within journals…. At this point in time, we are particularly concerned with patient safety and transferring of knowledge…. We would use clinical guidelines, or best

> practices, and the standards we are obliged to follow…, and we make a guideline or checklist or questionnaire for [auditors] to compare against [journal documents in] the EHR system. (Quality advisor, division level)

Granularity refers to the level at which data are extracted and organized, ranging from aggregated data at the division level to individual-level data for clinicians. For information targeting clinicians, actors emphasized an individual level of granularity, as stated by one informant:

> I made a summary of consultation productivity for the first half period of the year because we were told that we were performing low. Then I designed it on an individual level for [the clinicians] to get feedback on whether they were top-third performers, and thus delivering as expected, if they were in the middle, which is tolerable, or if they were among the bottom-third performers. (Manager, unit level)

Consistency was found to be an important quality dimension for data custodians and was related to adequacy of scope. Whereas adequacy of scope relates to how criteria for data extraction are operationalized and correspond to intended specifications, consistency relates to how the same criteria for data extraction are used between data sets. One informant responsible for extracting BSC data reflected on the importance of consistency and how this was achieved by using a data extraction manual provided by the data custodian:

> We often achieve [consistent] data because we have a really good [data extraction] recipe. It's as simple as that. Then all the data from all the departments are being extracted in the same way, and we avoid people saying, "I used this report because I thought it was the best for the purpose and gave the best results." You'll avoid that. We'll all have the same basis if everyone follows the recipe. And I think they do. (Administrative consultant, department level)

Presentation quality. Presentation quality represents the perception of IQ from the information producer's perspective—actors compiling data into information. This is a highly sociotechnical process that involves both human actors and data-processing technology, where information producers use the functionalities of

data-processing tools to generate information artifacts. For structured EHR data, the role of information producers is often held by administrative personnel, most frequently using a standard spreadsheet application as a data-processing tool. For unstructured data extracted through division-level audits, the role of information producer is held by a division-level staff member, often the same person who holds the custodian role. Information is produced by using analytical and descriptive functionalities of the data-processing tool, followed by visualization of the findings in report format. At lower organizational levels, information production is less systematic than at the division level, where unit managers often hold the role of information producers. Because of differences in the use of data-processing tools, where there is a tendency to use more sophisticated tools at higher organizational levels, data presentation varies accordingly. In general, more sophisticated tools provide a more systematic analysis and a more advanced graphical visualization of the results.

The analysis showed that information producers emphasized non-ambiguity, understandability, conciseness, comparability, and amount as important IQ dimensions. Ambiguity, which refers to designing the information artifact in a way that reduces the possibility of misunderstanding the content, is illustrated by the following statement from an administrative consultant about delivering the information to a unit manager:

> When I deliver the document [of quality management information]…, I often write comments… so there will be no doubts or misunderstandings of what I have written. (Administrative consultant, department level)

By understandability, actors designed the information artifact in a manner that they believed was understandable. Closely related to understandability, actors also emphasized conciseness, stating that information needed to be concise, clear, and to-the-point to amplify the message. Comparability refers to a quality dimension where results are compared over time, or between different organizational entities. A quality advisor described how this dimension was included in both the analysis and presentation of data:

> I made a pivot table [in the spreadsheet application] to compare the results [between the units] because there is a learning [opportunity] in doing that, and it's interesting to compare…. Then, we performed an analysis and compiled it [into an information artifact]. (Quality advisor, department level)

In presenting the data, the amount of data was perceived as important when targeting both managers and clinicians, but for different reasons. Whereas information producers emphasized presentation of all data so that managers could see the bigger picture, it was important when designing for clinicians to keep the amount of data to a minimum, to reduce information overload.

7.1.3 Information Communication

After generation, information artifacts are communicated between individuals or groups within the organization. The role of actors communicating the information is labelled *information mediators* in this study, as introduced by Hausvik, Thapa, and Munkvold (2019). Information mediators transport and/or translate the information to relevant actors. By transportation, information mediators distribute the information to relevant actors unidirectionally, whereas translation is bidirectional communication between information mediators and information users. At SHT, such communication of quality management information is sometimes mediated through different technologies, including email, presentation applications, and paper-based reports. This communication can be oral or written, or a combination of the two. At SHT, the line of management is prominent in the flow of information, making managers information mediators to successive management levels.

Communication quality (CQ). CQ represents the perspective of information mediators and their emphasis on important aspects when communicating information within SHT. The analysis identified the following key CQ dimensions: priority, reciprocity, frequency, trust, efficiency, targeted, and demanding. Targeted communication was the most frequently mentioned quality dimension and refers to how actors attempt to target communication to the actor(s) accountable for enacting upon the information. This is illustrated by a department manager in a situation where a quality indicator revealed some variations of performance between clinicians:

> [About the clinicians], we can tell that they've been doing… good work, and that the quality, for the most part, is very good. If someone is struggling, then we confront that individual. You cannot tell everyone to [improve] when it's just one individual that is not performing. Then, you need to talk to that one person. (Manager, department level)

In communication, actors sometimes put different emphasis on various parts of the information and give priority to certain aspects they believe are most important to communicate. This is illustrated by a department manager explaining how he communicated the monthly report from the BSC, which he received from the division staff, to his subordinate unit managers:

> I present [the report] in our management meetings…. And we all know each other so well that we don't boast about how good we are…. We stopped doing that years ago. Now, we discuss where the shoe pinches. It does get a bit negative sometimes because we only discuss the things that don't work. You know, out of 77 slides, we might just have one [slide presenting a challenge]. But it's that challenge we talk about, and in this meeting, everyone understands that we just talk about that one. (Manager, department level)

Reciprocity refers to the possibilities for feedback and dialogue when information is communicated. Informants emphasized that reciprocity increased accountable actors' engagement and commitment. This is illustrated by an informant's recollections of how he communicated quality management information to his subordinates:

> It's a balancing act between making [the communication] too pompous and serious because you need to understand how they work. It's an act of balance, you know. I cannot tell them to do this and that—it has something to do with presenting it in a way that makes them feel like a part of the team and inviting them to bring solutions, rather than making them feel [overwhelmed]. (Manager, unit level)

The demanding dimension contrasts with reciprocity and denotes a more demanding attitude, particularly in communication with clinicians, as illustrated by one informant:

> We try to sort out and highlight what's up for discussion [with the clinicians] and what's not up for discussion. We try to get an attitude that there are some things that are not up for discussion because it's just the way it is. It's part of the job—a part of our mission—and it simply must be done. (Manager, unit level)

Frequency refers to the amount of communication between managers and clinicians. Trust refers to the actors' perceptions of the mediators during the communicative act of the information. Trust was found to be important for communication success, as described by a unit manager who experienced challenges in communication because of educational asymmetry between managers and clinicians:

> It's challenging to be heard when we don't have the specialist competence. It's challenging when information is provided by someone that, according to the clinical specialists, has nothing to do with this…. I believe that if [clinical experts] presented [the audit results], it would have been received differently than when [the department manager] and I presented it. (Manager, unit level)

Finally, managers reported that problems with the communication efficiency were sometimes impeding the message being communicated, as illustrated by the following excerpt:

> [The department manager] always presents the [quality] results in our meetings…. He runs through the results very quickly, and I'm always left wondering whether I managed to catch everything or not. (Manager, team level)

7.1.4 Information Use

Subsequent to information generation and communication, information is used for various purposes and by different information users in the quality management process. Information users are usually considered the end-users of information (e.g., clinicians). However, this study shows that information users exist at various organizational levels prior to the end-users. For example, managers can be information users, but they are also information mediators to subsequent

information users in the line of management. The quality dimensions suggested by information users at SHT are described next.

Application quality. Application quality represents the perspective of information users (i.e., managers and clinicians) and their emphasis on important aspects in the application of the information. The analysis revealed granularity, urgency, relevancy, comparability, completeness, usefulness, and conciseness as the most frequently mentioned application quality dimensions. Appendix G presents a complete list of dimensions. As emphasized by information producers, information users confirmed the importance of granularity. Informants stated that it was critical to match the level of granularity with the organizational level of application. This is illustrated by a statement describing why information at a too high level of aggregation is insufficient for clinicians at the operational level:

> There is no use in communicating [quality management information] that nobody understands…. When [the information] is available at the lowest [organizational] level, however, [the clinicians] know what it means, and what they need to do. (Administrative consultant, department level)

Urgency, usefulness, and relevancy were found to be important quality dimensions, particularly for clinicians. If clinicians failed to see the urgency, usefulness, and relevancy of the information, managers acknowledged that it was difficult to accomplish enactment. Several informants emphasized the tension between information relevancy and clinical autonomy:

> We are struggling to get the clinicians to open their ears to what we are trying to communicate. There is a high degree of autonomy, where people decide on their own what's relevant or not…. There's no escaping from the fact that some people put on their Teflon suit and just let things go and continue doing things the way they think is right—the same way they've always done. (Manager, unit level)

Since quality of health care services is a relative concept, informants stated that comparability is an important quality dimension for managerial application of information. Thus, application of information sometimes depends on the comparability dimension, as illustrated by an informant:

> When you compare your [audit] results to other departments, or to units that are comparable, you may observe discrepancies. And you wonder—why are there discrepancies and what's the reason? That's when the discussion becomes interesting. (Manager, department level)

Even though there existed a hospital-wide data warehouse for quality indicators based on structured data, it was never used by managers in the division for various reasons. First, the data warehouse provided only some of the quality management information that was needed by managers, and thus lacked completeness. Furthermore, information was not easily available for managers, as expressed by the division director:

> Availability…. That's true—it's something that I'm struggling with every day. Even though information exists, it's stored in a way that if I want to access it, then I need to click, like, 200 times and in a sequence that I can't remember, in order to reach the spot where I know the information is stored. The consequence is that I never do it because I don't have the energy to dig my way to the information that I know someone has put somewhere. (Division director, top management)

Because of the lack of completeness and availability of information from the data warehouse, the division staff compiled data from various sources (including the BSC) and provided this to all department managers by email once every month. This distribution (rather than retrieval) of information was institutionalized and preferred by the managers in the division.

Even though completeness was emphasized as an important dimension from the data extractors' view of quality, both managers and clinicians stated that this dimension challenged application, particularly for information artifacts based on unstructured audit data. This challenge is illustrated by a statement from one of the informants describing the differences of completeness in information based on structured data (BSC) and information based on unstructured data (audit):

> I think that the biggest difference is that for the balanced scorecard, you'll extract the entire data set. So, if you could do the same for subjects closer to their clinical work [as in auditing], then I think it would weigh heavier [for

> the clinicians]. But because of the small sample size, no one feels accountable at all, and they would say, "It doesn't apply to me, it applies to someone else." So, it doesn't get the weight that it should. (Manager, unit level)

As emphasized by the information producers' view of quality, conciseness was particularly perceived as an important dimension for operational enactment. The following description of the quality of an audit report illustrates the differences in perceptions of conciseness between managerial and operational perspectives:

> [The clinicians] are allergic to this. It's the amount. It's the graphs and tables. This is really something special—there are colors and all that stuff. [The clinicians] want it to be concise. This is too much and is meant for people like me…. Some might find it entertaining, but most people don't. (Manager, department level)

7.1.5 Interrelations of IQ Dimensions within the Life Cycle

In the previous subsections, I presented the findings on the different IQ dimensions emphasized by the actors involved in the three processes of the IQ life cycle: information generation, information communication, and information use. Next, the findings of how the different views of actors are interconnected throughout the IQ life cycle are presented. Appendix H presents a full list of interrelations between IQ dimensions.

IQ in the information generation process. In the transformation of data into information, the analysis revealed that IQ transformed through the three subprocesses of information generation, as illustrated in Figure 7-1. In these subprocesses, and from their perspectives, different actors addressed specific quality dimensions toward a final information artifact; data extractors addressed intrinsic extraction quality dimensions, such as accuracy, completeness, credibility, and objectivity; data custodians addressed organization quality dimensions, such as adequacy of scope, consistency between data sets, and granularity; and information producers addressed presentation quality dimensions, such as ambiguity, amount, comparability, conciseness, and understandability.

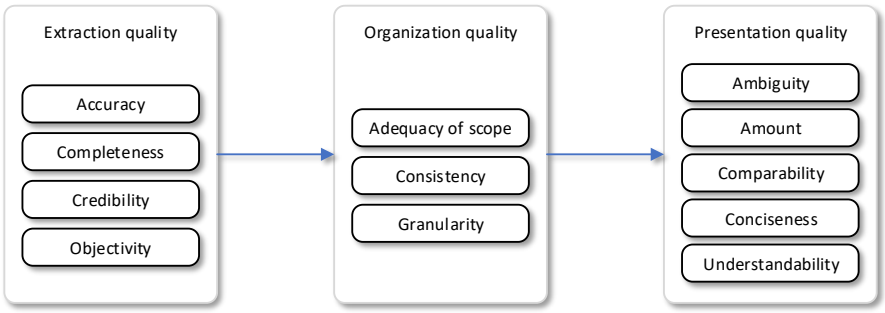


Figure 7-1: IQ in the information generation process.

IQ in the information use process. When information artifacts are transferred to the application context, the analysis identified that some IQ dimensions in the information generation process could affect information users' perceptions of several application quality dimensions in the information use process, as exemplified by granularity in Figure 7-2. Consider the following statement:

> [The unit managers] won't relate to this unless [the information] is split into their unit levels. They don't need it and don't know how to use it…. So, for them to take it seriously, we need to get it broken down for their units. (Assistant manager, department level)

Here, the assistant department manager describes how the lack of granularity, an IQ dimension included by the data custodian in the data organization process, leads to unsatisfactory application quality in the information use process (i.e., relevancy, urgency, and usefulness).

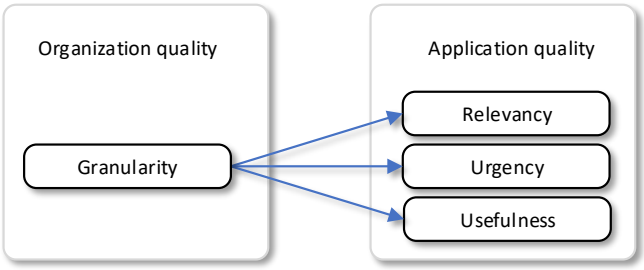


Figure 7-2: Example of relations between organization quality and application quality.

An example of how quality dimensions did not transform satisfactorily between the information generation and information use processes is illustrated by a data

custodian who was responsible for organizing audits from several units within a department:

> I made a somewhat standardized form containing the elements [that the auditors were] supposed to evaluate, but it became obvious that they evaluated far too much…. Some things [were audited] consistently across all units, but additionally, some [units] included subjects that others didn't. It cannot be compared…. What I learned was that I'll provide a template next time. I assumed they'd all be evaluating the same…. Next, I visualized [the results] and tried to keep things simple. [When communicating the results], I emphasized the poor basis of data. It was only based on three journals. I told [the unit managers] that this is really coarse-grained and only meant to be an indication of what they needed to bring their attention to. (Quality advisor, department level)

As the example illustrates, the scope of data was not clear to the data extractors, leading to inconsistencies between the data sets from the units. Furthermore, the informant emphasized the incompleteness of data that he included in the final information artifact (and thus acting as both data custodian and information producer). This information was communicated to unit managers by email, where a unit manager reflected on the quality of this information:

> I received [the audit results] from [the quality advisor] with bar charts and stuff. But it has limited value because it was so subjective in many ways. There were no commonalities. We didn't extract the data consistently… and it didn't make much sense to me…. I don't think I'll pass it on [to his subordinates]… because it was too few numbers and too few journals. (Manager, unit level)

The unit manager illustrates how his perceptions of quality dimensions from an information user's perspective, which originated from various actors in the information generation process, prevented him from using the information. The perceived challenges of IQ dimensions were the lack of completeness of data (i.e., extraction quality), a lack of data consistency (i.e., organization quality), and a lack of understandability (i.e., presentation quality), resulting in a lack of usefulness and understandability as perceived by the information user.

Impact of information communication on IQ. The analysis identified that the way information was communicated by information mediators impacted how information users perceived the application quality. Specifically, CQ dimensions could either decrease or reinforce users' perceptions of specific application quality dimensions. One example illustrating this is how targeted and reciprocal communication can affect several quality dimensions perceived by information users, as expressed by a clinician:

> To me, I don't understand [the audit report]. It would've been better if the unit manager said to me, "We've now assessed some of your documentation, and we see that you need to improve on this or that." That would really be useful. When I see something like this [the audit report], I just think that it's difficult to understand and relate to. That's why I don't read it…. I just think that the [audit report] is boring and hard to understand. I don't understand everything. It's much easier when you have a person in front of you who you can talk to and ask if you wonder about anything…. I think [dialogue] is more useful, as when [the unit manager] informed us about a journal audit of treatment plans. She briefed us about it, and—since people have different opinions on treatment plans—it became a subject of discussion. To me, that's much more useful. (Clinician, operational level)

This statement illustrates that the clinician was unable to realize the relevance or understand the content of the audit report and emphasized that a targeted communication could amend this and improve the perception of its usefulness. Furthermore, the clinician expressed that engaging in a dialogue (reciprocity) would improve the perception of its usefulness and increase understandability of the information. This is illustrated by the lines between communication (i.e., reciprocity and being targeted) and application quality dimensions (i.e., relevancy, understandability, and usefulness) in Figure 7-3.

For the communication to be targeted, the information artifact needs to have adequate granularity, hence the line between "granularity" and "targeted" in Figure 7-3. This finding illustrates the interrelations between IQ dimensions in the information generation, communication, and use processes. Furthermore, information users' perceptions of application quality relate directly to the information artifact. These relations are illustrated in Figure 7-3 as lines between

IQ dimensions of organization quality (i.e., granularity) and IQ dimensions application quality (i.e., relevancy and usefulness).

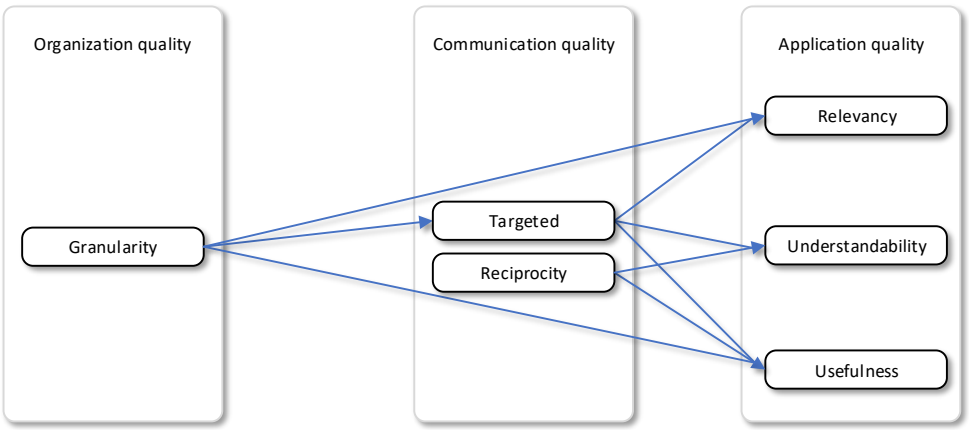


Figure 7-3: Example of relations between organization, communication, and application quality.

This example illustrates the crucial role of mediators in the secondary use of EHR data. By only transporting the information to information users, there is a risk that information users are unable to perceive the intentions of the information, and thus fail to take responsive actions. Through translation, however, mediators actively translate the information to achieve a shared understanding between the information mediator and the information user. Such translation can be achieved through CQ dimensions (e.g., reciprocity), and it often influences information users' perceptions of the understandability, urgency, relevancy, and usefulness dimensions of application quality. Translation is also associated with distortion, since a shared understanding is required in sequences and across organizational levels, as the division director stated:

> It's like that whispering game, where people are whispering something to the next person. And, eventually, you see whether the information ends up like it started. It's precisely the same—it's a whispering game. And it's absolutely critical for the task or phenomenon, and particularly critical if it concerns an agreed-upon change. (Division director, Top management)

As the informant implies, translation can lead to unintended modifications of the information (i.e., distortions) that can hamper enactment, or even result in taking adverse actions.

Feedback loops in IQ transformation. In trying to address IQ issues that prevent actors from applying or enacting information, the analysis revealed how information transformed throughout the organization. After the information artifact was generated and communicated, actors actively modified it to address perceived shortcomings in specific quality dimensions. The analysis identified three distinct feedback loops from information use to information generation, where the goal was to amend the application quality dimensions to increase the possibility of enactment. These feedback loops were filtering, integration, and regeneration of information.

Whereas *filtering* refers to reducing the information, *integration* refers to combining and/or merging additional information to the information artifact. Common to filtering and integration is that the original information is being modified by altering IQ dimensions included in the data presentation stage of the IQ life cycle. Such modification is illustrated by a department manager's response to the monthly quality report from the BSC received from the division staff:

> I think it's okay for us at a department management level to receive [the full quality report]. And then it's up to the management at the various locations to modify it by selecting the parts important to them and, if necessary, adding more background data. (Manager, department level)

This statement illustrates how modifications, such as filtering and integration, were needed before communicating the information in the line of management. For example, filtering sought to include urgency and conciseness by removing excess information, and integrating more details sought to reach completeness of the information.

Sometimes, integration and filtering of the information is not possible because the shortcomings in the quality dimensions are rooted in the processes of data extraction or organization. In such cases, *regeneration* of information is needed to address the required quality dimensions. This is illustrated by a team manager's reflection on how the quality of a department-level information was insufficient for team-level application:

> [The unit manager] communicates [the monthly quality report] that she receives from the division management, and we're really happy that [the quality advisor] breaks this down for us… because I think it's much more interesting to compare ourselves with the other units. And, in managing our daily work, I think it's most important to know what this means to us—where we are performing satisfactorily and what we need to improve. So, it is definitely more convenient for me when the information reflects our [organizational] level. (Manager, team level)

This statement illustrates how the granularity dimension (i.e., too high level of aggregation) of the BSC inhibited use of the information at the unit level. Since granularity was included in the data organization process, the information needed to be regenerated through an iteration of the information generation process. Through regeneration (referred to in the statement as "breaking down"), the quality advisor included granularity at the unit level, resulting in increased comparability, usefulness, and relevancy. Such regenerated information is also subject to filtering and integration when communicated in the line of management, which demonstrates the transformative nature of IQ throughout the life cycle. Figure 7-4 illustrates the IQ life cycle identified in this study, including the identified feedback loops.

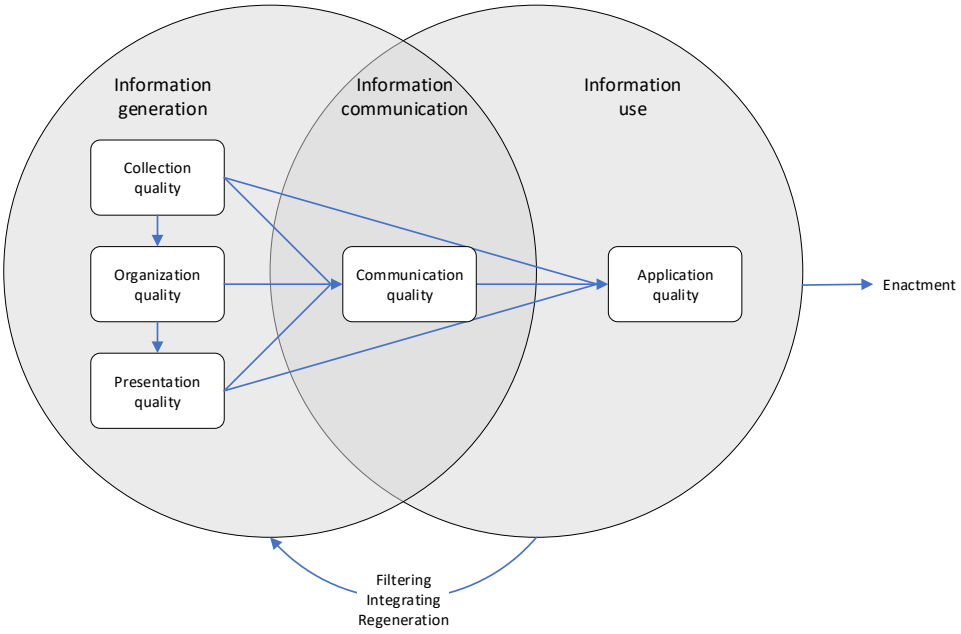


Figure 7-4: The IQ life cycle.

To be able understand the sociotechnical underpinnings of the IQ life cycle, the following section presents the findings of applying the theory of affordances.

7.2 Affordances in Secondary Use of EHR Data

As presented in Chapter 2, the health care context is viewed as a complex context with a multitude of users, heterogeneity and ambiguity of the data, and diversity and multi-level uses of EHR data (Cabitza & Batini, 2016). In secondary use, it is challenging to obtain value from EHR data, since the process is often not well defined and characterized as ad hoc, without standards in terms of empirical measures of core processes and a lack of understanding of information needs (Botsis et al., 2010; Foshay & Kuziemsky, 2014). Thus, treating information processing as a standardized manufacturing process performed by an IS provides a static view that fails to address the sociotechnical dynamics between human actors and technologies in extracting, organizing, generating, communicating, and using information.

This section presents the entities and events identified in the case, and the findings from the analysis of the actor-technology relations using the framework presented in Figure 5-3. This section extends the work previously published by Hausvik and Thapa (2017). Seven affordances in the process of secondary use of EHR data for quality management in SRH were identified: extractability, systematizability, analyzability, visualizability, communicability, prioritizability, and accountability. The identified affordances, which were categorized as IS and information affordances[3], were related to technological features, employee capabilities, facilitating conditions, conversion factors, and outcomes.

7.2.1 Entities and Events in the Secondary Use of EHR Data

The events of this case were identified by analyzing all interactions between human actors and EHR data and information in the quality management process. Through several rounds of clustering (see Appendix E), the key events of the case were identified as data extraction, data organization, data presentation, information

[3] Originally labeled as technosocial and sociotechnical affordances by Hausvik and Thapa (2017)

communication, and information use. Section 6.2 describes the key events of this case in detail. When the events were identified, I reanalyzed the data to identify the entities, including their relations, involved in each event. The relations between entities for each event are summarized in Appendix F. Next, a brief description of the entities and events are presented, corroborated with statements from the informants.

Data extraction event. In the data extraction event, human entities (i.e., administrative personnel or clinicians) use functionalities of technological entities (i.e., the EHR system) to extract data. For unstructured data, patient records retrieval features are used, whereas built-in reports are used to extract structured data, as illustrated by one informant:

> The first thing I do [when I extract data] is to find a report … that can provide me the data that I need…. When I find a report, I test the report by filtering and activating patients to find the corresponding data fields that are used in the report. To be able to understand the report, I investigate how the report data are entered into the system. (Administrative advisor, department level)

Data organization event. In data organization, human entities (i.e., administrative personnel, clinicians, quality advisors, and unit managers) use various technological entities, such as IS (e.g., information-processing tools, surveying tool, spreadsheet applications, or paper) to systematize the extracted EHR data. The reason for organizing the data in the external IS is because the EHR system lacks functionality to provide the needed data for quality management directly to the users. The following example illustrates how a secretary uses Excel to organize the structured data extracted from the EHR system:

> I make a table in Excel in which I enter the total number of patients being referred, how many of the referrals that have been rejected, how many patients are offered treatment, and how many referrals we have passed on [to other institutions]. (Secretary, unit level)

Data presentation event. In the data presentation event, data are often being analyzed by human entities (e.g., administrative personnel, managers, quality advisors, or unit managers) to detect patterns in the data. This is done by using

analytical features of various technological entities, such as data-processing tools (e.g., spreadsheet applications or surveying tools). After the data are analyzed, the data can be visualized using report and/or visualization features of the data-processing tools. An administrative advisor illustrated using Excel to visualize the data:

> If I'm unable to extract data [from the EHR system] directly into a table, I export the data to Excel. Then I arrange the data to make it easy for people not accustomed to the data to understand the information. I try to make the visualization very concrete. (Administrative advisor, department level)

Information communication event. When data are visualized, the next event is communicating the information. Such communication can involve human entities such as administrative personnel, managers, clinicians, and quality advisors. Often, the information is communicated using technological entities, such as email or presentation tools (e.g., PowerPoint). An administrative manager describes how the monthly report, based on the BSC, is distributed within one department:

> [The monthly report] is sent to all department managers and further passed on to the unit managers. The unit managers are supposed to… distribute it within their units. I can only speak for myself—I always distribute the report to the administrative staff. (Administrative manager, unit level)

Information use event. After being communicated, the information can be used for several purposes. In this case, the information was used as a basis for managerial discussions and prioritizations of actions to take, and to inform clinicians about how to enact the information. The use of the information does not involve technological entities other than the information itself. The following excerpt illustrates how the monthly report is used to prioritize and take actions accordingly:

> [The monthly quality report] provides us a really good indication of how we are doing. Are we achieving the goals we are being measured on? If not, which goals are we failing to achieve? Then, when we see that we have a problem or a challenge, we can prioritize and focus on this [problem]. (Manager, department level)

7.2.2 IS Affordances

As discussed in Subsection 4.2.4, IS affordances are action possibilities between goal-oriented actors and the properties of an IS. The IS affordances identified in this study are extractability, systematizability, analyzability, and visualizability. Common to these affordances is the direct relation between actors and specific features of various IS and the output information artifacts of such systems. The following paragraphs present each affordance in turn.

Extractability. In this case, extractability was the first affordance that needed to be actualized in the process of secondary use of EHR data for quality management. Extractability, as illustrated in Figure 7-5, is an affordance constituted by the relation between data extractors (i.e., administrative staff, managers, or clinicians) and features of the EHR system, and it could be described as the possibility for actors to extract patient-level EHR data according to the actor's goal. For example, an administrative consultant described the actualization of extractability for unstructured EHR data as follows:

> The previous audit I participated in, I extracted data [from the EHR system] from the past two months and assessed all admitted patients whether there existed a treatment plan or not. (Administrative consultant, department level)

The technological features of the EHR system necessary to constitute this affordance include individual patient data storage, metadata (e.g., timestamps, data creator credentials, and organizational affiliation), and data-extraction feature. Unstructured data are extracted by accessing individual patient documents, wherein data extractors assess the extracted data in accordance with an auditing template. Actors need system access to relevant patient records as a necessary facilitating condition for the affordance to be available. Furthermore, capabilities such as basic EHR data extraction skills and medical skills are needed to actualize extractability:

> Someone with medical knowledge must [perform the audit] because it is not an exact science, where something is either present or absent. Also, people express themselves differently, and mostly in narratives. (Quality advisor, division level)

For structured data, extractability is constituted by a different feature of the EHR system, such as the built-in reporting system. Access to relevant reports by actors is a necessary facilitating condition. Furthermore, actors must be knowledgeable in using the reports, determining which report is suitable for the task, and understanding the kind of data the report offers.

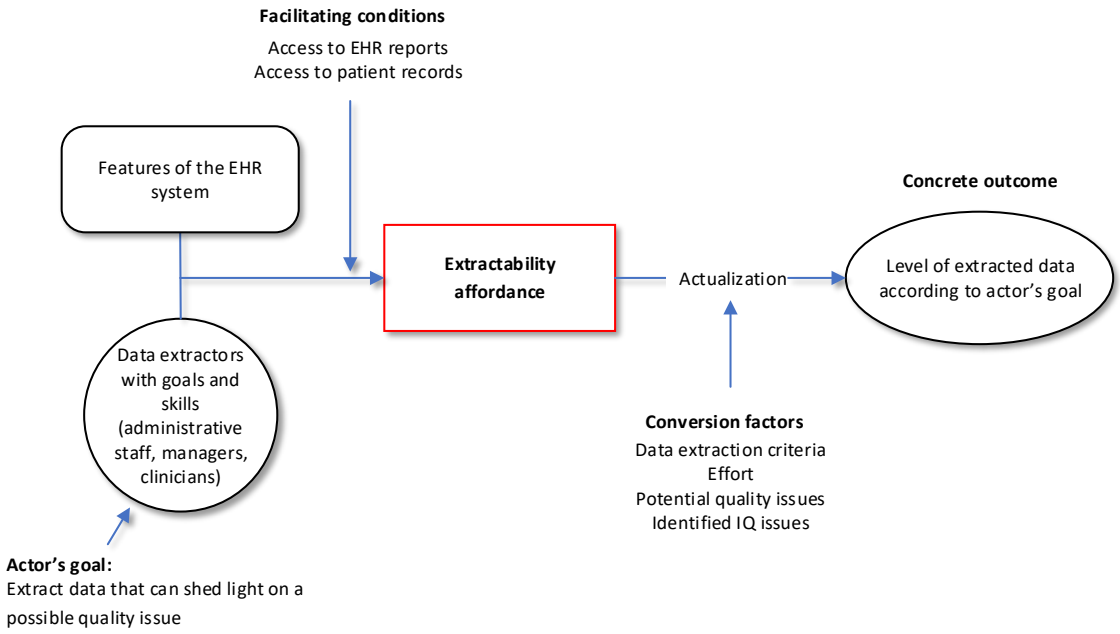


Figure 7-5: Extractability affordance.

The conversion factors identified for this affordance, include "effort", "potential quality issues" "identified IQ issues" and "data extraction criteria." The former relates to the amount of effort it takes to extract the data from the EHR system. Several informants stated that extracting unstructured data by auditing was time consuming and an important reason for the infrequent actualization of extractability. Furthermore, when actors have suspicions of non-compliance with clinical or administrative guidelines, the conversion factor "potential quality issues" often led actors to actualize extractability. This is illustrated by one informant as she explained the reason for performing clinical audits:

> When we perform an audit, it's because you need to provide evidence for a hypothesis of whether something is good or bad. Then we'll think—this might be a weak spot, so let's investigate this further. (Manager, department level)

When a quality issue is identified, the information could sometimes be insufficient to determine the appropriate action(s). In such cases, the facilitating condition "identified IQ issues" could lead to the actualization of extractability to provide more granular information. A unit manager explained why she performed a unit audit, based on the result of a department audit:

> It [the department audit results] is way too general. It gives a general hint and provides a status. But how to use it concretely…. Additionally, there are differences between the units. That's why I chose to do it. (Manager, unit level)

The conversion factor "data extraction criteria" facilitate the actualization process by providing actors with clear guidelines to maintain consistency in data extraction. An administrative consultant illustrated the usefulness of such guidelines when extracting data for the BSC:

> It [the data extraction process] is very well explained. I've done this procedure ever since we started using balanced scorecards, but I tend to forget which column to sort in the EHR system, and to find the right report—let's say, [I need to extract] the number of patients below the age of 23 years having their referrals administered within 10 days. Then, the guideline tells how to proceed to find the correct number. It [the guideline] is really good. (Administrative consultant, department level)

The outcome of actualizing extractability is raw quality management data provided to the data extractor by the EHR system. The level of correspondence between the actual outcome and the actor's goal is influenced by the conversion factors. For example, the statement by the administrative consultant above illustrates how the use of a guideline influenced the actor in extracting correct data for the BSC. Without the guideline, actors are still able to actualize the affordance, but with a reduced possibility to meet the actor's goal of extracting correct data, as specified by the management.

Systematizability. Systematizability is an affordance constituted by the relation between data custodians (i.e., administrative staff, managers, or clinicians), and data-processing tool(s) for organizing extracted EHR data. The affordance,

illustrated in Figure 7-6, could be described as the possibility for actors to systematize the EHR data. Such data includes unstructured and/or structured data that needs to be analyzed with supplementary tools. The primary goal of actors actualizing this affordance is to systematize the data in a data-processing tool for further analysis, without altering the original meaning of the data obtained from the EHR system. This affordance is illustrated by an informant:

> What we extract from [the EHR system] is one thing, and it's there you can see what's missing. It's in [the EHR system] we perform the record audit, but for the results of the audit…, we have used [a data-processing tool]. Simply for us to be able to have an overview of what we see. (Quality advisor, division level)

Multiple data-processing tools were used for systematizing the data at SHT, such as standard surveying tools, spreadsheet applications, standard word-processing tools, and manual processing using sheets of paper. Features of the data-processing tools include customizable data entry and data storage. Basic skills of data entry are required to systematize the extracted data in the data-processing tool.

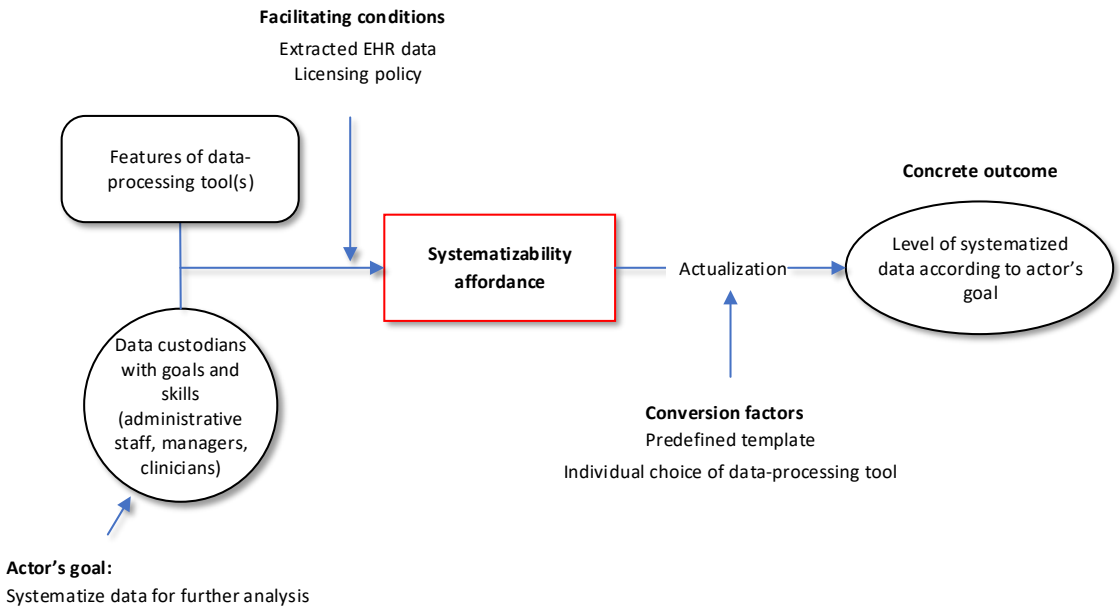


Figure 7-6: Systematizability affordance.

The actualization of extractability is a necessary facilitating condition for actualization of systematizability. Without extracting the data from the EHR

system, systematizability is not available for actualization. In this context, extractability and systematizability are actualized in parallel and by the same actors. Furthermore, since the EHR system lacked features of systematizing quality management data, additional data-processing tools were needed to systematize the data. Some data-processing tools were not available to all users because of limited software licenses. Thus, "licensing policy" serves as a facilitating condition for systematizability.

Since several tools could be used to systematize EHR data, the conversion factor "individual choice of data-processing tools" influenced the actor's selection of tools based on his/her preferences, abilities, and goals. The facilitating condition "licensing policy" could limit the choice of tools. Data custodians furthermore expressed that consistent actualization of systematization was important to reach the overall goal of quality management, where the "use of a predefined template" is a conversion factor facilitating such consistent actualization. For example, all departments are provided with predefined Excel files for entering their results. These files are further used as a basis for the BSC. One data custodian illustrated the challenge of inconsistent actualization of extractability and its implications for systematizability: when managing several unit-level audits, the data custodian discovered that several data extractors failed to faithfully follow the predefined template for extracting data. The result was that inconsistent data could not be systematized across the audits.

Organized EHR data in the external data-processing tool is the outcome of actualizing systematizability. The outcome of the actualization process is influenced by the conversion factor; the example of the data custodian above illustrates how the absence of a predefined template influenced the systematized data. Without a predefined template for systematizing the data, the actor was still able to actualize the affordance, but the outcome was not satisfactory according to the actor's goal.

Analyzability. Analyzability is an affordance constituted by the relation information producers (i.e., administrative staff, managers, or clinicians) and tool(s) for data processing. The affordance, illustrated in Figure 7-7, could be described as the possibility for actors to analyze the EHR data, where the primary

goal is to analyze the EHR data and discover patterns of compliance with clinical or administrative guidelines. As one of the informants stated:

> You must see if it's a trend…, if these incidents are convergent over time. Do we see if things [content of documents] are missing or [if there are] multiple discrepancies? Then, the point is to see it collectively and not just a random spike of something that doesn't really say anything. (Quality advisor, division level)

Most often, the data-processing tools used for systematizing data are also used for analyzing the data. The necessary features of the data-processing tool include descriptive statistics, filtering, ordering, grouping and/or pivoting, and basic numerical operations. To identify patterns within the data, actors need to acquire analytical skills and knowledge of the tools. Furthermore, actors need to understand the relation between the data entry process and the extracted EHR data.

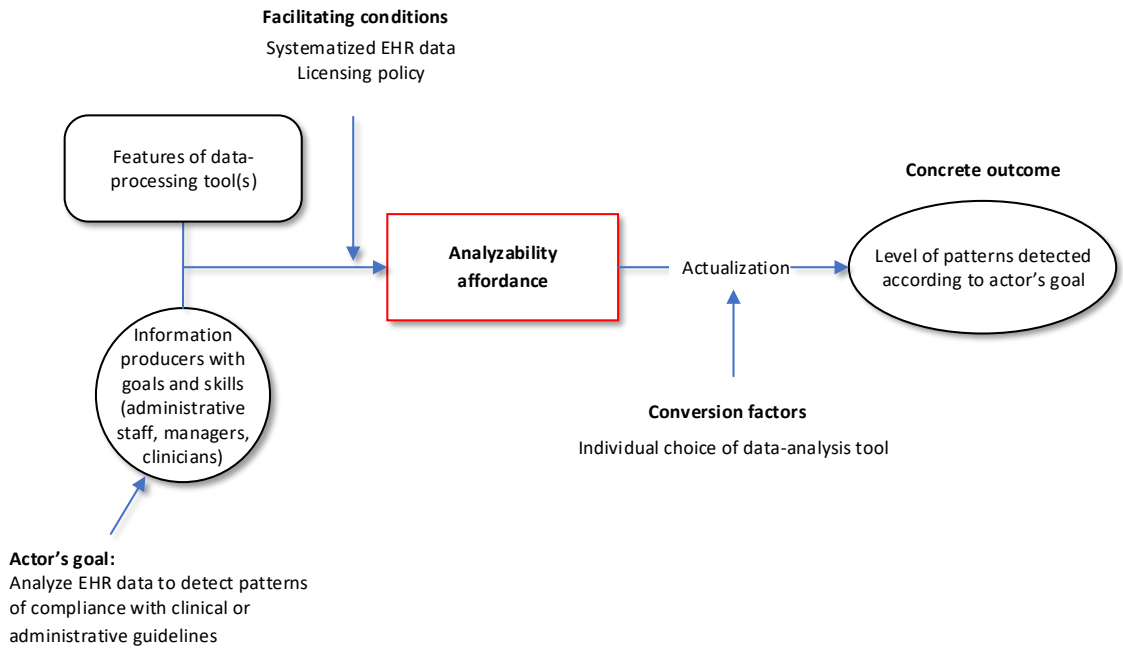


Figure 7-7: Analyzability affordance.

The actualization of systematizability was identified as a facilitating condition for making analyzability available. Thus, detecting patterns of clinical practice are only possible when the outcome of systematizability is in line with actors' goals. As with systematizability, several tools could be used to analyze EHR data, and

the facilitating condition "licensing policy" could limit the choice of tools. Hence, the conversion factor "individual choice of data-analysis tools" influenced the actor's selection of tools based on his/her preferences, abilities, and goals.

The outcome of actualizing analyzability is the patterns and knowledge of non-compliance with clinical or administrative guidelines.

Visualizability. Visualizability is an affordance constituted by the relation between information producers (i.e., administrative staff, managers, or clinicians) and the data-processing tool(s). This affordance, illustrated in Figure 7-8, could be described as the possibility for actors to visualize patterns of compliance with clinical or administrative guidelines of EHR data. The primary goal of actors actualizing this affordance is to visualize the analyzed results:

> I just visualize it [the data]. I think this is one way of doing it, and the response has been positive. When I showed them [the unit managers] the graphs, they said it seemed tidy, something I think they are concerned about. And I'll just try this out, until they tell me to do otherwise. If they don't like it, I might try something else, like making a report. (Quality advisor, department level)

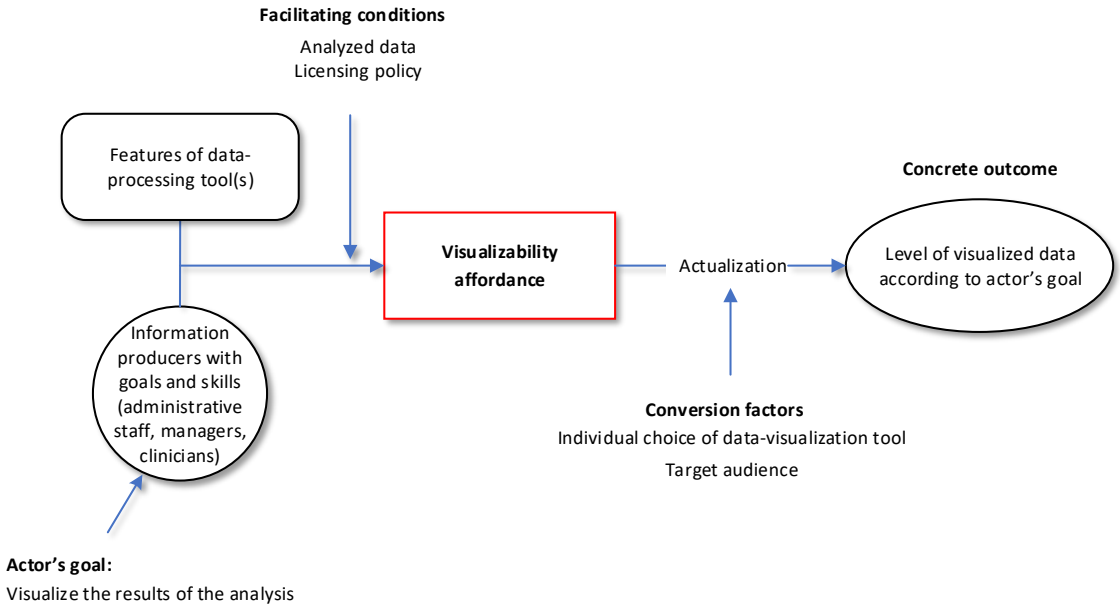


Figure 7-8: Visualizability affordance.

The data-processing tools used for systematizing and analyzing data are also used for visualizing data. The comprehensiveness of visualizations in the case ranged between simple depictions of the findings using tables to more advanced diagrams and graphs. Thus, the technological features needed to visualize the data also varied. Some of these features include simple print options, descriptive statistics, diagram and chart operations, and output report generation. To actualize this affordance, information producers need analytical skills and knowledge of how to use the available tools.

The actualization of analyzability was identified as a facilitating condition for making visualizability available, since the goal of the actor is to visualize the detected patterns of clinical or administrative practices. Furthermore, analyzability and visualizability are actualized sequentially and by the same actor.

Like systematizability and analyzability, several tools could also be used to visualize EHR data, and the facilitating condition "licensing policy" could limit the choice of tools. Hence, the conversion factor "individual choice of data-visualization tools" influenced the actor's selection of tools based on his/her preferences, abilities, and goals. Moreover, "targeted audience" was observed as a conversion factor affecting how the information was visualized. For example, when actualizing visualizability, actors need to keep the relevant audience in mind and to customize the visualized information accordingly. This customization of visualized data is exemplified by one informant:

> [Visualized] data or numbers need to be adjusted all the way down [the line of management] because there are so many considerations that need to be taken into account when presenting [the information]. (Manager, unit level)

The outcome of actualizing visualizability is quality management information artifact displaying the patterns of compliance with clinical or administrative guidelines. The outcome of the actualization process is influenced by the conversion factors, as illustrated by the above statement.

Summary of IS Affordances. The analysis identified that the IS affordances in this case are characterized as relations between a small number of actors, such as

administrative personnel and managers, and specific features of multiple IS. Furthermore, the outcome of actualizing one affordance is the facilitating condition to the subsequent affordance. Another characteristic of the IS affordances in this study is the low number of conversion factors identified.

The outcome of actualizing the IS affordances is quality management information based on EHR data. Subsection 7.2.3 describes the information affordances, including their facilitating conditions, conversion factors, and outcomes.

7.2.3 Information Affordances

As discussed in Subsection 4.2.4, information affordances are action possibilities between goal-oriented actors and properties of information artifacts. The information affordances identified in this case are communicability, prioritizability, and accountability. These affordances are primarily constituted by the relationship between organizational actors and the outcome of the actualization process of IS affordances (i.e., the information artifact). The following paragraphs describe these affordances in turn.

Communicability. Communicability, illustrated in Figure 7-9, is an affordance constituted by the relation between information mediators (i.e., administrative personnel, managers, and clinicians), the visualized quality management information, and communication and/or presentation tools. Thus, the outcome of actualizing visualizability (i.e., the information artifact) serves as the main artifact of the communicability affordance. The affordance could be described as the possibility of actors to communicate visualized patterns of quality practice based on EHR data. As discussed in Subsection 4.2.5, the actors actualizing affordances that involve interpersonal communication, are defined as information mediators in this dissertation. Thus, the primary goal of information mediators actualizing this affordance is to create a shared understanding of the implications of the quality management information. To actualize this affordance, communicative and rhetorical skills are required. The following excerpt demonstrates the actualization of communicability:

> The unit manager brings information to the team manager meetings, which in turn brings the information to the teams. Or, she distributes the information to everyone working here. She also brings the information to staff meetings, or I email the information. (Manager, team level)

The actualization of visualizability served as a facilitating condition to make communicability available, since the goal of the actor was to reach a shared understanding of the visualized quality management information.

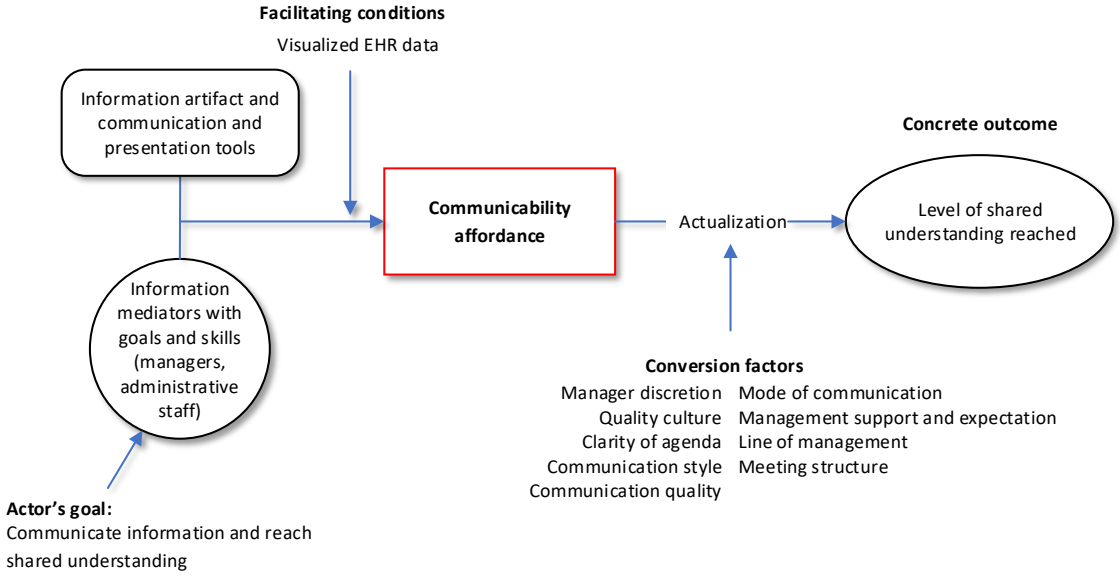


Figure 7-9: Communicability affordance.

The "mode of communication" was found to be a conversion factor influencing the achieved level of shared understanding. For example, communicability is actualized on different organizational levels and often supported by communication tools, such as PowerPoint and email. Sometimes, however, communicability is actualized without the direct use of technology. In these instances, printed copies of the information are handed out, or the information is communicated orally in meetings or face-to-face. Such cases are most evident when actualizing communicability between unit managers and clinicians. A unit manager explained why he presented the results orally without using technology:

> We have a meeting every second week, which is an informal forum. And I want it to be this way because, if I make it more pompous, it would be against the format that I want this meeting to be. (Manager, unit level)

The “meeting structure” was perceived to be an important conversion factor when actualizing communicability at various levels of the organization. This is expressed by a team manager:

> If I can say one thing, then it would be that… the meeting structure are determinant for raising quality. (Manager, team level)

The “communication style” was also observed to be a factor hampering shared understanding. Informants expressed that the information presented to them was sometimes difficult to comprehend, as illustrated by a unit manager explaining a situation wherein the department manager presented the monthly results of quality indicators:

> He usually presents this at the management meeting…. It is usually done quickly…. We work in a line of business that… —we are not statisticians like many people are. As for myself, I can spend a long time looking at this before I really understand [the meaning] of what has been presented. (Manager, unit level)

Other conversion factors included “manager discretion,” the “quality culture,” “clarity of agenda,” “communication quality”, “management support and expectations,” and a clear “line of management.” Appendix L presents more details about these conversion factors.

The level of shared understanding (i.e., the outcome of actualizing communicability) between the actual outcome and the information mediator’s goal was influenced by the conversion factors. For example, the statement by the unit manager above illustrates how communication style influenced the actor in reaching a shared understanding.

Prioritizability. Prioritizability is an affordance constituted by the relation between information users (i.e., management actors) and the communicated quality management information. The affordance, illustrated in Figure 7-10, could be described as the possibility for actors to prioritize interventions based on communicated quality-management information. The primary goal of actors actualizing this affordance is to decide on appropriate actions to take in response

to the information. As an example of actualization, managers in one department actualized prioritizability after the results from an audit were presented at a quality conference:

> We were first split up into department groups, and then the department group was split up into smaller groups. We chose three areas of challenges…: documentation and writing patient journals, diagnostic assessments, and suicide and overdose assessments. These were three challenges that we could agree upon. (Assistant manager, department level)

To actualize this affordance, actors need organizational knowledge to understand the potential effects of the prioritized options. Furthermore, the level of shared understanding of the quality management information communicated (i.e., the outcome of communicability) serves as a facilitating condition to make prioritizability available. Communicability and prioritizability are often actualized concurrently, for example, in management meetings where information is first presented and followed by discussions of prioritizations.

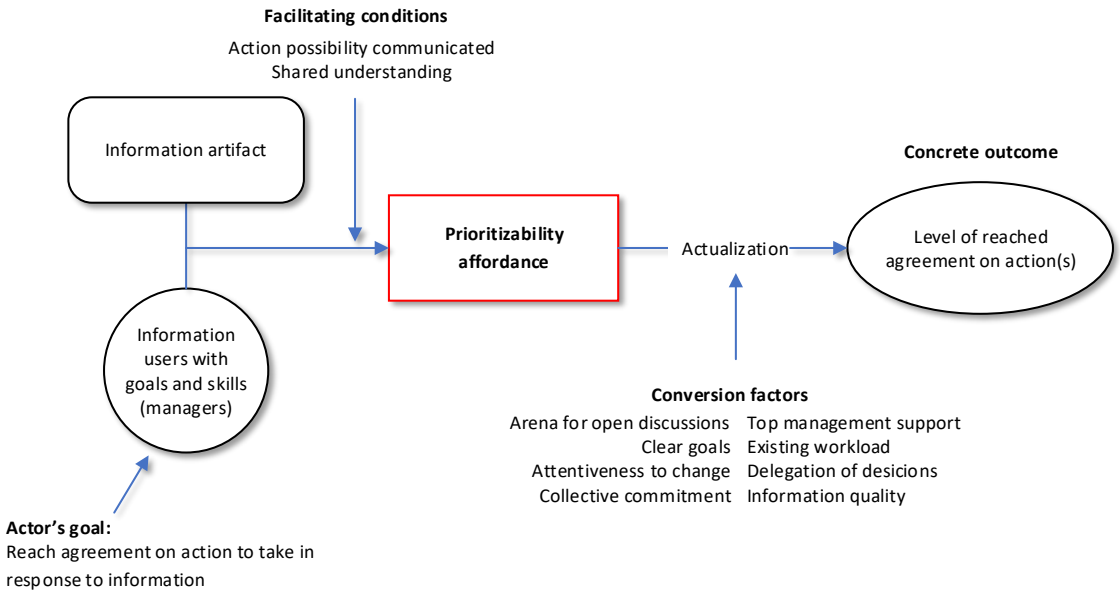


Figure 7-10: Prioritizability affordance.

The conversion factor "existing workload" (i.e., the extent of already-existing commitments) can affect prioritization, where one of the informants expressed his frustration:

> I think we have enough. We have enough. There is enough work following the results of the monthly report. Even though our department achieves satisfactory results on all quality indicators, it's still enough. (Manager, department level)

In such situations, "top-management support" and the "delegation of decisions" are two important conversion factors. For example, the delegation of decisions is aimed at increasing the local ownership of interventions. This is explained by a senior quality advisor after the results of a department audit were communicated to all department and unit managers in the division:

> Each department received their results at the quality conference. They chose what they wanted to prioritize, so they would own it. They need to own their own problems. (Quality advisor, division level)

Other conversion factors include "arenas for open discussions," "clear goals," "attentiveness to change," "collective commitment," and "information quality" (see Appendix L for more details).

The level of agreement on prioritized actions (i.e., the outcome of actualizing prioritizability) is influenced by the conversion factors. The statement by the senior quality advisor above illustrates how the "delegation of decisions" to the lowest management level resulted in local ownership of the interventions.

Accountability. Accountability, illustrated in Figure 7-11, is an affordance constituted by the relation between information users (i.e., management actors) and the prioritized quality-management information. The affordance can be described as the possibility for actors to make subordinate employees accountable for implementing prioritized actions based on quality management information derived from the EHR system. This is illustrated by one informant:

> [The unit manager] was struggling with how to make the clinicians be accountable and act on the information that has been provided to them…. She tried various approaches, but it was a major challenge. What really doesn't work is just sending an email to the managers and demanding them to implement it. (Quality advisor, department level)

To be able to actualize this affordance, management actors need to be committed to the prioritized action(s). Furthermore, the outcomes of actualizing communicability (i.e., the level of shared understanding of the quality information) and prioritizability (i.e., the level of agreement on interventions) are identified as facilitating conditions.

The level of commitment to enact prioritized actions by information users was identified as the outcome of the actualization process of accountability and was influenced by the various conversion factors observed in this case (see Appendix L). One noticeable factor was differences in the perspectives of quality, particularly for quality indicators based upon structured data. Several clinicians and unit managers illustrated this in the following way:

> What I think about quality?… Unfortunately, I have an impression that I understand this quite differently from the hospital [management]…. For me, it is the optimal and best therapy that is most effective for patients…. It is not about measuring the number of days until the discharge letter is sent. It is not about the number of approved journal documents… or such things, which I have an impression is how the division defines quality. (Manager, team level)

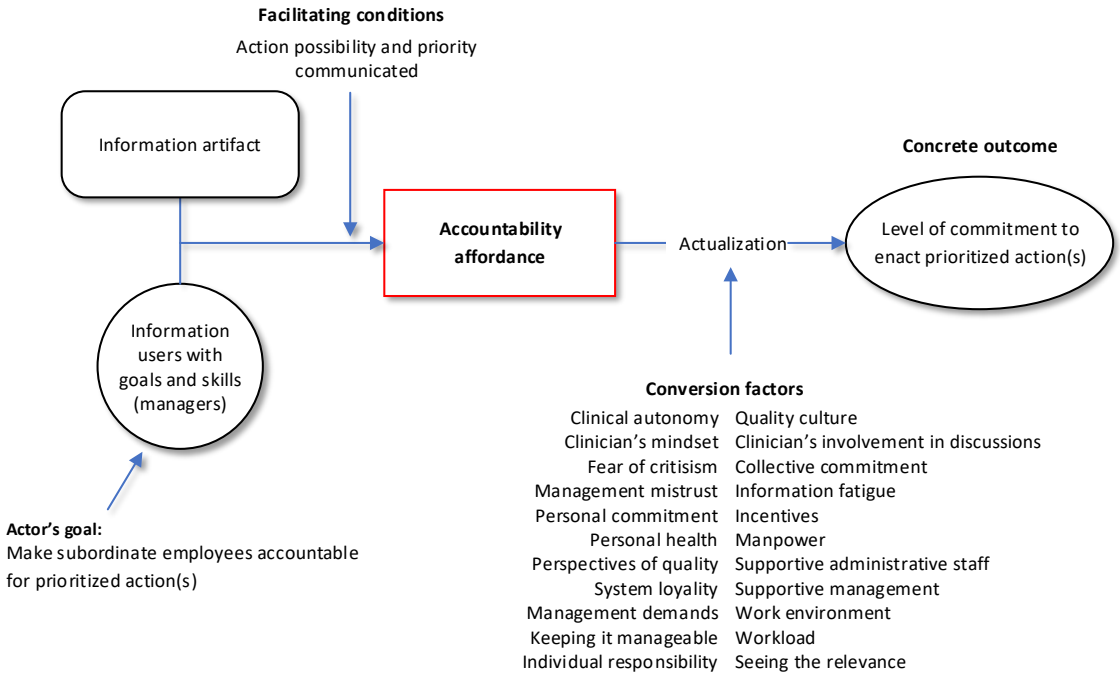


Figure 7-11: Accountability affordance.

Similarly, the conversion factor "clinical autonomy" can sometimes lead to an unfavorable outcome of accountability. Several managers at various organizational levels expressed frustration in trying to make clinicians accountable for prioritized actions. In particular, clinical autonomy often meant that clinicians were in the position to decide the relevancy of the decided actions to their clinical practices, which could sometimes result in clinicians considering the information irrelevant, and thus failing to commit to the prioritized actions.

Despite different perspectives of quality and clinicians' autonomy, other conversion factors can still lead to a favorable outcome when actualizing accountability. One example of such a conversion factor is "system loyalty," as explained by a team manager:

> There is some frustration here from time to time, but there is also a loyalty of doing the things we are being told to. However, it is not always an understanding of the purpose. (Manager, team level)

Summary of information affordances. The analysis identified that the information affordances in this case are characterized as relations between groups of actors and the quality management information. The information is derived from actualizing IS affordances, where the outcome of actualizing one affordance is a facilitating condition to make the subsequent affordance available. Another characteristic of the information affordances in this case is the multitude of conversion factors leading to indeterminate outcomes of actualization.

IS affordances, mentioned in the previous subsection, and the information affordances cannot be actualized in isolation. They are not only intra-dependent, but also interdependent, meaning that IS and information affordances may influence each other. Subsection 7.2.4 describes the interdependencies in detail.

7.2.4 Interdependencies of Affordances

The overall goal in this case was the quality management of health care services in the division. The reasons for setting this goal were various internal and external factors, such as government legislation and quality accreditation requirements. To

achieve the overall goal, it is important to actualize bundles of affordances. These affordances, however, are interconnected, interrelated, and interdependent. The analysis shows that the outcome of actualizing one affordance can be a facilitating condition for other affordances.

For division initiatives, such as department-level audits, the following affordances were actualized: extractability, systematizability, analyzability, visualizability, communicability, and prioritizability. However, only managers and administrative personnel were involved, and accountability at the operational level was not yet actualized. To actualize accountability, a favorable outcome of communicability is a necessary facilitating condition. For example, when prioritizing interventions based on the communicated results of a department audit, one department realized that the current information was insufficient for accountability to be possible, and thus auditing was needed at the unit level:

> Yes, [conducting unit-level audits] was of paramount importance. It doesn't have the same effect when division management performs audits… because they [the line management] must own it. They must see it themselves…. They won't relate to this unless it gets broken down to their units. They don't need it and don't know how to use it. So, for them to take it seriously, they need to get it broken down to their unit. (Assistant manager, department level)

In this example, the outcome of actualizing prioritizability serves as a facilitating condition (i.e., "identified IQ issues") for a second cycle of actualizing the affordances of extractability, systematizability, analyzability, and visualizability. After re-actualizing this bundle of affordances, the conditions then facilitated communicability between the unit managers and clinicians, which was actualized in this department. Furthermore, the outcome of communicability served as a facilitating condition for making employees committed to the prioritized actions (i.e., actualizing accountability). As the assistant department manager illustrates, the level of intention to enact prioritized actions (i.e., the outcome of accountability) was influenced by conversion factors (e.g., seeing the relevance). In this department, accountability was actualized, and agreed interventions were enacted.

In the same example, another department chose not to engage in a second round of auditing and instead actualized communicability between the unit managers and clinicians based on the overall audit results. However, accountability at the operational level was never actualized; an external audit revealed the same challenges in the department about one year after the first audit. One of the reasons for not reaching operational-level accountability was because the unit-managers were unable to actualize the accountability affordance of the aggregated quality management information communicated to them. This example illustrates three important findings: (1) the outcome of an affordance is indeterminate and can range between fully reaching (e.g., reaching a shared understanding, as in the former department) to not reaching the actor's goal (e.g., no shared understanding reached, as in the latter department); (2) the outcome of one affordance (e.g., communicability) can serve as a condition that either facilitates (e.g., in the former department) or inhibits (e.g., in the latter department) actualization of another affordance (e.g., accountability); and (3) the outcome of actualization is affected by conversion factors (e.g., actors at the former department enacted the information because they saw its relevance).

Another example of the interdependencies is when management actors have reached a shared understanding and agreement on actions. However, actors at the operational level may need further information appropriation to achieve the shared understanding, as illustrated by the division director:

> Department managers have meetings with their unit managers, who in turn disseminate information [to clinicians] through unit meetings…. I don't have control over how much information is reaching [clinicians] because [information] is being filtered all the way. (Division director, top management)

Such modifications include filtering and/or adding more background information, leading to the re-actualization of visualizability. The outcome of re-actualizing visualizability now serves as a facilitating condition at the operational level to make communicability available. Likewise, the outcome of communicability will furthermore serve as a facilitating condition to make accountability available. This example illustrates that some affordances sometimes need to be re-actualized (e.g.,

visualizability) to improve the facilitating conditions of other affordances (e.g., communicability) and finally achieve the organizational goals.

The analysis identified that IS affordances, even if they are related to multiple IS, were so tightly connected that they sometimes appeared to be actualized as one single affordance (i.e., extractability and systematizability, and analyzability and visualizability). However, there are subtle differences between these affordances: extractability is about extracting the data from the EHR system, whereas systematizability is about entering the extracted data systematically into a data-processing tool. Likewise, analyzability is about assessing the patterns that emerged, and visualizability is a further visual presentation of the patterns. The outcomes of actualizing individual IS affordances were identified as facilitating conditions for subsequent affordances. As the case illustrates, actualization of the affordances does not always follow the same sequence, but they are interconnected and interdependent through their outcomes. Figure 7-12 illustrates the interdependencies of the IS and information affordances.

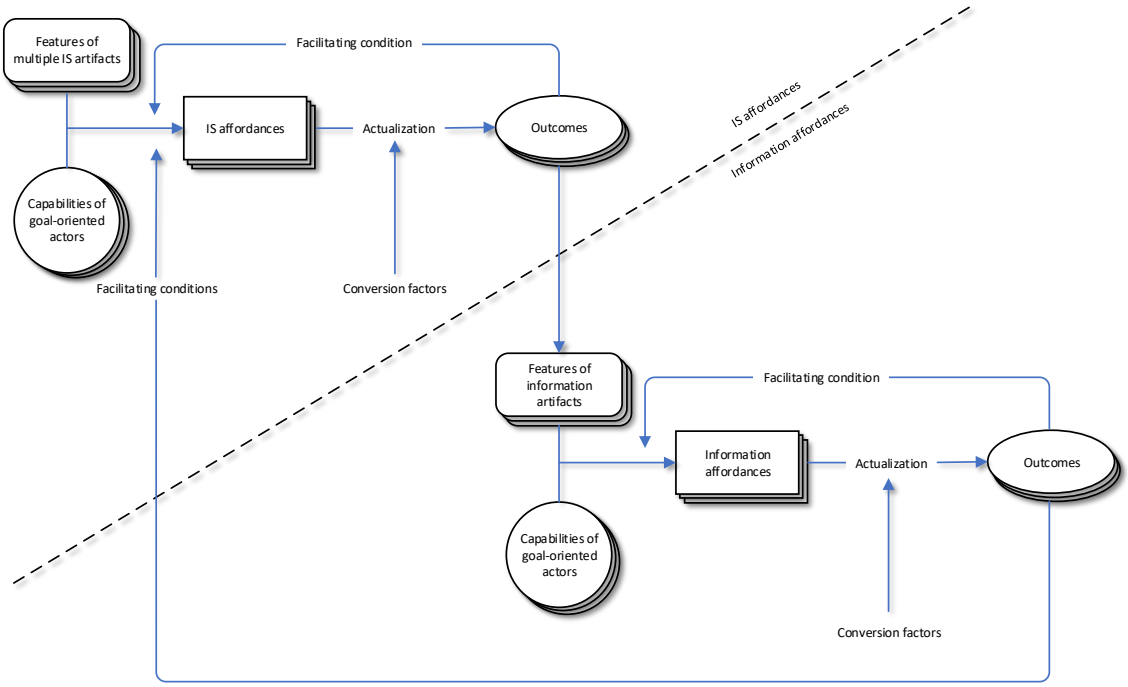


Figure 7-12: Interdependencies of IS and information affordances.

7.3 Generative Mechanisms Underpinning the IQ Life Cycle

By applying the distinction between affordances and mechanisms as described in Section 5.2, this study proposes four mechanisms underlying the process of secondary use of EHR data: the information generation mechanism, the information communication mechanism, the decision-making mechanism, and the accountability mechanism. Figure 7-13 illustrates the mechanisms underpinning the IQ life cycle and the interdependencies of the mechanisms.

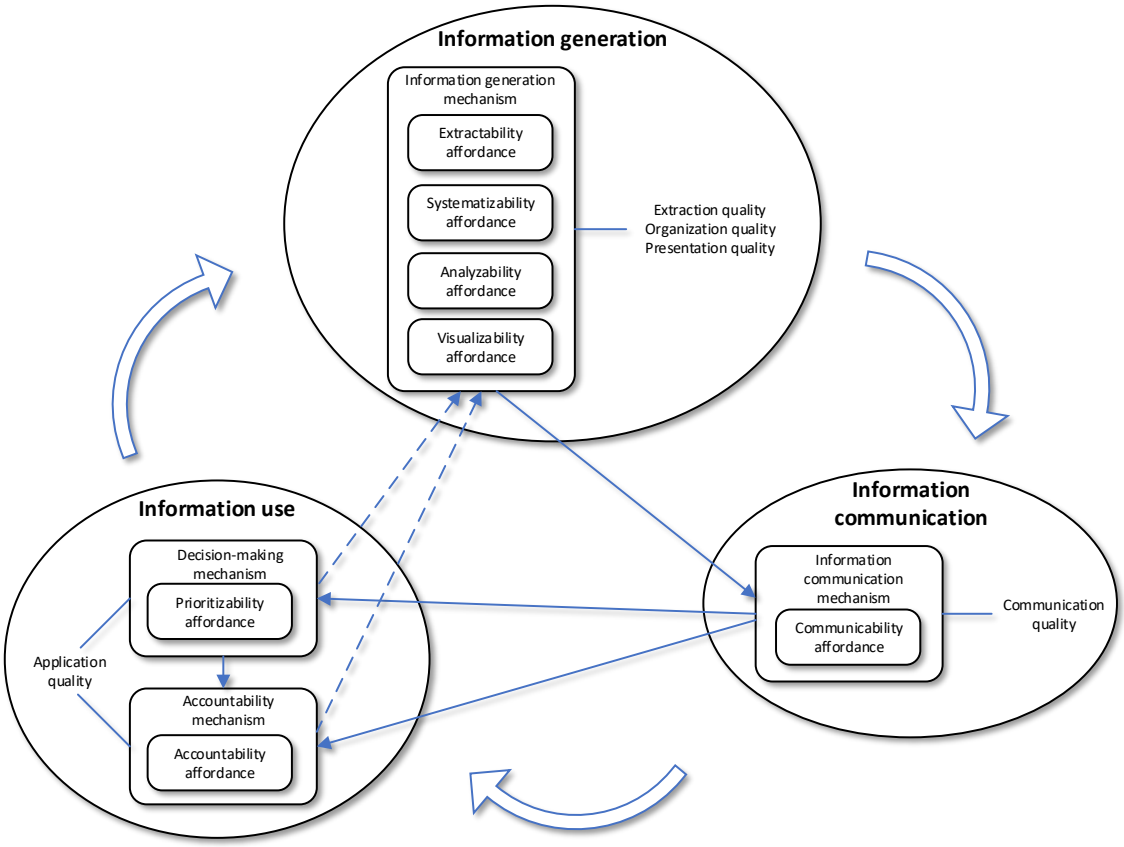


Figure 7-13: Mechanisms underpinning the IQ life cycle.

Information generation mechanism. The information generation mechanism proposed in this study can be considered a macro-mechanism comprising the four identified IS affordances and their facilitating conditions, conversion factors, and interrelations (micro-mechanisms), where each affordance is characterized as relations between specific goal-oriented actors and features of specific technologies. To generate the outcome event (i.e., production of an information artifact based on the routinely collected EHR data), the information generation mechanism needs to be triggered. This mechanism illustrates that, sometimes,

bundles of affordances need to be actualized to explain the observed outcome of a mechanism. For example, by failing to actualize any of the four affordances, the mechanism will not be triggered and will consequently not produce any outcomes. When the mechanism is triggered, the IQ of the outcome information artifact is transformed through actualization of the IS affordances: (1) by actualizing extractability, data extractors influence the extraction quality; (2) by actualizing systematizability, data custodians influence the organization quality; and (3) by actualizing analyzability and visualizability, information producers influence presentation quality. The details of the specific quality dimensions targeted by the actors in this case are described in Subsection 7.1.2 and illustrated in Figure 7-1.

Information communication mechanism. The information communication mechanism proposed in this study comprises the communicability affordance, including its facilitating conditions and conversion factors (see Figure 7-9). For the information communication mechanism to be triggered, there needs to be an information artifact to communicate. Figure 7-12 illustrates this by showing how IS and information affordances are interdependent. Thus, the information communication mechanism is dependent on the information generation mechanism (as illustrated by an arrow between the information generation and information communication mechanisms in Figure 7-13). The outcome event of triggering the information communication mechanism is some level of shared understanding of the action possibilities provided by the information artifact. The level of shared understanding is influenced by the conversion factors when actors actualize the communicability affordance. One of the conversion factors identified as influencing the outcome of actualizing communicability was communication quality. As described in Subsection 7.1.3, information mediators influence the level of shared understanding through their emphasis on communication quality dimensions. For example, by emphasizing reciprocity, information mediators sought to translate the information in order to reach a shared understanding (see Figure 7-2).

Decision-making mechanism. The decision-making mechanism proposed in this study comprises the prioritizability affordance, including its facilitating conditions and conversion factors, as illustrated in Figure 7-10. For the decision-making mechanism to be triggered, the information artifact must have been communicated

to relevant actors. Thus, the decision-making mechanism is dependent on the information communication mechanism, as indicated by an arrow between the information communication and decision-making mechanism in Figure 7-13. The outcome event of triggering the mechanism is some level of agreement on the actions to take based on the information. The level of agreement is influenced by the conversion factors of the prioritizability affordance. The feedback from the decision-making mechanism and the information generation mechanism (illustrated in Figure 7-13) indicates that the application quality of the information artifact is sometimes inadequate for information users to perceive its action possibilities. Thus, for triggering the decision-making mechanism, the information generation mechanism needs to be re-triggered with an improved outcome of prioritizability to be available to information users. For more details on specific application dimensions important to information users in this case, see Subsection 7.1.4.

Accountability mechanism. The accountability mechanism proposed in this study comprises the accountability affordance, including its facilitating conditions and conversion factors (see Figure 7-11). For the accountability mechanism to be triggered, the information artifact must have been communicated and priorities of actions must have been made. Thus, the accountability mechanism is dependent on both the information communication mechanism and the decision-making mechanism, as illustrated in Figure 7-13. The outcome event of triggering the accountability mechanism is some level of commitment by the clinicians to enact the prioritized action(s). The level of commitment is influenced by the conversion factors of the accountability affordance. Like the decision-making mechanism, the application quality of the information artifact is sometimes inadequate for information users to perceive the action possibilities of accountability. By filtering, integrating, or regenerating information, actors attempt to increase the application quality of the information (see Subsection 7.1.5). Such re-triggering of the information generation mechanism is sometimes needed for accountability to be available for users. This is illustrated with a feedback arrow between the accountability mechanism and the information generation mechanism in Figure 7-13. More details on specific quality dimensions important to information users in this case are presented in Subsection 7.1.4.

7.4 Chapter Summary

In this chapter, I addressed the research questions of this study by analyzing the empirical data collected from SHT. The overall research objective of this study was to understand the role of IQ in the process of secondary use of EHR data through the following research questions:

RQ1. How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data?

RQ2. What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data?

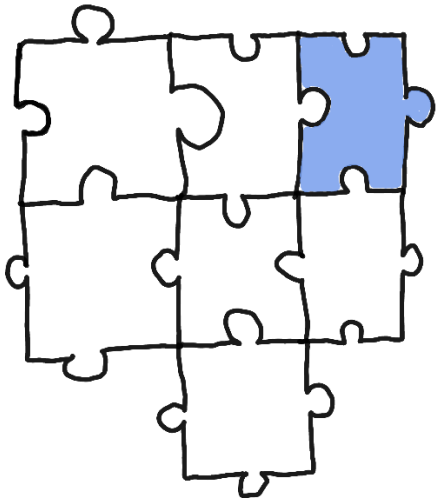
As illustrated in Figure 2-3, RQ1 was addressed by applying the IQ life-cycle perspective to, first, understand actors' perceptions of IQ in the various parts of the process of secondary use for quality management in SHT, and second, to understand how the various parts of the process were interrelated. The different quality dimensions perceived as important to the users are presented in Appendix G. Figure 7-4 illustrates how IQ was found to transform in the process of secondary use of EHR data for quality management. Through the processes of information generation, information communication, and information use, actors address specific quality aspects (i.e., extraction, organization, presentation, communication, and application quality). For example, in the data generation process, data extractors address intrinsic extraction quality dimensions, data custodians address organization quality dimensions, and information producers address presentation quality dimensions. Furthermore, in the information use process, information users' perceptions of the application quality are influenced by both the information generation and the communication process (communication quality). Sometimes, application quality is inadequate for information users. In such cases, information needs to be modified by filtering, integration, or regeneration (as illustrated in Figure 7-4).

The second research question (RQ2) was addressed in two stages: first, by applying the theory of affordances as a theoretical lens; and second, by proposing the generative mechanisms underpinning the IQ life cycle. By applying the theory of affordances, I identified IS affordances (i.e., extractability, systematizability, analyzability, and visualizability) and information affordances (i.e.,

communicability, prioritizability, and accountability). By analyzing the facilitating conditions, conversion factors, and the interrelations of the affordances, I was able to propose the mechanisms underpinning the IQ life cycle: information generation mechanism, communication mechanism, decision-making mechanism, and accountability mechanism. The mechanisms underpinning the life cycle, including their interrelations, are illustrated in Figure 7-13.

The next chapter presents a discussion on the findings within the context of the identified literature on IQ in secondary use of EHR data (presented in Chapter 3).

Part III
Research Contributions



8 Discussion

In the previous chapter, I addressed the research questions of this study by presenting the findings of the case analysis. In this chapter, I discuss these findings against the backdrop of the existing literature identified in Chapter 3. In Section 8.1, the findings related to RQ1 are discussed in the context of existing literature on IQ in secondary use of EHR data, whereas the findings related to RQ2 are discussed in Section 8.2. In Section 8.3, I address the overall research agenda by discussing how the findings of this study suggest the need to reconsider the prevailing perspective of IQ (see Subsection 2.2.2).

8.1 IQ Life Cycle

The empirical evidence of the case documented how IQ in the process of secondary use of EHR data is transformed through three distinct processes: information generation, information communication, and information use. In each of these processes, actors heuristically include IQ dimensions based on what they perceive as important for information users for enactment. Sometimes, the IQ is unsatisfactory for application, and the information needs to be modified through filtering, integration, or regeneration (see Figure 7-4). In this section, the IQ in the three processes is discussed against extant literature on the secondary use of EHR data, followed by a discussion of the different roles and the IQ life cycle against extant IQ research.

8.1.1 Processes in the Life Cycle

This subsection discusses the findings from the various processes of the IQ life cycle.

EHR Source Data. Recent literature characterizes routinely collected EHR data to be a potential goldmine for secondary use (Verheij et al., 2018). However, the data are argued to be an underused resource (de Lusignan et al., 2006), mainly because the quality of the data limits the potential impact of secondary uses (Byrd et al., 2013; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999). Existing literature suggests that quality insufficiency often relates to the data entry process

because of the complex and uncertain environment (Liaw et al., 2012), which requires discretionary judgement (Lindquist, 2004; Verheij et al., 2018).

However, the findings from this study suggest that the current quality of the EHR source data at SHT was not perceived as a barrier to secondary use of EHR data for quality management. Several informants stated that the quality of source data used to be a problem, but that several measures were taken to amend this. Even though variations in the documentation processes still exist between and within organizational units, they were no longer perceived as problematic for secondary use of the data. The past measures taken in this organization to amend IQ issues of source data are supported by existing literature, and they include the implementation of documentation policies for both structured and unstructured data (Clark et al., 2013; Liaw et al., 2013a; Perimal-Lewis et al., 2015) with definitions to ensure correct interpretation of data fields (Kerr & Norris, 2008). Such policies are furthermore standardized throughout the organization, which is emphasized in existing literature by de Lusignan et al. (2006).

Another reason why quality of the source data was not perceived as problematic could be ascribed to the culture of supporting clinicians in capturing high-quality data through training and continuous support from the mature administrative units in the data entry process. Such a culture has been found to be critical for organizations to secure sufficient quality for secondary use of the data (Chircu et al., 2013; Liaw et al., 2012; Verheij et al., 2018). Moreover, the organization was found to continuously govern the quality of the source data. For example, the administrative resources followed a division-level guideline stating which EHR system quality reports should be checked and distributed, and when this should be done. Any discrepancies found in the reports were communicated to the unit manager or directly to the responsible clinician. These measures are also supported by existing research, where dedicated roles (Liaw et al., 2013a) are continuously governing the DQ (Clark et al., 2013; Liaw et al., 2013b), by following policies for preventing, handling exceptions, and continuously improving the DQ of EHR source data (Chircu et al., 2013; Clark et al., 2013; de Lusignan et al., 2006; Verheij et al., 2018). On the technical side, the EHR system used standardized codes and terminology between all units both for structured data (classifications such as ICD), and for unstructured data by using predefined templates across

organizational units. Existing research suggests that such standardization of codes increases DQ, as found in this case (Clark et al., 2013; Kerr & Norris, 2008; Verheij et al., 2018).

In summary, although current research states that one of the main barriers to the secondary use of EHR data is the quality of the routinely collected source data, this was not currently perceived as a challenge at SHT. The reason for this finding could relate to the measures taken in the past to increase the quality of the EHR source data. Thus, this study suggests that the main challenges limiting the potential impact of the secondary use of EHR data are not attributed to the DQ of EHR source data, as emphasized by existing research (Byrd et al., 2013; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999). The following paragraphs discuss the challenges identified in this study.

Information generation. Existing literature suggests that data can be extracted from EHR systems by direct integration between the EHR system and the data-processing system (Foshay & Kuziemsky, 2014), using data-extraction tools and batch importing the data into the data-processing system (Lindquist, 2004), and by manually extracting EHR data and entering them into the data-processing system (Foshay & Kuziemsky, 2014). According to existing literature, errors in the extraction process are found to influence the quality of the extracted EHR data (Liaw et al., 2013a). Such errors can be caused by inconsistencies between the data-extraction tools and the EHR system, a mismatch between data models (Liaw et al., 2013b), or a lack of semantic interoperability between EHR data and the extracted data (Liaw et al., 2012; Liaw et al., 2013a). Such inconsistencies, however, relate to the use of the data-extraction tools or to when the EHR system and the data-processing systems are integrated. Since the information generation process is often immature in health care organizations, data are often manually extracted from the EHR system and entered into basic data-processing tools (Foshay & Kuziemsky, 2014), as evident in this case. Thus, in addition to understanding how the extraction tools can influence IQ, this case illustrates the importance of understanding how actors manually extract data from the EHR system and organize the data in the data-processing tool also influence IQ. This study thus revealed how extraction quality dimensions, such as accuracy, completeness, credibility, and objectivity were addressed when data were

extracted, and how organization quality dimensions, such as adequacy of scope, consistency between data sets, and granularity, were affected when data were organized in the data-processing tool. The quality of data extraction was found to be influenced by data extraction criteria, meaning that clear guidelines of how to extract the data would positively impact the extraction quality. Similarly, the use of predefined templates for entering the data into the data-processing tool positively impacted the organization quality.

After extraction and organizing, the data are analyzed and visualized. Such processes of analysis and visualization can also affect IQ (de Lusignan et al., 2006). For example, analyzing data from the EHR system in conjunction with other data sources (e.g., population denominator for interpreting data for a population), and interpreting data on a precision level that is not supported by the data (Clark et al., 2013), can both lead to incorrect conclusions (de Lusignan et al., 2006). These examples may result in a low presentation quality of the output information artifact, even though extraction and organization quality are high. In this case, informants sometimes add comments to explain the findings, thus making the information more understandable for information users. Such modifications illustrate the transformative nature of IQ between the different processes of information generation and shows that such transformation need not necessarily be linear in terms of increased quality.

Existing literature suggests that making the information relevant for information users is crucial when producing the information artifact (Ginsburg, 2003; Lindquist, 2004). For information to be relevant, it is suggested that information users should be involved in both processes of data extraction and information production to ensure the information artifact corresponds to the information needs of users (de Lusignan et al., 2006; Foshay & Kuziemsky, 2014). Thus, by identifying the relevant information users and their needs, information producers can tailor the information accordingly (Ginsburg, 2003) and provide the preferred level of specificity for different user groups (Ginsburg, 2003; Lindquist, 2004; Michelberger et al., 2011). In this study, however, information needs were often not fully articulated ex ante, as also noted by Lillrank (2003). Moreover, artifacts were found to be extensively communicated in the line of management. Therefore, the actual use of information often resided outside of the information producer's

control (Mettler et al., 2008), making it challenging for information producers to involve information users in this process and to tailor the information artifact to make it relevant for specific user groups. Having potential information users in mind, information producers in this study were found to heuristically include presentation quality dimensions, such as ambiguity, amount, comparability, conciseness, and understandability when producing the information artifact.

Information communication. Provision of high-quality information relevant to information users has previously been identified as critical in enabling action in response to the information produced by EHR data (de Vos et al., 2013; Foshay & Kuziemsky, 2014; Jeffs et al., 2015). Existing literature suggests, however, that information outcomes are often received by only a small group of frontline managers (Ginsburg, 2003) and that lack of information access hampers action taken by frontline information users (de Vos et al., 2013). In this study, communication of information artifacts was found to follow the line of management by almost exclusively using a push strategy, ranging between lean (e.g., email) and rich (e.g., face-to-face) communication (Ginsburg, 2003). Between management levels, managers exercised discretionary judgement on whether to pass information on to subordinates. Thus, information did not always reach frontline information users, resulting in no action taken. However, most often, information was found to be communicated extensively in the line of management, consequently risking information overload, according to Michelberger et al. (2011). This paradox of information availability and communication intensity has previously been found to relate significantly to information users' perceptions of usefulness (Ginsburg, 2003). In this study, I identified that the CQ dimension "frequency," which relates to the intensity of communication, influenced information users' perceptions of not only usefulness, but also several other application quality dimensions (e.g., urgency, relevancy, and availability).

This finding illustrates that communication of high-quality information alone is often insufficient to engage frontline information users in action (Ginsburg, 2003). As an important prerequisite for being accountable and engaging in action, information must be understood and interpreted correctly by information users (Jeffs et al., 2015), and perceived as useful, urgent, and relevant (Jeffs et al., 2015;

Liaw et al., 2013a; Lindquist, 2004). In addition to frequency, the CQ dimensions identified in the analysis were priority, reciprocity, trust, efficiency, targeted, and demanding. All CQ dimensions influenced the various application quality dimensions that are important for information users. "Targeted communication" and "reciprocity" were the two most frequently mentioned quality dimensions. The former refers to how mediators attempt to target the communication to the actor(s) accountable for enacting upon the information, whereas the latter relates to the dialogue between information mediators and information users to reach a shared understanding of the information. Both quality dimensions influenced the information users' perceptions of several application quality dimensions, including usefulness, urgency, understandability, and relevancy.

This finding suggests that frontline managers, through their strategic position close to clinicians, are crucial information mediators for making sense of and translating the data for clinicians to see clear links to their daily practice and provide a shared accountability of action. This finding relates closely to previous research stating that frontline managers act as catalysts for information dissemination by aligning the information with corporate priorities and standards so that clinicians are able to perceive the relevancy of the information (Jeffs et al., 2015).

Information use. Through information generation and communication, organizations can leverage the information to understand clinical and operational processes and make appropriate changes in those processes resulting in improved outcomes (Jeffs et al., 2015). However, merely generating and providing high quality information based on the secondary use of EHR data to information users will not, in itself, lead to use (Ginsburg, 2003). Previous research has found that information users evaluate IQ based on several quality dimensions, which originate from the entry process of EHR source data and the information generation process (Clark et al., 2013; Jeffs et al., 2015; Perimal-Lewis et al., 2015). This study confirms such dependencies, where information users valued the quality dimensions that originated from the data extraction, data organization, and data presentation during the information generation process. For example, information consumers valued completeness, which was included in the extraction process (extraction quality); granularity from the data organization process (organization quality); and comparability from the presentation process

(presentation quality). Completeness, granularity, comparability, and conciseness were thus found to be the most mentioned quality dimensions by information users that originated from the information generation process.

Existing literature also emphasizes the importance of more subjective quality dimensions perceived by information users (Lindquist, 2004) to perceive information as fit for the intended use (de Lusignan et al., 2006). Information users' perception of relevancy is often stated as the most important subjective application quality dimension influencing the actual use of information artifacts based on EHR data (de Vos et al., 2013; Ginsburg, 2003; Jeffs et al., 2015). Thus, if information users fail to see the relevance, information will be disregarded, resulting in no action being taken (Ginsburg, 2003). The findings from this study suggest that information users evaluated the quality of the information artifact on several "subjective" application quality dimensions. In addition to relevancy, this study identified other subjective quality dimensions, such as urgency and usefulness. Furthermore, the analysis identified that CQ dimensions could either decrease or reinforce information users' perceptions of both subjective and "objective" (although all dimensions are subject to individual interpretations) application quality dimensions. For example, reciprocity could make the information more understandable (objective dimension of presentation quality) and, at the same time, increase the relevancy dimension (subjective dimension of application quality).

8.1.2 Actors in the Life Cycle

From the existing information manufacturing view, EHR data are collected by data collectors, maintained by data custodians, transformed into information, and made available by an IS for data consumers (Osesina et al., 2011; Sachdeva & Bhalla, 2012; Strong et al., 1997). IQ is assessed as high if the information artifact is fit for use (Neely & Cook, 2011) or appropriate for health care interventions (Cabitza & Batini, 2016), and there is an assumption that consumers will act on given information if IQ is maintained. However, the caveat in the existing approach is the inability to differentiate between IQ in the primary and secondary use of EHR data. As this study identified, secondary use of EHR data for quality management is a highly sociotechnical process. Compared to primary use of data, human actors

are more involved in the process of transforming data into information in secondary use. Furthermore, the output information artifacts resulting from this process were communicated and transformed throughout the organization before reaching end-users. Next, the roles involved in the life cycle identified in this study are discussed against existing literature.

Data extractors. In the primary use of data, data collectors provide the initial input of organizational (i.e., clinical and administrative) data (Cao & Zhu, 2013), which is usually performed by clinical and administrative personnel (Cruz-Correia et al., 2009). In secondary use, however, such data already exists in the EHR system. Thus, this study uses the term "data extractors," which is a more descriptive labelling of the actors extracting data for secondary use, to avoid confusion between the two roles.

In this case, both structured and unstructured data were extracted during the quality management process. Data extractors of structured data were identified as administrative personnel using reporting features of the EHR system, whereas clinical experts extracted the unstructured data through performing clinical audits. For both structured and unstructured data, the data extractors entered the extracted data manually into data-processing tools for further processing. In this study, the data extractors of the structured data emphasized correctness as the most important extraction quality dimension, whereas the extractors of the unstructured data emphasized completeness and objectivity as important dimensions.

Data custodians. In this study, data custodians were involved in both the preparation for data extraction and the organization of the extracted data. For example, before division audits, the data custodian provided instructions on how data extractors should extract the data. Furthermore, custodians customized the data-processing tool to secure a coherent extraction and organize the data to facilitate further analysis.

The existing literature describes data custodians as actors that design, develop, or maintain the computing resources for storing, processing, and securing data (Kahn et al., 2002; Wang, 1998); the term often includes actors in health care organizations such as database administrators and computer scientists (Cruz-

Correia et al., 2009). Findings in this study, however, show that IT personnel were not involved as data custodians in the secondary use of EHR data for quality management. For division initiatives, such as department-level audits and data extraction for the department-level BSC, the role of data custodians was prominent and held by division-level administrative staff. At the unit level, however, this role was less prominent and often intertwined with other roles. For department- and/or unit-level extraction of structured data, administrative staff often held the roles of both data extractors and custodians. For unstructured data at unit levels, unit managers often held the role of data custodian, and sometimes also the role of data extractor. The main IQ challenge in relation to data custodians in this study was found to be the consistency dimension, which was particularly evident at lower organizational levels, where unit managers held the role of data custodian.

The lack of involvement from IT personnel, the diversity of actors involved as data custodians, and the mixture of roles are all characteristics of the manual circumventions evident in this case, where actors were struggling to get the most out of the technologically immature process of quality management. Such circumventions, by manually extracting and organizing data in various data-processing tools, are common in health care organizations, and are the result of the non-standardized handling of requests and execution of extractions; a lack of skillful and knowledgeable actors executing data extraction, manipulation, and analysis; and a lack of sophisticated data-processing tools (Foshay & Kuziemsky, 2014).

Information producers. Information producers are actors who generate and provide information (Kahn et al., 2002) by utilizing data for further integration, aggregation, presentation, and interpretation (Lee, 2003). Similarly, Latour (2005) introduced the concept of mediators (described in the next paragraph) as human or technological actors that "transform, translate, distort, and modify the meaning of the elements they are supposed to carry" (p. 39). In this study, transformation of the data into information was mainly performed by information producers. For structured EHR data, the role of information producers was often held by administrative personnel, most frequently using a standard spreadsheet application as a data-processing tool, whereas for unstructured data extracted by division-level audits, transformation of the data was performed by division-level staff members.

This was often the same person who held the custodian role, where transformation was done using analytical and descriptive functionalities of the data-processing tool, followed by visualization of the findings in report format. At lower organizational levels, transformation was less systematic than at the division level, where unit managers often held the role of information producers. Granularity was found to be the quality dimension most often emphasized by information producers.

Existing research applying the manufacturing view often distinguishes between the three Cs: data collectors, data custodians, and data consumers (Lee, 2003; Lee et al., 2006; Osesina et al., 2011), where the data–information transformation is performed by the IS (Wang, 1998). However, secondary use of EHR data often involves manual processes to infer meaning from the data, and presenting the information artifact in a useful format (Liaw et al., 2013b; Lindquist, 2004) which is actionable for information consumers (Jeffs et al., 2015). Findings from this study suggest that the process of transforming data into information is highly sociotechnical and involves both human actors and data-processing technologies. Compared to the primary use of data, human actors (i.e., information producers) are more involved in the process of transforming data into information in secondary use. For example, since quality management information was not readily available from the EHR system, information producers heuristically transformed EHR data into quality management information by using various data-processing tools. Existing literature rarely discusses the information producer's role in the transformation process, possibly because of the current focus of IQ research on the primary use of EHR data (Cabitza & Batini, 2016).

Information mediators. In this case of secondary use of EHR data, the information artifact was communicated extensively within the organization, as supported in existing literature (Avison & Young, 2007). As described in Section 4.3, the concept of mediators involves how human or technological actors can modify the meaning of elements through transformation, translation, or distortion (Latour, 2005). Additionally, Latour (2005) differentiated between mediators and intermediaries, where the latter is defined as human or technological actors "transporting meaning or force without transformation" (p. 39). Findings from the present study suggest, however, that the distinction between intermediaries and

mediators is not clear-cut and that the roles are sometimes intertwined. Therefore, when referring to the role of information mediators, we need to distinguish among the actions taken. Thus, in this study, information mediators are defined as human actors that transform, translate, and/or transport information artifacts to other human actors. Such interpersonal communication can be supported by technology, though this is not a requirement (Eppler, 2006).

Unlike information producers who transformed data into information, information mediators were often observed transforming the already existing information artifacts through filtering and integration. Transformation by filtering refers to reducing the information artifact, whereas integration refers to adding additional information to the information artifact. One reason why information mediators transformed the information artifact relates to the information users' expectations of the information; thus, mediators heuristically adapted the information to specific users or user groups to increase the possibilities of reaching a shared understanding. Previous organizational research emphasizes that such transformation of existing information artifacts is a response to coping with excessive amounts of information, which always occurs when information is communicated within organizations (Rogers & Agarwala-Rogers, 1976). As a typical information-intensive organization, it is not surprising to find extensive modifications of information artifacts in this context. Thus, from Latour's (2005) perspective, viewing IS as the single most important mediator of information, like in the prevailing manufacturing view, is insufficient; human actors communicating the output information artifact of an IS to other humans are also important mediators.

In the process of communicating quality management information, information mediators transported and/or translated the information artifact to relevant information users or group of users. According to Latour (2005), transportation does not involve any transformation, but refers to where the information input of a communicative process equals the output. In this study, the line of management is prominent in the flow of information, making managers at all organizational levels act as mediators of information to successive management levels. In terms of transportation, information artifacts were transported from the mediator to information users, often facilitated by technology (e.g., email). Since information

often needed to travel through multiple information mediators at different organizational levels before reaching the end-users, simple transportation may be challenging. The main challenge with transportation in this study related to the overwhelming amounts of information competing for users' attention, consequently risking information overload (Michelberger et al., 2011).

One of the characteristics of transportation is that the IQ of the information artifact remains unchanged when communicated from one individual to another. In the secondary use of EHR data for quality management, this study identified that transportation was often insufficient, since information artifacts were often targeted to managers, not for a general audience. Thus, clinicians were not always able to understand, interpret, or see the relevance of the data, which existing research has proposed to be a prerequisite for being accountable and engaging in action (Jeffs et al., 2015). For actions taken in response to the information, it was important that quality management information was communicated to, and understood by, clinicians. Thus, information mediators needed to translate the information artifact to users in order to reach a shared understanding of the information and its implications. Managers at all levels were found to be crucial in acting as information mediators in the process of translation. This finding confirms previous research stating that frontline managers are strategically positioned to make sense of, and translate, the data for clinicians to see clear links to their daily practice and provide a shared accountability of action (Jeffs et al., 2015). Thus, in their role as information mediators, frontline managers act as catalysts for information dissemination by aligning the information with corporate priorities and standards so that clinicians are able to perceive the relevancy of the information (Jeffs et al., 2015).

Translation is also associated with distortion (Latour, 2005), since a shared understanding is required in sequences and across organizational levels. Such distortion was identified in this study, and it was found to hamper enactment, and potentially result in adverse actions.

Information users. Information users are actors who access and use the information artifact (Kahn et al., 2002); thus, in health care organizations, they are often clinicians, researchers, and managers (Cruz-Correia et al., 2009). In

prevailing IQ research, the actors accessing the information directly from the IS are often treated as the end-users of information (Lee et al., 2002). In a life-cycle view, however, this study shows that information users also exist at various organizational levels prior to the end-users. For example, managers can be information users, but they are, at the same time, information mediators to subsequent information users in the line of management. The analysis revealed that granularity, urgency, relevancy, comparability, completeness, usefulness, and conciseness were application quality dimensions that were of importance to information users. Low IQ of the more objective quality dimensions (e.g., granularity, comparability, and completeness) could result in adverse actions, whereas the more subjective IQ dimensions (e.g., urgency, relevancy, and usefulness) were found to influence the level of accountability and further enactment by information users. These findings resonate with existing research stating that information users failing to see the relevance will disregard the information (de Vos et al., 2013), and that action taken on poor IQ may result in adverse outcomes (Foshay & Kuziemsky, 2014).

8.1.3 The Life-Cycle View of IQ

As described in the previous subsection, information users' perceptions of the application quality dimensions originated from various subprocesses of the information generation process, as described in existing literature examining the secondary use of EHR data (Clark et al., 2013; Jeffs et al., 2015; Perimal-Lewis et al., 2015), where the information users' perceptions were influenced by the CQ dimensions. Furthermore, the analysis identified feedback loops within the life cycle, where actors actively modified the information artifact to address perceived shortcomings in specific application quality dimensions. Specifically, three distinct feedback loops were identified, where the goal was to amend the application quality dimensions and increase the possibility of enactment. The feedback loops identified were filtering, integration, and regeneration of information. Filtering involves reducing the information artifact, thus modifying presentation quality dimensions. Integration involves expanding the information artifact by adding more data, thus modifying the presentation quality dimension. Regeneration involves a complete reiteration of all subprocesses of information generation, thus modifying extraction quality, organization quality, and

presentation quality dimensions. Regeneration was often needed when actors perceived challenges of IQ rooted in extraction or organization quality dimensions. Such modifications of information artifacts illustrate the challenges for information producers in producing tailored information artifacts for specific groups, since the actual use of information often resided outside of the information producer's control (Mettler et al., 2008). Figure 7-4 illustrates the life-cycle model of IQ for the secondary use identified in this study.

In the prevailing manufacturing view of IQ, an information artifact is viewed as the output of a well-defined manufacturing process performed by an information system, and where data are the input to this process (Lee et al., 2006; Wang, 1998; Wang et al., 1998). In this view, IQ is often viewed in terms of product quality and service quality, where product quality is information users' perceptions of the information artifact (Kahn et al., 2002; Wang, 1998; Wang et al., 1998; Wang & Strong, 1996), and service quality is information consumers' perceptions of the delivery process of the information from the IS (Kahn et al., 2002). This study illustrates three basic challenges of the manufacturing view, which the life-cycle view accounts for in the secondary use of EHR data. First, the information generation process is often treated as a black box in the manufacturing view, since it assumes that the IS transforms raw data into information artifacts. As this case illustrates, human actors are deeply involved in the data extraction, organization, and production of information artifacts. The idea of viewing IQ as a life-cycle concept is that in such processes of user-data/information interactions, the value judgements of IQ dimensions depends on the actors and their different roles in the various processes (Knight, 2011). Thus, a life-cycle view allows us to understand how IQ changes through various processes involving actors with different value judgements.

Second, the manufacturing view assumes that the process of producing and using information is well defined (Lee et al., 2006; Wang, 1998; Wang et al., 1998). This study confirms previous research describing the information generation process as immature in health care organizations (Foshay & Kuziemsky, 2014), where EHR data are extracted and imported in data-processing tools manually. Unlike the manufacturing view, the life-cycle view opens the black box of human–data interactions in the information generation process.

Third, an important idea of a life cycle is that it represents a continuous process (Knight, 2011). In the manufacturing view, IQ is determined by the information users' perception of whether the information is fit for use (Neely & Cook, 2011) or whether it conforms to specifications and/or meets or exceeds consumer expectations (Kahn et al., 2002). Thus, the manufacturing view concludes that the output information artifact is either of adequate quality for use, or it is not. By understanding IQ as a continuous process (i.e., as in the life-cycle view), however, it is possible to follow the entire process towards the actual use of the information. For example, this study found three distinct feedback loops where insufficient, as perceived by information users, where actors modified the information to increase the possibilities of enactment.

Previous research has identified that the output information artifacts of the information generation process are often subject to interpersonal communication within health care organizations (Avison & Young, 2007; Mettler et al., 2008). The findings from this study suggest that in the secondary use of EHR data for quality management, interpersonal communication was an important part of information distribution. Such interpersonal communication is not addressed in either the manufacturing- or the life-cycle view. The idea of service quality from the manufacturing view is perhaps closest, by conceptualizing information users' perceptions of the delivery process of the information from the IS (Kahn et al., 2002). Since the service quality relies on a pull strategy of communication (i.e., information users actively seek and retrieve information directly from an IS), this view of communication is insufficient in this context where information was found to be pushed extensively in the line of management. Rather than applying the concept of service quality, the distinction between IQ as a deliverable and artifact better explains the role of communication in the secondary use of EHR data in the life cycle. IQ as an artifact refers to the quality of the information (Lillrank, 2003), and thus resembles the product quality from the manufacturing view. High IQ of artifacts is when the information user understands the intention of the information (Lillrank, 2003). The findings from this study confirm that information users assessed the quality of the information artifact (application quality) and the quality dimensions that originated from other processes in the life cycle (i.e., extraction, organization, and presentation quality). Moreover, IQ as a deliverable refers to the negotiated quality of information between the sender and the receiver of

information, where high IQ is the achievement of a shared understanding of the action possibilities that the information provides (Lillrank, 2003). As evident in the analysis, information users' perceptions of quality were not only influenced by the information artifact but also the communication process. By applying the concept of CQ (Eppler, 2006), the analysis revealed that information mediators, through specific CQ dimensions, could influence specific application quality dimensions necessary for information users to enact. This illustrates the need to treat IQ as both an artifact and a deliverable to better understand how communication influences information users' perceptions of quality. The next section discusses the underlying mechanisms of the life cycle.

8.2 Generative Mechanisms Underpinning the IQ Life Cycle

This section discusses the findings from the identified affordances and proposed mechanisms in the IQ life cycle—information generation mechanism, information communication mechanism, decision-making mechanism, and accountability mechanism—against existing research. The mechanisms are illustrated in Figure 7-13.

8.2.1 The Information Generation Mechanism

The information generation mechanism comprised the four IS affordances, constituted by the relations between various actors (i.e., data extractors, data custodians, and information producers) and multiple IS (i.e., EHR system and various data-processing tools). One important reason why the actors needed to actualize affordances from multiple IS was because of lacking features from the EHR system. Thus, even though the EHR system lacked the functionality to generate information artifacts for the secondary use of EHR data, actors perceived the affordances of systematizability, analyzability, and visualizability from various data-processing tools. Such manual circumventions are common in health care organizations (Foshay & Kuziemsky, 2014), since EHR systems are often not designed to support the secondary use of data directly (Byrd et al., 2013), and data often need to flow through multiple data-processing systems to infer meaning and value from the routinely collected EHR data (Verheij et al., 2018). Thus, merely

investigating the affordances of the EHR system would not provide a complete map of the information generation mechanism in this case.

Existing literature states that extraction of EHR data for secondary use is challenging (Verheij et al., 2018) because of inaccessibility of data for extraction (Foshay & Kuziemsky, 2014) and the mixture of structured and unstructured data (de Lusignan et al., 2006). The findings from this study suggest that accessibility to data for extraction is a facilitating condition for making the extractability affordance available for actors; without access to relevant EHR system reports, extraction of structured data was not possible. Likewise, access to relevant patient records was a necessary facilitating condition for extracting unstructured data. The mixture of structured and unstructured data was not, in itself, found to be a facilitating condition for making extractability available. It was, however, found to affect the actualization process; similar to existing literature, it was identified that unstructured data were far less frequently extracted than structured data (de Lusignan et al., 2006) because of the time-consuming process of extracting unstructured data. Thus, even though extractability of unstructured data was available for actors (i.e., the facilitating conditions were favorable), the conversion factor "effort" influenced the actualization. This finding is also supported in the affordances literature, where Bernhard et al. (2013) argued that actualization is influenced by users' perceptions of the efforts needed to be invested. Similarly, Anderson and Robey (2017) argued that the level of ease (i.e., mental and/or physical energy) influenced actors in actualizing any affordances.

Furthermore, immaturity of the extraction process is suggested to hamper the process, where health care organizations are often lacking both sophisticated data-processing tools and skillful and knowledgeable actors (Foshay & Kuziemsky, 2014). Related to the conversion factor "effort," extraction of structured data was found to be more mature (internalized) than extraction of unstructured data. Such differences of process maturity also explained the differences in use of data-processing tools for actualizing systematizability and the actors' skills between the extraction of structured and unstructured data. To compensate for this difference, clear "data-extraction criteria" was found to be a conversion factor for actualizing extractability, whereas use of "predefined templates" was identified as a conversion factor for actualizing systematizability. Without these conversion

factors, actors were still able to actualize extractability and systematizability. However, by using clear extraction criteria (i.e., by extraction guidelines), the need for technical extraction skills was reduced, resulting in coherent data extraction between actors. Furthermore, by using predefined templates, actualization of systematizability resulted in comparable data between units.

For analyzability and visualizability to be available for actors, data needed to be extracted and organized. Thus, the actualization of extractability and systematizability serves as facilitating conditions. From the IQ literature, the output information artifact of the information generation mechanism is also affected by how data are analyzed and visualized by the human actors using data-processing tools (de Lusignan et al., 2006). For example, misunderstandings in the data analysis can lead to wrong conclusions (de Lusignan et al., 2006), and inaccurate visualizations can lead to misinterpretations (Clark et al., 2013). Thus, challenges in actualizing analyzability and visualizability points more toward the actors' skills and capabilities than to the conversion factors. This finding is supported in the literature, which emphasizes the need for actors involved in analysis and visualization to possess not only a deep understanding of the process underlying the EHR source data (Clark et al., 2013), but also knowledge of the complexity of the context and the strengths and weaknesses of the data extracts (Clark et al., 2013; de Lusignan et al., 2006; Lindquist, 2004; Needham et al., 2009; Perimal-Lewis et al., 2015; Verheij et al., 2018). In this case, variations between information artifacts were observed, between organizational levels and between departments. For example, there was a tendency that the information artifacts were more sophisticated at the division level and less sophisticated at the department and unit levels. This discrepancy was found to relate to the analytical and visualization skills of the involved actors and the capabilities of using more or less advanced data-processing tools.

As presented in Section 7.3, the outcome of the information generation mechanism is a quality management information artifact. By viewing information as an artifact (Lillrank, 2003), it is reasonable to discuss the affordances of information artifacts. Without connecting this to the affordances theory, research within the secondary use of EHR data discusses how the information artifact can be actionable for human actors (de Vos et al., 2013; Jeffs et al., 2015; Lillrank, 2003). For example,

Jeffs et al. (2015) discussed how the process of translating EHR data to actionable information enables health care organizations to "make appropriate changes in those processes resulting in improved outcome" (p. 269).

8.2.2 Information Communication Mechanism

The information communication mechanism comprises the communicability affordance, including the facilitating conditions and conversion factors. The analysis identified that the "mode of communication" was an important conversion factor influencing the level of shared understanding. Previous research has also found that the modes of communication can relate significantly to consumers' perceptions of the information (Ginsburg, 2003). Communication modes comprise pull strategies, where information users actively retrieve information themselves, and push strategies, where information is disseminated through information mediators (Foshay & Kuziemsky, 2014). In this case, the organization relied almost exclusively on push strategies in secondary use of EHR data. By using such a strategy, it is important to find the most effective combination of rich (e.g., face-to-face) and lean (e.g., email) communication modes (Jeffs et al., 2015). For example, it was found that communicability not always involved the use of technology (i.e., communication and presentation tools). Sometimes, printed copies of the information were handed out, or the information was communicated orally in meetings or face-to-face, which was most evident when actualizing communicability between unit managers and clinicians. Thus, the preferred communication mode was often found to be richer the further down the line of management the information travelled. However, the modes of communication between unit managers and clinicians varied within the organization, resulting in various levels of shared understanding. This variation illustrates the existence of different practices when actualizing communicability, where unit managers attempt to adapt the mode of communication to fit its audience.

Previous research has identified that information intensity (i.e., the frequency of communication) relates significantly to information users' perception of the information (Ginsburg, 2003). Information intensity involves a basic dilemma: too frequent communication of information can lead to information overload (Michelberger et al., 2011), whereas too little information fails to enable actions

in response to the information (de Vos et al., 2013; Foshay & Kuziemsky, 2014). In both cases, reaching a shared understanding of the information is difficult. Another study found that information outcomes from the secondary use of EHR data are often only communicated to a small number of unit managers (Ginsburg, 2003), thus hampering the action taken by clinicians (de Vos et al., 2013). Such interruptions in communication, where the information stops at the managerial levels, relates to the conversion factor "manager discretion" identified in this study. Even though communicability could be actualized (i.e., the facilitating conditions were favorable), managers exercised discretion when deciding on whether they would pass the information on to subordinate levels. The reasons for choosing to interrupt the communication varied, including fear of information overload and perceptions of information relevance.

The levels of shared understanding between unit managers and clinicians varied between units in this case. This variation points to the capabilities of the unit managers (e.g., rhetorical and communicative skills) and to the conversion factors when actualizing the affordance, such as modes of communication and manager discretion. Other conversion factors found in this case, not mentioned in existing literature examining the secondary use of EHR data, include quality culture, clarity of agenda, communication style, manager support and expectations, line of management, CQ, and meeting structure. These conversion factors, all influencing the level of reaching a shared understanding when actualizing communicability, illustrate the important role of unit managers as information mediators. Jeffs et al. (2015) suggested that role is strategically positioned to make sense of, and translate, the information for clinicians to see clear links to their daily practices, which is a necessary facilitating condition for making clinicians accountable for actions taken in response to the information.

8.2.3 Decision-Making Mechanism

The decision-making mechanism involved the prioritizability affordance and its facilitating conditions and conversion factors. The analysis identified that actors, primarily managers, needed to possess organizational knowledge to be able to make informed decisions of the actions to prioritize. From existing literature on the secondary use of EHR data, Foshay and Kuziemsky (2014) found that use of

such information can often lead to adverse decision-making because of a lack of decision confidence and timeliness. Lack of decision timeliness relates to the information access and distribution (i.e., the communication mechanism), whereas lack of decision confidence was found to relate directly to information artifact and personnel issues—poor information and/or actor capabilities could hamper the use of information (de Vos et al., 2013) or lead to making adverse decisions (Foshay & Kuziemsky, 2014). From an affordance viewpoint, such artifact and personnel issues from existing research point to the affordance itself. That is, poor quality of the information artifact can lead unskilled information users to perceive an action potential of the information that is not grounded in the EHR data, where the outcome of actualization could be adverse. Gaver (1991) separated affordances from the information available about them and distinguished between correct rejected, perceived, hidden, and false affordances. For example, if the information artifact is of poor quality, actors might perceive non-existing affordances (false affordances), leading to adverse outcomes of actualization. Moreover, if the information artifact is of high quality, then the affordances might be perceivable for information users, and the outcome may be according to the actor's goal. In fact, since EHR systems comprise enormous amounts of data, they are considered to be potential goldmines of action possibilities for secondary use (Verheij et al., 2018). Such action potentials are, however, not readily perceivable by actors (i.e., hidden affordances). Through triggering the information generation mechanism, the action potentials of the information artifact might become perceivable. Thus, triggering the information generation mechanism is a necessary facilitating condition for mechanisms that include information affordances (i.e., decision-making and accountability mechanisms).

The actor's goal in actualizing prioritizability was to reach agreement on the actions to take in response to the information. To actualize the prioritizability affordance, several conversion factors, influencing the level of agreement, were observed. These included an arena for open discussions, clear goals, attentiveness to change, collective commitment, top management support, existing workload, and delegation of decisions.

8.2.4 Accountability Mechanism

Existing research on the secondary use of EHR data states that merely generating and providing high quality information will not, in itself, lead to action (Ginsburg, 2003). Thus, while the information generation, communication, and decision-making mechanisms need to be triggered, they are insufficient for action.

For action to be taken in response to the information, clinicians need not only understand the action potential (shared understanding), but there also needs to be a commitment to using the information at the clinical level (Jeffs et al., 2015). The accountability mechanism proposed in this study comprises the accountability affordance, including the facilitating conditions and conversion factors. The outcome of triggering this mechanism is a given level of commitment by the clinicians to perform actions.

Existing research emphasizes that information users (i.e., clinicians) need to perceive the information as relevant, useful, and urgent (Jeffs et al., 2015; Liaw et al., 2013a; Lindquist, 2004). Otherwise, information users will disregard the information and thus fail to enact it (Ginsburg, 2003; Kerr & Norris, 2008; Preuss, 2003). This study found several conversion factors influencing the actualization of accountability, thus affecting the level of commitment to enact the prioritized actions (i.e., the outcome). For example, a high existing workload could negatively influence clinicians' level of commitment when trying to make them accountable for implementing extensive actions. Similarly, de Vos et al. (2013) found that time and resource constraints challenge information users' perceptions of relevancy.

Other factors from the literature that support clinicians in committing to action based on information from the secondary use of EHR data includes a culture for supporting such use of information, commitment from managers, and required support to clinicians (Ginsburg, 2003). Corresponding conversion factors identified in this study include quality culture, a supportive management, and supportive administrative staff.

A noticeable finding not mentioned in existing secondary use of EHR systems literature involves the following conversion factors that clearly constrained the actualization process of accountability, and thus challenged the commitment of

clinicians: “clinical autonomy,” “perspectives of quality,” and “management mistrust.” Even though clinicians understand the action potential of the information, the most challenging endeavor for unit managers when actualizing accountability is to make clinicians perceive the relevance. For example, clinicians could sometimes choose not to commit to agreed actions because they believed it would interfere with their clinical autonomy. Alternatively, clinicians’ perspectives of quality could sometimes mismatch managers’ perceptions. For example, several clinicians expressed that some quality indicators based on structured data were not patient treatment quality measures, but rather productivity measures of clinicians. Thus, when managers attempted to make them accountable for improvements, an increasing mistrust of managers could prevent clinicians’ commitment to do so.

Notably, it was found that even if several conversion factors constrained the actualization of accountability (e.g., perspectives of quality and clinical autonomy), other conversion factors could still lead to clinician commitment. Examples of such conversion factors included “system loyalty” and “fear of criticism,” where system loyalty could make clinicians commit to enactment, even if they did not perceive the clinical relevance. This example indicates that the conversion factors influencing the outcome of affordances possesses various degrees of causal powers, where some enabling conversion factors (e.g., system loyalty) could “override” other constraining conversion factors (e.g., perspectives of quality).

8.3 The Sociotechnical Nature of IQ

By identifying the life cycle of IQ (see Figure 7-4) and its underlying mechanisms (see Figure 7-13), it is possible to discuss the overarching research agenda of this study. Namely, to understand the sociotechnical nature of the phenomena of IQ in secondary use of EHR data. In this section, I first discuss IQ against the prevailing manufacturing view, and I then propose an alternative definition of IQ in the secondary use of EHR data.

8.3.1 Challenges of the Prevailing View of IQ

As presented in Section 2.3, the prevailing manufacturing view of IQ holds the following assumptions: (1) data are transformed into information by the IS, where the output information artifact is the product of a well-defined manufacturing process (Lee et al., 2006; Wang, 1998; Wang et al., 1998); (2) the information user accesses the information directly from the IS (Lee et al., 2006; Wang, 1998; Wang et al., 1998); and (3) IQ is perceived as high if it conforms to specifications and meets or exceeds the information user's expectations (e.g., Kahn et al., 2002). The findings from this study, which are discussed next, suggest that all these assumptions are problematic in the secondary use of EHR data.

First, human actors were found to be deeply involved in the transformation of EHR data into information for secondary use. Furthermore, the process could not be characterized as "well-defined," but rather immature and ad hoc (Foshay & Kuziemsky, 2014). In fact, the findings identified that information is the output artifact of the information generation mechanism, which consists of several affordances that need to be actualized by various actors using multiple IS, where the outcome of each actualization processes is influenced by the conversion factors and furthermore serves to facilitate the condition for subsequent affordances. Thus, IQ of the information artifact is dependent on how actors actualize each affordance. For example, without the conversion factor "extraction guidelines," the extractability affordance was available by actors, but the outcome was the extraction of incomparable data, thus making it impossible to address the comparability dimension for actors actualizing systematizability.

The second assumption of the manufacturing process implies that information users access the information directly from the IS (Lee et al., 2006; Wang, 1998; Wang et al., 1998). Evident in this study, information is extensively being communicated in the line of management. Through triggering the information communication mechanism, the level of shared understanding of the action potential of the information is determined. The level of shared understanding is influenced by several conversion factors, which illustrates the crucial role of information mediators in translating the information to make the information affordances perceivable and available for information users. If the information mediator perceived challenges in reaching a shared understanding or

accountability of the existing information artifact, then the information artifact was modified through filtering, integration, or regeneration. Such modifications illustrate the life cycle of the information artifact and demonstrates how actors actively modify the IQ for the action potential to be perceivable for information users.

The third assumption is that information will be used by information users when IQ is perceived as high; that is, when information conforms to specifications and meets or exceeds the information user's expectations (e.g., Kahn et al., 2002). The challenge with this assumption is that the information specifications are often not fully articulated ex ante (Lillrank, 2003), and output information artifacts are communicated extensively in the line of management (i.e., push strategy). Thus, actual use of information often resides outside of the information producer's control (Mettler et al., 2008), where information users rarely have any predefined expectations of the information. To understand how information users translates the action possibilities of the information into action, this study suggests the need to understand the decision-making mechanism (i.e., managerial use of information) and the accountability mechanism (i.e., committing clinicians to act in response to the information). Whereas research on secondary use of EHR data states that insufficient quality of EHR source data is one of the major factors limiting the potential impact of secondary uses (Byrd et al., 2013; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999), this study suggests that the main challenge is to commit clinicians to perform actions in response to the information. More specifically, the main challenge is not to reach a shared understanding of the action possibilities (i.e., the outcome of triggering the information communication mechanism), but rather to succeed in making clinicians see how the action possibilities are useful, urgent, and relevant in their work situation. This finding suggests that the conversion factors of accountability influence clinicians' perceptions of the quality dimensions of relevancy, urgency, and usefulness.

In sum, these challenges highlight the need to approach IQ in secondary use of EHR data differently from the prevailing view by increasing the balance between the social and technical aspects of the phenomenon. This aspect is further discussed in the next subsection.

8.3.2 Towards a Definition of IQ in the Secondary Use of EHR Data

This study found that information is generated through actualizing the affordances of the information generation mechanism. Through actualizing IS affordances, various aspects of IQ (i.e., extraction, organization, and presentation quality of the information artifact) are addressed. Once an information artifact is produced (i.e., the outcome of the information generation mechanism), information users assess the application quality of the information artifact. This view of IQ as an artifact implies that "the quality of information depends on the meaning assigned to it; the value of information depends on the actions it enables in given situations equipped with certain resources and capabilities" (Lillrank, 2003, p. 700). Thus, IQ can be characterized as the functional properties (i.e., quality dimensions) of the information artifact, where the information artifact possesses action possibilities (i.e., actionable information) available for information users. However, this study also found that the primary concern is not the generation of the information artifact, but rather how information can be used to enable and control action. It is generally recognized that quality is relational and involves a human agency perspective (Lillrank, 2003), which implies that human actors pass judgment about the quality of information; however, whereas information can be evaluated as good by one actor, the same information may be inappropriate for another (Neely & Cook, 2011). Stated differently—while one actor may be able to perceive the affordances, another may be unable to see the affordances of the same information artifact.

In addition to viewing IQ as an artifact, it must also be understood as a deliverable: information artifacts in the secondary use of EHR data are generated in more or less open systems, where the information needs are not fully articulated ex ante (Lillrank, 2003) and are furthermore found to be extensively pushed to information users through the line of management. This study found that information users' perceptions of the information were influenced by the information communication mechanism, where the level of shared understanding of the affordances of the information artifact between information mediators and information users was found to be the outcome of this mechanism. Reaching a shared understanding was found to be a necessary facilitating condition, but not enough for information users (i.e., clinicians) to engage in action. Jeffs et al. (2015) observed this challenge in the simple transportation of information: "Having outcomes data alone (even if high quality) is not enough to motivate and change behavior for clinicians to

translate findings into practice improvements" (p. 269). Thus, we need to distinguish between how IQ influences whether (1) the affordances of the information artifact are perceived by the information users—the outcome of the information communication mechanism (de Vos et al., 2013; Jeffs et al., 2015; Lillrank, 2003), and (2) whether information users intend to commit to actualizing the affordances—the outcome of the accountability mechanism. Whereas the former points to the more "objective" application quality dimensions of the information artifact (e.g., understandability, completeness, and granularity), the latter points to the more "subjective" quality dimensions (e.g., usefulness, urgency, and relevance). This distinction is important, since information users may perceive the affordance of the information, yet disregard it if users fail to see its relevance, thus resulting in no action taken (Ginsburg, 2003). The main challenge, therefore, is not to reach a shared understanding of the action possibilities, but to succeed in making clinicians see how the action possibilities are useful, urgent, and relevant in their work situation.

In conclusion, the findings of this study suggest that we need to understand IQ both as an artifact and as a deliverable in the secondary use of EHR data. Consequently, information having adequate IQ in the secondary use of EHR data from an information user's perspective could be stated as *information that can enable relevant action possibilities and be perceived as relevant, urgent, and useful by the information user*.

9 Contributions and Recommendations

Following the logics of research by Mathiassen (2017), the research questions of this study were formed based on concerns from practice and the related areas of concern raised in previous IS research literature. Addressing the research questions involves drawing on a method of inquiry and by framing the analysis with theoretical underpinnings. As illustrated with feedback arrows in Figure 9-1, this dissertation makes several contributions to research literature, to practice, and to the theoretical framing of this research. Sections 9.1, 9.2, and 9.3 summarize the contributions to IQ research, to the theory of affordances, and to practice, respectively. Finally, I offer nine managerial recommendations based on the findings of this study in Section 9.4.

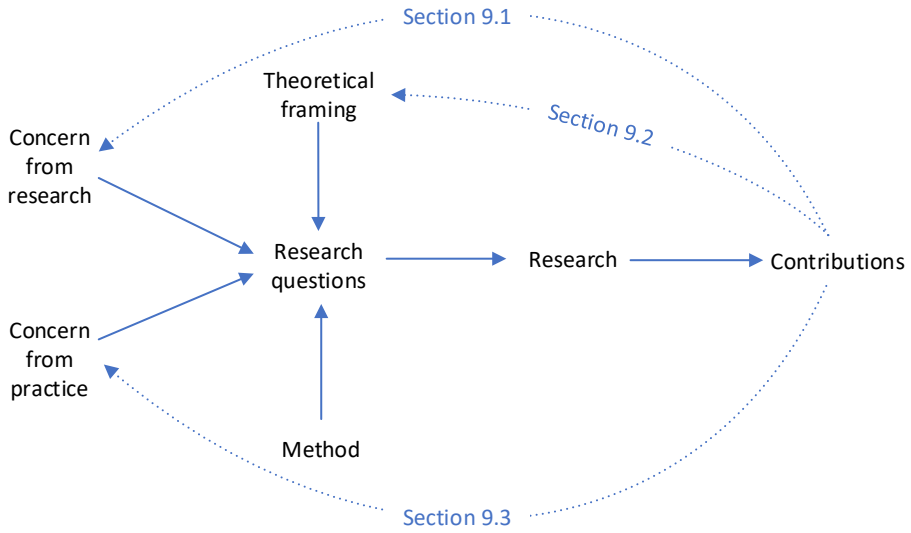


Figure 9-1: Overview of contributions, adapted from Mathiassen (2017).

9.1 Contributions to IQ Research

The contributions to IQ research, summarized next, are categorized into contributions to research on the secondary use of EHR data and contributions to general IQ research.

9.1.1 Contributions to IQ Research in the Secondary Use of EHR Data

The main contribution of this research is an alternative to the prevailing manufacturing view to understanding the role of IQ in the secondary use of EHR data. The contributions are summarized as follows:

IQ as a life cycle. Unlike the manufacturing view of IQ, where information is treated as a product of a well-defined manufacturing process (Lee et al., 2006; Wang, 1998), this study identifies the complexities of the process of secondary use of EHR data, where multiple actors and IS are involved in generating, communicating, and using the information. The study contributes by providing empirical evidence that IQ is multi-dimensional and is transforming within a life cycle. By focusing on actors' interactions with information and their perceptions of IQ, this study contributes by providing an IQ life-cycle model (see Figure 7-4), emphasizing the dynamics throughout the process of secondary use of EHR data. In the life cycle, IQ dimensions important to various actors in this case when generating, communicating, and applying information artifacts were identified. The quality dimensions in the various phases were furthermore categorized into extraction quality (e.g., accuracy and objectivity), organization quality (e.g., adequacy of scope and consistency), presentation quality (e.g., relevancy and comparability), communication quality (e.g., targeted, authoritarian, and reciprocity), and application quality (e.g., granularity, relevancy, comparability, and completeness).

Interpersonal communication. This study furthermore contributes by addressing the lack of interpersonal communication in existing literature (Avison & Young, 2007; Mettler et al., 2008), by integrating CQ in the IQ life cycle. In the context of the secondary use of EHR data addressed in this study, interpersonal communication was found to be prominent where the information was distributed extensively in the line of management. In contrast to existing literature, where information is treated as a product provided to users by the IS (Lee et al., 2006; Wang & Strong, 1996), this study found that the quality of the interpersonal communication influenced users' perceptions of application quality, and thus their commitment to enact the information. Moreover, this study confirms the findings of Foshay and Kuziemsky (2014) that the processes of producing and disseminating EHR data for quality management is unclear, with a low

understanding of information needs, and with extensive use of additional data-processing tools to obtain value from the data.

Modifications of the information artifact. While the manufacturing view of information treats the output information as a fixed artifact, this study contributes by demonstrating that actors continuously modify the information artifact when communicated throughout the organization. Such modifications of information artifacts are likely to happen in the process of interpersonal communication within any organization (Rogers & Agarwala-Rogers, 1976). It is thus important to understand not only how data evolves in the information generation process, but also how IQ changes through the communication and information use processes, including the interplay of technical and social processes within the life cycle. Such modifications were found to be made heuristically by actors to adapt the information to specific users or groups of users and included filtering (removing parts of the information), integration (adding more information), partial regeneration (reiteration of the data presentation subprocess), or full regeneration (reiteration of the entire information generation process).

The role of human actors. This study describes how the process of secondary use of EHR data relies on manual processes of human interactions to infer meaning from the data, and in presenting the information artifact in a useful format (Liaw et al., 2013b; Lindquist, 2004) to be actionable for information users (Jeffs et al., 2015). Thus, this study contributes to existing IQ research by presenting the roles involved in secondary use of EHR data. The contributions are summarized in Table 9-1.

Table 9-1: *Contributions to Roles Involved in Secondary Use of EHR Data*

Role	Contribution
Data extractors	Unlike data collectors who routinely collect organizational data, data extractors extract existing EHR data for organizational purposes.
Data custodians	Often described as database administrators and computer scientists who design, develop, and maintain computing resources. In secondary use of EHR data, IT personnel were not involved. Instead, administrative personnel and unit managers were identified as custodians.

Table 9-1 continued

Role	Contribution
Information producers	The human role as information producer is often neglected in extant research, since the EHR system is perceived as the main information producer in primary use of EHR data. In this study, administrative personnel and unit managers were identified as information producers.
Information mediators	The role of information mediators is not properly described in existing literature. This study suggests that the information mediator transports and/or translates the information artifact to information users. Translation was found to be more effective in reaching shared understanding than by transportation.
Information users	Unlike existing literature on primary use of EHR data, information users are not accessing the information directly from the EHR system. Thus, assessing IQ of the information output of the IS alone is insufficient in understanding quality from an information user's perspective. Additionally, we need to understand how IQ transforms within its life cycle, and how communication influence information users' perceptions of quality.

Understanding IQ through the affordance lens. The literature review of this study identified that most of the existing research on the secondary use of EHR data were not based on any specific theoretical frameworks. Thus, investigating the underlying sociotechnical processes of IQ by applying the theory of affordances as the theoretical lens is a novel contribution of this study. The information manufacturing view assumes that quality is achieved and information will be used when the information is "meeting or exceeding consumer expectation" (Kahn et al., 2002, p. 185), or when information is "fit for use" (Neely & Cook, 2011, p. 82). This idea of "fitness" originates from the contingency theory (Haußmann et al., 2012) and relates closely to the manufacturing view of information, where technology is perceived as the production system that manufactures information based on data (Leonardi, 2010). In this study, however, this view becomes challenging when it comes to the role of technology, where contingency theorists have been criticized for being technological imperative and leaving individual and social issues unaddressed (Haußmann et al., 2012). According to Leonardi (2010), contingency theory posits a strong deterministic

view, where technology acts as a causal agent of organizational change. For example, merely generating and providing high quality information (that is fit for use) based on the secondary use of EHR data to consumers, will not, in itself, lead to use (Ginsburg, 2003). Chemero (2003) addressed this by showing how the theory of affordances moves away from the "fit" paradigm. By applying the theory of affordances, this study contributes by taking a more balanced view of IQ (Mettler et al., 2008; Neely & Cook, 2011) to understand not only how data transforms in the information generation process, but also how IQ changes through communication and information use processes.

Identification of the underlying mechanisms of the life cycle. By applying the theory of affordances from a critical realist viewpoint, this study contributes by identifying the underlying mechanisms of the life cycle in this case (see Figure 7-13). The various IS and information affordances, including their facilitating conditions and conversion factors, were found to constitute the underlying mechanisms of the secondary use of EHR data, including the information generation mechanism, information communication mechanism, decision-making mechanism, and accountability mechanism. This study furthermore shows that some mechanisms can comprise clusters of affordances (i.e., the information generation mechanism), whereas other mechanisms consist of only one affordance (e.g., information communication mechanism). For the mechanisms to be triggered, all the constituent affordances need to be actualized. For example, the information generation mechanism will not trigger when any one of the IS affordances fails to actualize. Moreover, the mechanisms are interdependent, meaning that some mechanisms are dependent on the triggering of other mechanisms. In this study, for example, the information communication mechanism could not be triggered before the information generation mechanism was triggered.

Towards a definition of IQ in secondary use of EHR data. By introducing information affordances, this study adds to existing literature by acknowledging that only actualizing IS affordances is insufficient to understand IQ in an information use context. Since information artifacts were found to be subject to modifications and communication within the organization, focusing on the action possibilities of the IS and information artifacts provides an end-to-end

understanding that the prevailing manufacturing view excludes. Since information users need to perceive both the action potentials of the information artifact and the action potential as relevant, urgent, and useful in order to be committed, this study contributes by suggesting the following definition of adequate IQ from an information user's perspective in the secondary use of EHR data: information that can enable relevant action possibilities and perceived as relevant, urgent, and useful by the information user.

Shift of research focus. The literature review of this study identified that the main focus of IQ research in the secondary use of EHR data revolved around the usability of EHR data for secondary use. Current research states that insufficient quality of EHR source data limits the potential organizational impact of secondary uses (Byrd et al., 2013; Perimal-Lewis et al., 2015; Prybutok & Spink, 1999). The findings of this research, however, challenge this assumption. In this study, it was found that the main barrier to organizational impact was found in the use process of the information. That is, in reaching a shared understanding of the action potential of the information and ensuring the information users perceive the action potential as relevant, urgent, and useful. Thus, this study contributes by urging a shift of research focus from assessing the usability of EHR data to researching the actual use of information in organizational settings.

9.1.2 Contributions to General IQ Research

Even though this study is based on data from a particular case of secondary use of EHR data, this study also makes the following contributions to general IQ research.

Shift of research focus. Since existing research on IQ primarily focuses on primary use of EHR data (Cabitza & Batini, 2016), research on IQ in secondary use of data can also be characterized as an unexplored area in general IQ research. In fact, the use of supplementary systems for obtaining value from core IS data is not a unique phenomenon for this study context or for health care organizations in general. Such use of supplementing systems, such as databases and spreadsheet applications, can be critical in the day-to-day work in organizations (Handel & Poltrock, 2011), implying that the generation of information artifacts can be far more sociotechnical than the prevailing view of IQ suggests. Thus, this study offers

novel contributions by identifying the life cycle of IQ, including the underlying sociotechnical mechanisms, which can be useful for understanding the phenomenon of IQ in the secondary use of IS data in other contexts as well.

The role of communication. Even though data from the core IS are directly integrated with data-processing systems (Foshay & Kuziemsky, 2014), including business intelligence or analytics systems (Chae et al., 2014; Foshay & Kuziemsky, 2014), performance management systems (Ginsburg, 2003), and process management systems (Michelberger et al., 2011), most organizations use a mixture of push and pull strategies for communicating the information artifact to information users (Foshay & Kuziemsky, 2014). As long as information is being pushed to information users, transformation and filtering of the information artifacts is likely to happen in all organizations (Rogers & Agarwala-Rogers, 1976), consequently modifying the IQ. This process implies that a life-cycle view of IQ holds the potential to better explain the role of IQ than the manufacturing view. Furthermore, the existing definitions of IQ, in which information conforms to specifications and meets or exceeds the information user's expectations (e.g., Kahn et al., 2002), become challenging. The reason for this is that the information specifications are often not fully articulated ex ante, where information users rarely have any predefined expectations of the information (Lillrank, 2003). Thus, this study contributes by suggesting that the information communication mechanism also exists in contexts other than this case.

Action potential of information. Understanding information as artifacts with action potentials for information users (de Vos et al., 2013; Jeffs et al., 2015; Lillrank, 2003) is not limited to the secondary use of EHR data in a health care context. In an organizational context, I argue that information from any IS provides information users' action possibilities, whether in primary (e.g., in clinical decision-making) or secondary use (e.g., in quality management). Thus, I argue that the definition of adequate IQ from the information user's perspective suggested in this study can apply to both primary and secondary use of IS data in organizations.

9.2 Contributions to the Theory of Affordances

By applying the theory of affordances, this study offers the following novel contributions to this theory.

Affordances of multiple IS. This study contributes to affordances research by identifying the importance of being explicit about relations between the features of multiple IS artifacts and capabilities of goal-oriented actors. The analysis showed that no one-to-one relation exists between the features of the EHR system and the actors involved in the quality-management process. Rather, the IT artifact was found to be an intertwining of different artifacts, such as the EHR system, information-processing tools, analysis tools, presentation tools, and communication tools. Thus, investigating the properties of the EHR system exclusively may not provide a complete map of the affordances required to be actualized in achieving organizational goals.

Facilitating conditions and conversion factors. I argue that direct perception and actualization of affordances, unlike ecological psychology, does not work in organizational contexts. In addition to the features of the IS artifact and the capabilities of the actors, certain facilitating conditions, i.e., sociotechnical factors that must be present for an affordance to be available for actors in the specific context, are required to make affordances available for actualization. In this case, data were stored in the EHR system, but facilitating conditions, such as EHR system access to patient records, were needed to for the extractability affordance to be available. In understanding the actualization process, this study also introduces conversion factors. Unlike facilitating conditions, conversion factors affect the actualization of affordances, and thus its outcome. Volkoff and Strong (2017) argued that affordances can be both enabling and constraining; I, however, argue that affordances are always enabling. In fact, it is the conversion factors that can either enable or constrain the actualization process.

Interdependencies of affordances. This study also contributes by identifying dependencies between the affordances. Instead of categorizing dependencies as a dichotomy of strong and weak (Strong et al., 2014), affordances were found to be interrelated with actualization outcomes and facilitating conditions. The outcome of actualizing one affordance serves as facilitating condition to make other

affordances available. Since the actualization process is influenced by conversion factors, the outcome is indeterminate (Volkoff & Strong, 2013), potentially resulting in significantly different outcomes (Strong et al., 2014). Thus, the facilitating conditions for subsequent affordances are also indeterminate, leading to a more complex relation than that captured in the strong/weak dependencies by Strong et al. (2014). Finally, the dynamics of dependencies were found to be temporal and may change over time.

IS and information affordances. Affordances can be classified as IS or information affordances. For IS affordances, the dependencies of affordances are closer to the properties of the IS artifact, and conditions and conversion factors play a lesser role; however, for information affordances, the influence of conversion factors and facilitating conditions play a significant role. Moreover, by actualizing the visualization affordance, its outcome (the information) becomes the artifact that provides the affordances. The outcome of actualizing the initial information affordance can also serve as a facilitating condition to make subsequent information affordance available. To understand the impact of IS within an organization, I argue that we also need to understand the affordances of the information artifacts.

Relation between affordances and mechanisms. Generative mechanism and affordances are apparently closely related since both refer to potentiality for events to occur, rather than the event itself. The distinction is, however, rarely addressed in existing literature. One exception is Volkoff and Strong (2013), who proposed that affordances are the subset of generative mechanisms that involves human agency. Since affordances cannot be actualized by themselves, but require human agency, we can only understand how events occur if we include the facilitating conditions and the conversion factors as part of the mechanism. Thus, this study contributes by distinguishing affordances, which relate only to the action possibility between actors and objects, from mechanisms, which consist of affordances, their facilitating conditions, and conversion factors enabling or constraining actualization.

9.3 Contributions to Practice

This study reveals some practical managerial implications in utilizing EHR data in secondary use. First, the IQ life cycle presented in this study (see Figure 7-4) provides managers with a holistic view of secondary use of EHR data. Rather than treating the different processes of the life cycle in isolation, the model provides an understanding of how IQ keeps transforming throughout the life cycle, and how the various processes are interconnected. For managerial purposes, such holistic understanding of the life cycle enables organizations to manage the entire life cycle of the secondary use of EHR data through increased standardization, monitoring, and continuous improvements.

Second, this study contributes to practice by identifying the roles involved in the life cycle as data extractors, data custodians, information producers, information mediators, and information users. Furthermore, this study categorized the IQ dimensions important to the actors in the various processes of the life cycle into extraction quality, organization quality, presentation quality, communication quality, and application quality (see Appendix G), which illustrates that actors have different perceptions of IQ in the various processes of the life cycle. By identifying the roles and their different perceptions of IQ, managers can formalize the roles within organizations and design the process of secondary use of EHR data in a way that facilitates the different actors.

Third, for information to be used, this study found that information users not only needed to perceive the action potential of the information. For information users to act in response to the information, they additionally needed to perceive the usefulness, urgency, and the relevance of the information in relation to their daily practices. Since the organization exclusively relied on interpersonal communication of the information artifact in the secondary use of EHR data, the study revealed the important role of information mediators. Through different modes of communication, information mediators could influence the outcome of the communication. For example, by rich communication (e.g., translation of the information in face-to-face meetings), the possibilities of reaching a shared understanding was found to be higher than by lean communication (e.g., transportation of information by email). Therefore, the practices of information mediators can significantly influence actors' enactment in response to the

information, and hence the organizational impact, by translating both the action possibilities of the information and the relevance, urgency, and usefulness as perceived by the information users. For example, several unit managers in this study acknowledged their roles as mediators and recognized that failure to communicate the information as relevant, urgent, and useful would constrain the enactment by clinicians. From a managerial viewpoint, this suggests that optimizing the communication process should be a priority for organizations. In particular, the communicative skills and practices of unit managers, which are positioned close to clinicians, should be recognized as crucial information mediators in achieving organizational impact of the secondary use of EHR data.

Fourth, by identifying the underlying mechanisms, managers can pinpoint challenges in the life cycle. In particular, the facilitating conditions (see Appendix K) identified in this study that make the affordances perceivable and available for actualization, and the conversion factors (see Appendix L) that influence the actualization process and its outcome in this study context illustrate the existence of factors that influence the possibilities of reaching organizational goals by secondary use of EHR data. By identifying such factors, managers can optimize the process accordingly.

In Section 9.4, I present managerial recommendations based on the results of this study.

9.4 Recommendations

Based on the findings of this study, I propose the following nine managerial recommendations for the process of making an organizational impact by secondary use of EHR data.

Recommendation 1: Manage IQ in a life-cycle view. As an overall recommendation, the findings of this study emphasize the need to manage IQ from a life-cycle perspective rather than treating the various processes in isolation. The rationale for this recommendation relates to the interdependencies of the processes, where the outcome of one process was found to influence the action possibilities of subsequent processes, ultimately influencing the organizational impact of the

secondary use of EHR data. Failure to manage IQ as a life cycle can result in suboptimal processes with extensive organizational variations of outcomes, as observed in this study. The following recommendations build upon this recommendation.

Recommendation 2: Initiate an adaptive standardization. In this case, the processes of data extraction, data organization, and data presentation were executed at various organizational levels and for various purposes. For example, information generation based on structured EHR data was found to be a more internalized and mature process than for unstructured EHR data. Moreover, information generation at higher organizational levels (i.e., division level) was found to be more sophisticated and with less variations than at lower organizational levels (i.e., unit levels). Because of such variations in executing the process, the outcomes of the information generation process varied correspondingly. To reduce the variations of outcomes, this process can consequently benefit from increased standardization (Foshay & Kuziemsky, 2014) between the different secondary uses of EHR data and between various organizational levels.

In standardizing the information generation process, it is important to establish formal roles, responsibilities, policies, and procedures (Liaw et al., 2013a), which includes formalizing the more ad hoc processes of information generation through documenting extraction requests and extraction fulfillment, and ensuring proper definitions and criteria for data extractions (Foshay & Kuziemsky, 2014). In this case, the use of data extraction criteria and predefined templates were often used at the division level to secure extraction and organization quality, whereas use of such tools was less evident on lower organizational levels, thus suggesting the potential for standardization in the case organization.

According to existing literature, however, standardization of the processes within the life cycle needs to account for contextual complexities (de Lusignan et al., 2006). In this case, local practices varied between units due to personal, cultural, and professional differences. Hence, standardization of the processes needs to be adapted to various organizational levels and groups of professionals, since a one-size-fits-all type of standardization may be unfavorable in large organizations.

Finally, by achieving a higher level of standardization, managers can govern and consequently optimize the process continuously (Liaw et al., 2013a).

Recommendation 3: Facilitate organizational learning. As an initial step of standardizing towards a more process-oriented information logistics (Michelberger et al., 2011), the existing literature suggests that effective management of the secondary use of EHR data requires organizations to analyze the existing processes within the life cycle (Liaw et al., 2013b). Such analysis may help in pinpointing the challenges of the existing processes, while identifying the best practices already existing within the organization. For example, some departments and units were found to be using secondary EHR data more actively, and consequently achieving better results, than other departments. This finding suggests that there is an opportunity for organizational learning of such best practices when standardizing the process.

Recommendation 4: Know the audience. Information should be designed judiciously by making it relevant, urgent, and useful for the information user (Liaw et al., 2013a; Lindquist, 2004). Thus, information users should be identified ex ante to be able to tailor the information accordingly (Ginsburg, 2003).

Evident in this case, information producers generated the information artifact heuristically without having full knowledge of all potential user groups of the information artifact. When communicated within the organization, this often led to modifications by filtering, integration, and/or regeneration of the information artifact. Such modifications of information artifacts were found to be an important characteristic of the IQ life cycle, confirming that the actual use of information may often reside outside of the information producer's control (Mettler et al., 2008). Thus, fully knowing the actual audience of the information ex ante may be challenging (Lillrank, 2003). The information, however, was found to be extensively communicated in the line of management, which has two important implications: (1) managers use the information for decision-making at various managerial levels; and (2) the unit managers communicate the information to clinicians for enactment. Hence, it is possible for information producers to broadly distinguish between the use of information for managerial decision-making and clinician enactment when producing the information artifact. As found in this

study, and supported by existing literature, relevancy relates to the level of specificity (Ginsburg, 2003; Lindquist, 2004; Michelberger et al., 2011), or granularity, and different information user groups tend to prefer various levels of specificity, where senior managers tend to prefer high-level summaries, and line-managers tend to prefer detailed and unit-specific information (Ginsburg, 2003). To increase the potential of organizational impact of the secondary use of EHR data, I therefore recommend that organizations better understand the preferences of actors throughout the line of management, rather than just of senior managers. Such improved understanding can be achieved by engaging in dialogue with actors representing different organizational levels to better understand the information preferences to support core health care processes (Foshay & Kuziemsky, 2014) and by involving such actors throughout the process of data extraction, organization, and information production to achieve transparency and trust in the information (de Lusignan et al., 2006).

Recommendation 5: Find the most effective mode of communication. Providing high-quality information to relevant consumers is critical in enabling action in response to the secondary use of EHR data (de Vos et al., 2013; Foshay & Kuziemsky, 2014). In this case, information was communicated extensively in the line of management by using multiple modes of communication, including email, presenting, and/or discussing information face-to-face in meetings. Because of variations in the outcomes of the secondary use of EHR data within the organization, possibilities exist to improve the communication process. Existing literature suggests that for information to be communicated effectively and efficiently (Jeffs et al., 2015), health care organizations need to establish communication strategies (Foshay & Kuziemsky, 2014), which includes finding the best combination of lean (e.g., emailing) and rich (e.g., discussing the information face-to-face) communication strategies (Ginsburg, 2003; Jeffs et al., 2015). Furthermore, such strategies should consider other factors suggested by existing research to increase the success of communication, such as the use of multiple modes and channels and having a redundancy of key messages (Ginsburg, 2003).

Recommendation 6: Understand IQ-in-practice. This study confirms existing research stating that merely generating and providing high quality information

based on the secondary use of EHR data to information users, will not, in itself, lead to use (Ginsburg, 2003). The information must also be perceived as relevant and urgent by the information user (Jeffs et al., 2015; Liaw et al., 2013a; Lindquist, 2004), in an environment where several factors challenge the users' perceptions of relevancy (de Vos et al., 2013). This research identified specific facilitating conditions needed for actors to make the action possibilities of the information available, as well as conversion factors that enable and/or constrain actors' commitment to the action possibilities. For example, even though information users perceived the action possibilities of the information, actors in this study sometimes chose not to engage in action because it would contradict their clinical autonomy, or they would consider the proposed actions irrelevant for their clinical practice. To achieve organizational goals in the secondary use of EHR data, managers need to identify and manage such factors actively. Without understanding how such factors influence actors in applying the information, organizations will still experience substantial and unfavorable variations in the process outcome.

Recommendation 7: Understand the crucial role of mediators. Information users (e.g., clinicians) are not always able to understand, interpret, or see the relevance of the data, which is a prerequisite for being accountable and engaging in action (Hausvik, 2017a; Jeffs et al., 2015). Through extensive use of interpersonal communication, this study identified the important role of information mediators in the communication process. For example, several clinicians in this study emphasized how the communication practices of the unit managers contributed to their comprehension of the information. Thus, by translating the content of the information artifact, information mediators and information users can reach a shared understanding of the action potential of the information. Furthermore, information mediators can influence information users' perceptions of relevancy, urgency, and usefulness in the communication process. In particular, frontline managers are strategically positioned for clinicians to see clear links to their daily practice and provide a shared accountability (Hausvik, 2017a; Jeffs et al., 2015). By aligning the information with corporate priorities and standards, information mediators can increase information users' perceptions of relevancy, urgency, and usefulness of the information (Jeffs et al., 2015).

Thus, I recommend that organizations recognize the role of information mediators in the secondary use of EHR data. By understanding the crucial role of frontline managers in translating information to end-users (i.e., clinicians), organizations can better utilize this role to achieve their organizational goals.

Recommendation 8: Develop appropriate skills. By exploring the actor-technology relation, this study identified several actor capabilities needed to perceive and actualize action possibilities provided by various IS and information artifacts in the process of secondary use of EHR data. Since the various roles within the life cycle require different actor capabilities, I recommend formalizing the roles as a first step to developing actors' skills. Formalizing the roles is an important part of the process standardization (Liaw et al., 2013a), and it will help managers in identifying the current skillset and revealing which capabilities need to be developed. From this study, the lack of IS resources as data custodians was evident and could be one possible reason for the multitude of IS involved in the process. By following existing literature, which states the importance of developing IS skills and allocating IS resources to facilitate this process (Foshay & Kuziemsky, 2014), such resources represent the potential of streamlining the process and reducing variations of the process outcome.

Current research emphasizes the importance of information producers to have deep knowledge of the complexity of the context, the strengths and weaknesses of the extracted data (Clark et al., 2013; de Lusignan et al., 2006; Lindquist, 2004; Needham et al., 2009; Perimal-Lewis et al., 2015; Verheij et al., 2018), and the underlying processes of data entry (Clark et al., 2013), since data analysis may lead to different conclusions among analysts (Verheij et al., 2018). Thus, organizations needs to prioritize the development of analytic capabilities (Foshay & Kuziemsky, 2014). This study also found that information mediators needed to possess rhetorical and communicative skills to translate the information accurately to information users.

Recommendation 9: Standardize the tools. The case organization of this study used multiple IS in the process of extracting, systematizing, analyzing, and visualizing EHR data in secondary use. The use of multiple IS is not unique to this particular case, since EHR systems are often not designed to support secondary

use of data directly (Byrd et al., 2013), and where data are often flowing through multiple data-processing systems (Verheij et al., 2018). This case furthermore demonstrated that actors at different organizational levels used different tools for the same task—more sophisticated tools were used at higher organizational levels (e.g., surveying tools), and less sophisticated at lower levels (e.g., word processors and manually on paper). This discrepancy illustrates the potential for standardizing the tools for the information generation process throughout the organization and relates closely to the IS resources (or lack thereof) involved in the process (see Recommendation 8). In standardizing the tools, existing research suggests that the tools need to be maintained and adapted constantly to changes in the structure and content of the EHR system (Verheij et al., 2018).

10 Conclusion

In conclusion, this dissertation provides a synthesis of the existing literature on IQ in secondary use of EHR data, offers new contributions, and makes suggestions for future research directions. This chapter addresses the research questions, discusses the limitations of this dissertation, and presents the future research opportunities.

10.1 Summary

The aim of this dissertation was to understand the role of IQ in secondary use of EHR data through analyzing empirical data from a case study of quality management in a Norwegian hospital. The study was guided by the two following research questions: (1) How do human actors influence in transformation of IQ while generating, communicating, and using information in secondary use of EHR data? and (2) What are the underlying generative mechanisms through which IQ transforms in the process of secondary use of EHR data?

The first research question was addressed by applying the view of IQ as a life cycle, rather than a manufacturing process. Through this view, I found that IQ first evolves through the three subprocesses of information generation: data extraction, data organization, and data presentation. In these subprocesses, data extractors address extraction quality dimensions, data custodians address organization quality dimensions, and information producers address presentation quality dimensions. After the information generation process, information mediators communicate the resulting information artifact to information users. In the use process, information users evaluate the application quality of the information artifact using several quality dimensions. Such quality dimensions relate to the information artifact (i.e., "objective" dimensions, including completeness and granularity), which originate from the information generation process, and quality dimensions that are relative to the user and the use situation (i.e., "subjective" dimensions, including relevancy, urgency, and usefulness). Moreover, information mediators can influence information users' perceptions of application quality through the quality of communication. For example, the CQ dimension "reciprocity" was found to increase information users' perceptions of several application quality dimensions, including understandability and relevance. When

information mediators acknowledged that the IQ of the information artifact was insufficient for information users, such quality dimensions were amended through modifications, including filtering, integration, and regeneration of the information artifact. In conclusion, this study suggests taking an information user's perspective and a life-cycle view of IQ to understand how IQ is impacting organizations' secondary use of EHR data, as illustrated in Figure 7-4.

To attain a deeper understanding of the phenomenon, the second research question sought to identify the underlying generative mechanism of the IQ life cycle. In doing so, I applied the theory of affordances and identified seven affordances: extractability, systematizability, analyzability, visualizability, communicability, prioritizability, and accountability. A noticeable distinction is that some affordances relate to various IS (i.e., IS affordances), while other affordances relate to action possibilities of the information artifacts (i.e., information affordances). Thus, IS affordances need to be actualized to generate information artifacts in the secondary use of EHR data, whereas information affordances need to be actualized to make an organizational impact. Since IQ characterizes the information artifact (i.e., properties), it relates directly to human perceptions of the action possibilities provided by the information artifact.

Affordances cannot be actualized without human agency. Thus, we need to understand the facilitating conditions making affordances perceivable and available to human actors, and the conversion factors that influence the actualization process and its outcome. In this dissertation, generative mechanisms are understood as affordances including such facilitating conditions and conversion factors. I proposed four underlying generative mechanisms of the IQ life cycle: information generation mechanism, information communication mechanism, decision-making mechanism, and accountability mechanism (see Figure 7-13). To achieve organizational impact in the secondary use of EHR data, actors need to reach a shared understanding of the action possibilities of the information (i.e., the outcome of triggering the information communication mechanism), and ultimately commit to engaging in action (i.e., the outcome of the accountability mechanism). Whereas existing research suggests that the reason for limited organizational impact of secondary use of EHR data is attributed to insufficient quality of EHR source data (Byrd et al., 2013; Perimal-Lewis et al.,

2015; Prybutok & Spink, 1999), this study suggests that the main problem is to ensure sufficient quality of the information for information users to perceive its action possibilities and furthermore perceive it as urgent, relevant, and useful. Thus, the main challenges of IQ in secondary use of EHR data relate to the affordances of the information artifact and to the conversion factors of the accountability mechanism.

The main contribution of this dissertation is the provision of an alternative view to the manufacturing view for understanding the role of IQ in the secondary use of EHR data. Through the life-cycle view, including its underlying mechanisms, this dissertation provides novel contributions to, and insights into, this phenomenon.

10.2 Limitations

Like any study, this research also has limitations. Subsection 5.4.3 presents the validation issues, and Section 5.5 presents the ethical issues. In the following paragraphs, I discuss the limitations related to the literature review, case study approach, data collection, analysis, theory, and findings.

In conducting the literature review of this dissertation, some limitations can be identified. Even though I rigorously followed the literature review method suggested by Okoli (2012, 2015), there is always a risk of missing out on research articles that are relevant to the research. For example, when applying the exact same queries in both the original (in 2016) and the updated (in 2019) reviews, the search databases returned more articles in the updated search for the same period. Further investigations of these discrepancies identified that several databases had implemented auto-generated classifications and/or indexes of key terms somewhere between 2016 and 2019, leading to more articles than previously identified. All relevant articles identified were included in the core set of articles for this study. Such constant changes in database classifications and indexes, however, illustrates the challenges of updating a literature review, and pose a risk of missing out on relevant articles. Furthermore, several articles did not use the terms “EHR” and “secondary use” explicitly. Thus, I used the broad definitions described in Subsection 2.1.1 (EHR) and Subsection 2.1.3 (secondary use) when selecting articles. Such interpretations could have excluded relevant articles.

The choice of conducting a single case study approach may be considered a limitation by some. Particularly from a positivist view, evidence from multiple cases is considered more compelling and robust than single-case studies (Yin, 2014). However, increasing the number of cases for the purpose of generalizability to a population is not a logic that follows critical realism. On the contrary, the goal of a case study in critical realism is depth rather than breadth, and where a single case must be able to stand on its own (Easton, 2010). Since the aim of this research is to understand the role of IQ in the secondary use of EHR data by identifying the underlying mechanisms, the single case study is found to be well-suited to conducting critical realist research (Wynn & Williams, 2012).

From an interpretivist epistemology, it is important to focus on multiple interpretations and cover the viewpoints of all stakeholder groups involved in the phenomenon (Munkvold & Bygstad, 2016). By choosing a sampling strategy, starting with highly knowledgeable informants (Eisenhardt & Graebner, 2007), and further selecting informants by snowballing (Creswell, 2007), I collected data from several informants representing all relevant stakeholder groups. However, in any sampling strategy, there is always a possibility that some conflicting views within and between stakeholder groups are not identified.

During the interviews, I chose not to provide the informants with descriptions of IQ dimensions from the literature, but instead encouraged them to freely describe their perceptions of what constitutes high IQ. This decision was based on previous experiences where informants had difficulties relating to the concepts of quality dimensions, and where their responses were often colored by the descriptions provided. Such an empirical approach of researching IQ dimensions was also favored by Wang and Strong (1996). The downside of this approach is that the findings cannot be validated statistically (Wang & Strong, 1996). However, through interpreting the informant statements, I was able to corroborate the IQ dimensions important to the informants with existing definitions of the dimensions (see Appendix G).

Finally, from a critical realist viewpoint, all research, including this, inherently has epistemological limitations. Since critical realism recognizes that knowledge is always historically and socially located, where human access to knowledge is

limited, we can never make absolute truth claims (Mingers et al., 2013). Thus, the research is always limited to our perceptual and theoretical lenses and can always be challenged with better explanations. For example, other theories than the affordance theory applied by other researchers might have yielded different explanations of the phenomenon.

The contributions and limitations of this study also offer some opportunities for future research; these are presented in the next section.

10.3 Future Research

This dissertation offers several avenues for future research. In this section, I highlight the following six research agendas: applying other theories, validating the mechanisms identified in this study, the need for more research on communication in IQ research, validating the usefulness of the life-cycle view, validating of the proposed definition of IQ, and discussing the contributions to affordances theory.

Research agenda 1: application of theories. Research on IQ in health care contexts has focused mainly on the primary use of EHR data (Cabitza & Batini, 2016), and often from a technological viewpoint (Mettler et al., 2008; Mohammed & Yusof, 2013). In addition to the scarcity of research, the literature review of this study demonstrated that research on IQ in the secondary use of EHR data often lacks the theoretical underpinnings required for understanding the phenomenon. Though I argued that the theory of affordances was the most appropriate lens for this study, there is an opportunity to approach this phenomenon with other theoretical assumptions. From a critical realist viewpoint, the notion of "critical" means that not all viewpoints are equally valid (Mingers et al., 2013). Thus, such alternative explanations are valued and enable us to choose the explanation that better explains the phenomenon. In doing so, it is important to choose core theories that value the sociotechnical nature of the phenomenon. One example of such core theories to understand the phenomenon can be the actor-network theory (Latour, 2005).

In contrast to the core theories that offer the basic theoretical perspectives of the overall process, additional theories can be applied to increase the understanding of specific mechanisms. In particular, mechanisms comprising information affordances represent opportunities for future research using additional theories: the communication mechanism could be investigated further by using communication theories, such as the media synchronicity theory (Dennis, Fuller, & Valacich, 2008) or the media richness theory (Daft & Lengel, 1986); the decision-making mechanism could be investigated using decision or choice theories; and the accountability mechanism could be further investigated by applying attribution theories, such as the accountability theory (Tetlock, 1999). Bringing in additional theories must be considered cautiously, however, since they may be based on incompatible philosophical assumptions. Thus, it is important to understand the premises and boundaries of additional theories and assure their compatibility to the core theory applied.

Research agenda 2: validation of the mechanisms. Following the first research opportunity, research applying other theoretical assumptions is needed to validate the mechanisms identified in this study, and/or to propose alternative underlying mechanisms of the IQ life cycle. Moreover, the mechanisms identified in this study emerged from a specific case, and future research should aim to investigate their explanatory powers in other contexts. By doing so, there is a possibility of drawing more general conclusions and increasing the impact of the theoretical and practical contributions.

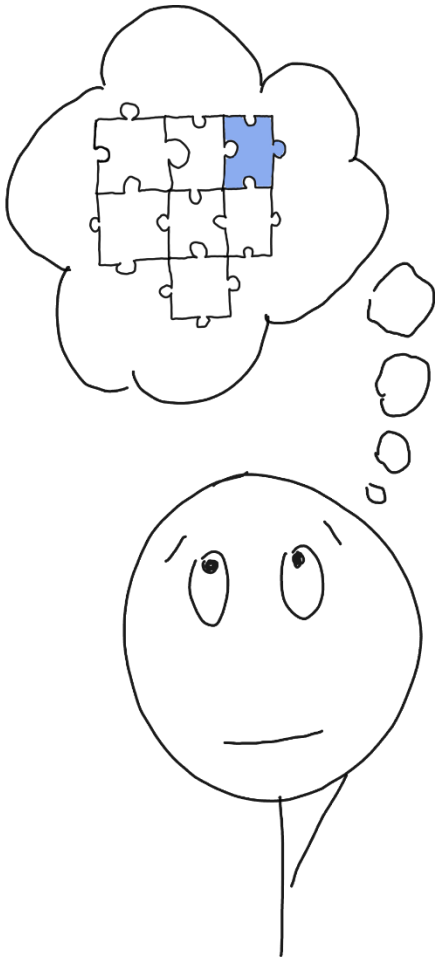
Research agenda 3: more research on communication in IQ. Information users' perceptions of IQ were found to be influenced by communication. Since information based on EHR data are the subject of interpersonal communication within health care organizations (Avison & Young, 2007; Mettler et al., 2008) both in secondary and primary use (Avison & Young, 2007), more research is needed to understand how CQ dimensions relate to the application quality dimensions. Such research includes the opportunity to further investigate the role of information mediators and establish how their practices influence the use of information.

Research agenda 4: validation of the usefulness of the life-cycle view. Even though the life-cycle view of IQ is not new, little empirical research exists. Thus, empirical research is valued to validate its usefulness. By applying this view, researchers can provide novel contributions and push the boundaries of IQ research in general, without the constraints of the manufacturing view. For example, the life-cycle view allows for more research on human interaction and the use of multiple IS in the information generation process, the role of communication (as discussed in the previous paragraph), and a deeper understanding of how modifications of information artifacts influence the actual use of the information.

Research agenda 5: empirical study of the proposed definition of IQ. Among several issues, current definitions of IQ, such as "meeting or exceeding consumer expectations" (Kahn et al., 2002, p. 185), fail to address situations when information needs are not expressed ex ante. Thus, this study offers an alternative definition of IQ: information that can enable relevant action possibilities and perceived as relevant, urgent, and useful by the information user. This definition makes the following fundamental assumptions: (1) information provides actors with action possibilities; (2) action possibilities can be perceived (or fail to be perceived) by information users; and (3) perceived action possibilities can be relevant, urgent, and useful (or otherwise) to information users. Future research validating this understanding and definition of IQ, within both primary and secondary uses of IS data, can potentially increase the understanding of how IQ impacts organizations.

Research agenda 6: discussion of the contributions to affordances theory. This research proposes several contributions to affordances theory that needs to be further discussed and empirically validated. In particular, the concepts of facilitating conditions, conversion factors, and information affordances, represent interesting avenues for future discussions and empirical research.

Part IV
Reflections



11 Reflections

In this chapter, I offer some personal reflections of the research process, theories/concepts of this study, and philosophical considerations.

11.1 Research Process

At the outset of this study, my focus was to reach a broad understanding of how the IQ of EHR data is impacting health care organizations. Through a clear vision of the subject of research and a plan of how to conduct the research, I soon realized the erratic reality of conducting Ph.D. research: as my knowledge matured, my preunderstandings of the reality were constantly challenged. My experience of this learning process could best be described as an emotional rollercoaster; on the one hand, deeply frustrating, but on the other hand, highly rewarding, and ultimately outweighing the frustrations by far.

Since this Ph.D. project is a publicly funded Ph.D. fellowship involving a public organization (i.e., SHT) and a university (i.e., UiA), there is an expectation of delivering both practical value to the hospital and theoretical contributions as required by the Ph.D. program. Even though the phenomenon addressed in this study originates from the field of practice and is thus relevant to the organization, I experienced this duality of goals as challenging. This challenge perhaps relates more to my ambitions than to the actual expectations, since the hospital employer offered me full flexibility and freedom regarding the research and sufficient allocation of time. However, I am left with the impression that I could have allocated more time to involving the field of practice.

What I have learned from this process is that you need to be perceptible to new ideas that challenge your current understandings, while being able to make decisions that will knowingly impact your overall research process. In conducting a Ph.D., such decisions can sometimes be difficult, particularly because of the time constraints. In my case, the support from the supervisors and faculty staff was invaluable for helping me make well-informed decisions throughout the process. Furthermore, I have learned the importance of balancing the various and sometimes conflicting expectations that exist in practice-academic collaborations. Such a balance between expectations would not have been possible for me to

achieve without the good support and flexibility provided by the hospital employer. One key take-away from this experience is the need to involve practitioners more frequently in the research process than I achieved in this study.

11.2 Theories and Concepts

The use of theories posed some challenges in this study. For example, the theory of affordances originates from ecological psychology, where Gibson (1979) focused on how animals engage in actions based on direct perceptions of action possibilities provided by the environment. In an organizational context, this understanding of affordances is a challenging premise: (1) affordances may not be directly perceivable by human actors, but they need to be discovered first; (2) even though affordances are discovered by actors, affordances may be impossible to actualize; and (3) even though affordances are perceived and possible to actualize, human agency is needed for actualization to happen. There has been a debate in IS research on the factors influencing the actualization process. However, current literature offers no clear consensus of how to distinguish between the factors that relate to the possibility of actualizing affordances and the factors that influence human agency in engaging in action. Thus, I needed to provide new terminologies (i.e., facilitating conditions and conversion factors) when applying the theory in this study. Furthermore, the theory of affordances does not explain how different actors can be involved in the process of perceiving and actualizing affordances. For example, some actors can influence other actors' perceptions and engagement in action. To address this shortcoming, I complimented the theory with the concept of mediators originated from the actor-network theory. Though such use of just one concept may not be according to the intentions of Latour (2005), I found this to be a useful addition for understanding the influence of interpersonal communication. To me, this illustrates the usefulness of sometimes adapting important elements from a theory, rather than the theory as a whole.

During the research, I experienced how the concepts from my analysis evolved in line with my increased knowledge of the subjects. For example, at the outset of this research, I wanted to understand how IQ of EHR data was impacting health care organizations. By organizational impact, my focus was not on the day-to-day use of EHR systems by clinicians but rather on how data could be reused for

organizational purposes. Thus, without realizing it at that time, the research focus was on the secondary use of EHR data. The notion of "secondary use" emerged in the process as a part of my learning experience—before arriving at the concept of secondary use, I used terms such as "quality improvement" and "quality assurance," before I realized that such concepts are part of the more general concept "quality management," which furthermore is an instantiation of the secondary use of EHR data. This example illustrates how the concepts of the research evolve, and how conducting a Ph.D. is analogous to shooting at a moving target.

Furthermore, some concepts from existing literature are not always clear cut. On the one hand, this lack of clarity leads to challenges in applying the concepts, and on the other hand, it leads to possibilities of contributions. In a broader perspective, trying to make contributions to all inconsistencies observed between the analysis and existing literature would arguably lead to a disjointed outcome. For example, primary use of EHR data is referred to in existing literature as use directly supporting patient care (Cabitza & Locoro, 2017) by providing clinicians real-time data for clinical decision-making at the point-of-care (Safran et al., 2007), whereas secondary use refers to using data for a different purpose than for which it was originally collected (Hripcsak et al., 2014) in a non-direct care use (Safran et al., 2007). Such definition raises questions such as, how about using data for a different purpose than originally intended in supporting patient care (e.g., innovative use of artificial intelligence systems for clinical decision support)?; and, how about using data for the purpose for which it was originally collected in a non-direct care use (e.g., patient reimbursement)? These questions illustrate that concepts from literature are not always clear. I chose not to focus on this ambiguity since it would not have any significant impact on this study; however, this example illustrates that it is necessary to prioritize and resist the temptation of providing contributions to all inconsistencies observed.

What I learned from this process is that your ways of understanding the data is a process that starts before data collection and ends when the dissertation is submitted. Thus, it is important to readjust your understanding of the phenomenon when new knowledge conflicts with your current assumptions. Furthermore, I learned the importance of being selective in pursuing all the potential contributions

that I observed. Discrepancies will always exist between your findings and existing literature. As long as it is not directly related to the scope of research, and omitting it will not have any significant impact, some doors needs to remain closed for the time being. A final lesson learned is the ability to be self-reflexive. Discrepancies between findings and existing literature remind me that my findings can also be the subject of ambiguity.

11.3 Philosophical View

I experienced the process of selecting the underpinning philosophical worldview to be an important part of this research because of the ontological and epistemological premises it lays. Such premises vary profoundly between different philosophical worldviews, and thus influence the research process directly. For example, in this study, the premises of critical realism influenced the purpose of the research (i.e., as formulated in the research questions), the strategy of inquiry (i.e., critical realist case study), the data collection (e.g., by focusing on events), the data analysis (i.e., by analyzing the events), and the outcome of the research (i.e., by proposing the existence of mechanisms that can explain the occurred events). By applying a different philosophical worldview than critical realism in this research, the research focus, data collection, and analysis could differ accordingly, possibly yielding different outcomes from those provided in this dissertation.

Through my master's thesis, I already had some prior knowledge and experiences of applying critical realism as the philosophical underpinning of research. Thus, I saw an opportunity to expand my knowledge by applying critical realism as the underpinning of this dissertation. To me, the most appealing idea of critical realism is the realist ontology—the existence of a reality independent of human knowledge—combined with the interpretive epistemology by acknowledging that knowledge is intersubjective and always fallible.

As my knowledge of critical realism matured, I experienced several challenges in putting philosophical ideas of critical realism into practice. For example, the idea of retroduction is essential in critical realism and refers to "moving backwards" as a "mode of inference in which events are explained by postulating (and

identifying) mechanisms which are capable of producing them" (Sayer, 1992, p. 107). In existing literature, retroduction is often described as a distinct analytical stage in the process of proposing candidate mechanisms (e.g., Bygstad & Munkvold, 2011b). In my experience, however, retroduction was an iterative and non-linear process of abduction, induction, and deduction as analytical modes of inferences. Chiasson (2005) supports this understanding of retroduction as an umbrella term for analytical modes of inference.

Another challenge I experienced using critical realism relates to the level of abstraction. In particular, the aim of abduction is to abstract the data through existing theoretical perspectives (Bygstad & Munkvold, 2011b). Furthermore, proposing mechanisms by retroduction represents another layer of abstraction. By selecting the affordances theory through the abduction process, I realized the risk of making too high-level abstractions of the proposed mechanisms because of the similarities of affordances and mechanisms. Thus, it was important to me to make a clear distinction between affordances (i.e., the relation between actors and artifacts) and mechanisms (i.e., affordances and their facilitating conditions and conversion factors). This distinction made it possible to propose mechanisms consisting of clusters of affordances (e.g., the information generation mechanism) and mechanisms comprising just one affordance (e.g., accountability mechanism).

From a philosophical viewpoint, I have learned that the choice of philosophical underpinnings has profound implications on the aim and/or purpose of the research, the collection and analysis of data, and the research outcome. By applying critical realism, I have learned to value different approaches of doing research and acknowledging that all research is fallible. To me, this brings a purpose to research—there are always possibilities to improve current knowledge. As researchers, we can never contentedly propose ultimate truth claims, but rather, we should strive continuously for better explanations of the phenomena we observe.

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Appendices

Appendix A: Literature Review Search Results

Search word	ISI Web	Pro-Quest	Scopus	IEEE Xplore	Ebsco-host	Total
"change process*"	3	1	15	0	5	**24**
"quality improvement*"	235	159	627	44	586	**1,651**
"process* performance*"	4	1	34	0	11	**50**
"process* improve*"	21	7	69	0	33	**130**
"process* impact*"	1	0	5	0	25	**31**
"process* management"	20	3	83	8	30	**144**
"organi* performanc*"	36	0	49	0	61	**146**
"organi* improve*"	0	0	3	0	4	**7**
"organi* impact*"	16	0	33	0	24	**73**
"service* improve*"	8	2	17	0	22	**49**
"service* performance*"	14	4	30	0	13	**61**
"service* impact*"	0	0	0	0	10	**10**
"operation* performance*"	21	0	29	0	11	**61**
"operation* improve*"	1	0	9	0	3	**13**
"operation* impact*"	2	0	3	0	14	**19**
"total quality management"	18	8	424	3	100	**553**
"tqm"	8	6	25	0	10	**49**
"information quality management"	20	15	122	17	42	**216**
"iqm"	2	2	16	4	5	**29**
"health* improve*	9	2	10	0	15	**36**
"adverse event*"	95	106	115	0	169	**485**
"secondary use"	39	48	52	0	348	**487**
Total	**573**	**364**	**1,770**	**76**	**1,541**	**4,324**

Appendix B: Consent to Participation

This consent concerns participation in the study according to the information enclosed in this document.

Name of interviewee: _____

Date of interview: _____

Place of interview: _____

I hereby consent to the following (please check the options you consent to):

- ☐ Participation is approved by my manager
- ☐ Audio recording can be used for collecting data
- ☐ Anonymized data can be used as a source for publications
- ☐ Anonymized data can be stored after the end of the research and used in relevant future research

I have received information about this research, and I am willing to participate in this interview:

(Signed by informant/interviewee, date of interview)

Appendix C: Interview Guide

1. Introduction

- Introduce myself and the project
- Briefly explain how the interview will be conducted
- Explain use of data (anonymity, recording, data storage)
- Have participants sign the consent form
- Offer to return the transcripts

2. Informant background

- Education and position
- Experience
- Structure of the unit
- Services offered at unit

3. Quality management process

- Explain quality management processes at this unit **in general**

4. Process: Clinical audit (unstructured data)

4.1 Process description

- Explain the **clinical audit process** in own words
- Explain **overall goal** of the process
- Explain your **role and responsibilities** in the process
- Explain **your goal** related to your tasks
- **Discrepancies** of overall goal and personal goal?
- Describe how the potential of the quality intervention was **discovered**
- **Perceptual** information?
- What were the **circumstances**?
- **IS** involved?
- **Features** of the IS used
- **Agreement** on intervention potential?
- Who made the **decision** of intervention?
- On what **basis**?
- Description of **actions based on the information**
- **Knowledge/skills** needed to perform the action
- **Challenges** or facilitators related to the action
- Description of **effects**
- **Current phase** of the project
- **Plans** going forward

4.2 Information quality

- Describe how **information flows** in this process.
- What do you mean by the term "**information quality**"?
- Describe "**good quality.**"
- Describe information quality in **this process.**
- Describe **production of information**—what do you emphasize?
- Describe **communication of information**—what do you emphasize?

- How do you **assess** the information received?

5. Process: BSC/monthly report (structured data)

- **Other ways** of using the secondary use of EHR data for quality management?

5.1 Process description

- Explain the **BSC process** in own words
- Explain the **overall goal** of BSC
- Your **role and responsibilities** related to BSC
- **Your goal** related to your tasks
- **Discrepancies** of overall goal and personal goal?
- Description of how the potential of the quality intervention was **discovered**
- **Perceptual** information?
- What were the **circumstances**?
- **IS** involved?
- **Features** of the IS used
- **Agreement** on intervention potential?
- Who made the **decision** of intervention?
- On what **basis**?
- Description of **actions based on the information**
- **Knowledge/skills** needed to perform the action
- **Challenges** or facilitators related to the action
- Description of **effects**
- The **current phase** of the project
- **Plans** going forward

5.2 Information quality

- Describe how **information flows** in the BSC process.
- What do you mean by the term "**information quality**"?
- Describe "**good quality.**"
- Describe information quality in **BSC.**
- Describe **production of information**—what do you emphasize?
- Describe **communication of information**—what do you emphasize?
- How do you **assess** the information received?

6. Unstructured vs. structured data

- **Similarities**?
- **Discrepancies**?

7. Closure

Is there anything you would like to **add** that you consider important? Thanks for participating!

Appendix D: List of Informants

Informant role	Organizational level	Organization	Background
Division director	Top management	Hospital	Psychiatrist
Division director			Psychologist
Senior quality advisor	Division level	Division	MSc, nursing
Clinical advisor			Psychologist
Assistant department manager	Department level	Department A	Child welfare officer
Quality advisor			Sociologist
Administrative advisor			Sociologist
Administrative manager	Unit level		Secretary
Unit manager			Clinical social worker
Unit manager			Registered nurse
Team manager	Team level		Social educator
Team manager			Clinical social worker
Psychiatrist	Operational level		Psychiatrist
Clinician			Social educator
Department manager	Department level	Department B	Psychiatric nurse
Administrative consultant			BSc, IT
Administrative consultant	Unit level		Secretary
Unit manager			Psychiatric nurse
Unit manager			Psychiatric nurse
Team manager	Team level		Psychologist
Team coordinator	Operational level		Registered nurse
Team coordinator			Nurse
Clinician			Registered nurse
Department manager	Department level	Department C	Psychiatric nurse
Consultant			Registered nurse
Secretary	Unit level		Secretary
Unit manager			Social educator
Unit manager			Psychiatric nurse
Team manager	Team level		Psychologist
Psychologist	Operational level		Psychologist
Nurse			Registered nurse
Department manager	Department level	Department D	Physiotherapist

Appendix E: Clustering of Events

Instances of events (open codes)	**First clustering**	**Second clustering**
Performing division audit	Extracting data	Data extraction
Performing local audits		
Running EHR system reports		
Randomizing patients	Preparing data extraction	Data organization
Setting criteria for data extraction (structured data)		
Setting criteria for data extraction (unstructured data)		
Systematizing structured data	Systematizing data	
Systematizing unstructured data		
Updating balanced scorecard		
Analyzing structured data	Analyzing data	Data presentation
Analyzing unstructured data		
Routinely checking data		
Verifying results		
Visualizing structured data	Visualizing data	
Visualizing unstructured data		
Complimenting and encouraging managers	Communicating results to managers	Information communication
Presenting results to managers		
Sending results and transferring responsibility in chain of command		
Sending results in chain of command		
Sending results to manager		
Confronting individuals	Communicating results to clinicians	
Demanding action		
Discussing results with clinicians		
Informing clinicians (group level)		
Informing clinicians (individual level)		
Reminding clinicians		
Analyzing information	Discussing	Information use
Presenting and discussing results with managers		
Prioritizing areas of improvement	Prioritizing	
Decision-making		
Breaking it down	Modifying information	
Designing new information		
Digging deeper		
Filtering information to managers		
Filtering information to clinicians		
Finding the cause		
Focusing	Focusing on improvement	
Working with the results		
Changing the work processes	Changing the work processes	
Organizational adjustment	Organizational adjustment	
Training	Training	
Reporting to director	Enactment feedback	
Reporting to external collaborators		
Reporting upwards in chain of command		

Appendix F: Entities and Relations

Event	Entities	Relation
Data extraction	Human entities - administrative personnel, clinicians	Human actors using EHR system functionalities to extract EHR data
	Technological entity - EHR system	
Data organization	Human entities - administrative personnel, clinicians, quality advisors, unit managers	Human actors systematizing extracted EHR data in external data-processing tool
	Technological entities - information-processing tools, paper, spreadsheet application, surveying tool	
Data presentation	Human entities - administrative personnel, department managers, quality advisors, unit managers	Human actors analyzing extracted EHR data in external tool
	Technological entities - spreadsheet application, surveying tool	
	Human entities - administrative personnel, clinicians, director, quality advisors, unit managers	Human actors visualizing the analyzed data by using various technology
	Technological entities - spreadsheet application, surveying tool, presentation tool	
Information communication	Human entities - administrative personnel, clinicians, managers, quality advisors	Human actors communicate the visualized information to managers by using technology
	Technological entities - communication tool, presentation tool, visualized information	
	Human entities - administrative personnel, clinicians, department managers, unit managers, team managers	Human actors communicate the visualized information to clinicians by using technology
	Technological entities - communication tool, visualized information	
Information use	Human entity - managers	Managers discussing the communicated information
	Technological entity - visualized information	
	Human entity - managers	Managers making prioritizations based on the information
	Technological entity - visualized information	
	Human entity - clinicians	Clinicians act in response to the information
	Technological entity - visualized information	

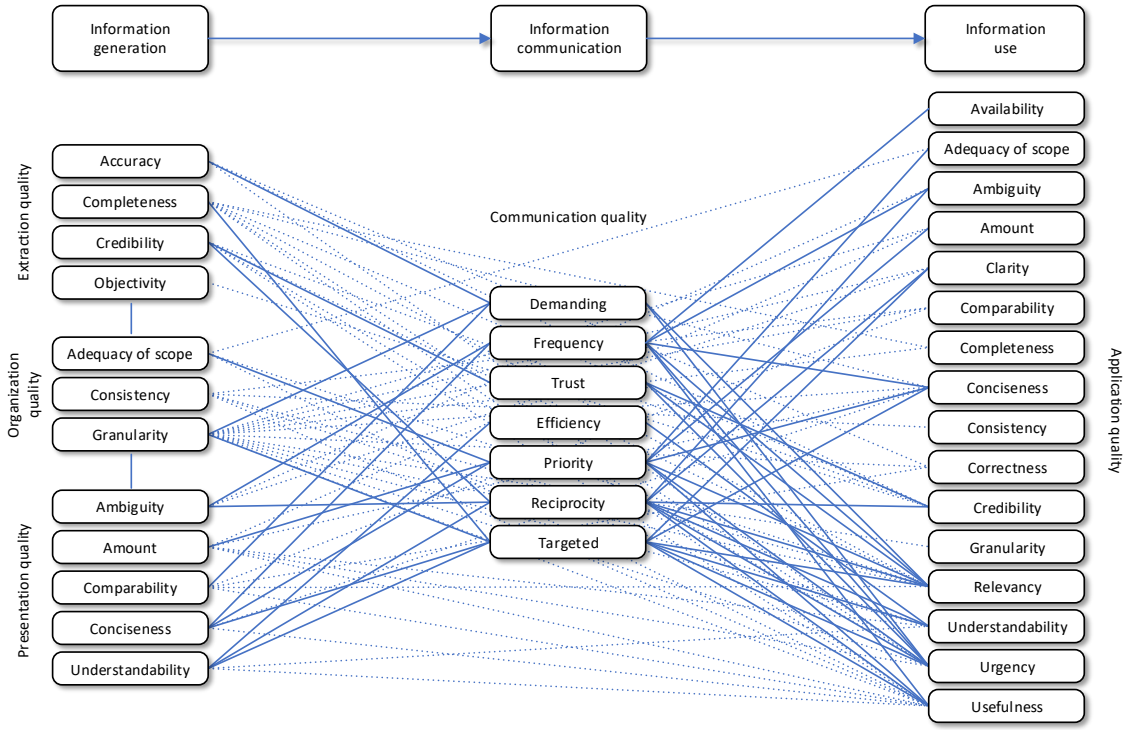
Appendix G: IQ Dimensions

Process	Category	IQ dimension	Definitions of IQ dimensions
Information generation	Extraction quality	Accuracy	"The extent to which collected data are free of measurement errors" (Liu & Chi, 2002, p. 302)
		Completeness	The extent to which "all values that are supposed to be collected … are collected" (Liu & Chi, 2002, p. 302)
		Credibility	"The extent to which the collector has integrity of not committing falsification" (Liu & Chi, 2002, p. 302)
		Objectivity	"The extent to which data are unbiased (unprejudiced) and impartial" (Wang & Strong, 1996, p. 32)
	Organization quality	Adequacy of scope	The extent to which "the scope of information [is] adequate (not too much nor too little)" (Eppler, 2006, p. 83)
		Consistency	The extent to which "different data in a database are logically compatible" (Liu & Chi, 2002, p. 302)
		Granularity	The extent to which "the aggregation of … information meets the requirements of … users" (Michelberger et al., 2011, p. 115)
	Presentation quality	Ambiguity	The extent to which information is "contradicting values of the same elements" (Stvilia, Gasser, Twidale, & Smith, 2007, p. 1728)
		Amount	"The extent to which the volume of information is appropriate" (Liu & Chi, 2002, p. 302)
		Comparability	The extent to which "the information is comparable over time and across jurisdictions, produced using common standards and methods, and can be combined with other sources" (Canadian Institute for Health Information, 2017, p. 22)
		Conciseness	"The extent to which information is compactly represented" (Kahn et al., 2002, p. 187)
		Understandability	"The extent to which information is easily comprehended" (Kahn et al., 2002, p. 187)
Information communication	Communication quality	Demanding	The extent to which employees are explicitly told "what actions to take, when to do so, and so on, with little allowance for employee input" (Johlke & Duhan, 2000, p. 157)
		Frequency	"The amount of contact between channel members" (Mohr & Sohi, 1995, p. 395)
		Trust	The extent to which "a message received is true and reliable and that the communicator demonstrates competence and honesty by conveying accurate, objective, and complete information" (Renn & Levine, 1991, p. 179)
		Priority	The extent to which core messages are prioritized, since "not all messages that are accessible will be enacted upon" (Hargie, Saunders, & Dickson, 1994, p. 31)
		Reciprocity	"The extent to which each party gives feedback and input to the other" (Mohr & Sohi, 1995, p. 395)
		Targeted	The extent to which "communication … address[es] the right audience (i.e., for whom the information is relevant" (Eppler, 2006, p. 282)
		Efficiency	The extent to which "you deliver your message quickly in a way that allows the receiver to hear it, interpret and make use of it as you intended" (Kyeyune, 2018)

IQ Dimensions continued

Process	Category	IQ dimension	Definitions of IQ dimensions
Information use	Application quality	Availability	The "speed and ease of locating and obtaining an information object relative to a particular activity" (Stvilia et al., 2007, p. 1729)
		Adequacy of scope	The extent to which "the scope of information [is] adequate (not too much nor too little)" (Eppler, 2006, p. 83)
		Ambiguity	The extent to which information is "contradicting values of the same elements" (Stvilia et al., 2007, p. 1728)
		Amount	"The extent to which the volume of information is appropriate" (Liu & Chi, 2002, p. 302)
		Clarity	The extent of "obscure language or expression, ease of understanding, interpretability" (Eppler, 2006, p. 364)
		Comparability	The extent to which "the information is comparable over time and across jurisdictions, produced using common standards and methods, and can be combined with other sources" (Canadian Institute for Health Information, 2017, p. 22)
		Completeness	"The extent to which information is not missing and is of sufficient breadth and depth for the task at hand" (Kahn et al., 2002, p. 187)
		Conciseness	"The extent to which information is compactly represented" (Kahn et al., 2002, p. 187)
		Consistency	"The extent to which information is presented in the same format" (Kahn et al., 2002, p. 187)
		Correctness	The extent of "conforming to an approved or conventional standard to or agreeing with fact, logic, or known truth" (Eppler, 2006, p. 364)
		Credibility	"The extent to which data are trusted or highly regarded in their terms of their source or content" (Wang & Strong, 1996, p. 32)
		Granularity	The extent to which "the aggregation of … information meets the requirements of … users" (Michelberger et al., 2011, p. 115)
		Relevancy	The extent of "pertinence to user's interests of the information" (Kim, Kishore, & Sanders, 2005, p. 78)
		Understandability	"The extent to which information is easily comprehended" (Kahn et al., 2002, p. 187)
		Urgency	"The characteristic of the state of the information needed to pursue actions" (Valecha, Oh, & Rao, 2013, p. 8)
		Usefulness	The "extent to which information is applicable and helpful for the task at hand" (Knight & Burn, 2005, p. 162)

Appendix H: Interrelations between IQ Dimensions



For presentation purposes, relations of IQ dimensions spanning one process level (i.e., between information generation and information communication, and between information communication and information use) are depicted as solid lines. Relations of IQ dimensions spanning more than one process level (i.e., between information generation and information use) are presented as dotted lines. The figure is only meant to show the complexity of the interrelations identified in this case, not to provide a one-to-one description of each relation.

Appendix I: Identified Affordances

Events	**Original text (examples)**	**Affordances**
Data extraction	*The previous audit I participated in, I extracted data [from the EHR system] for the past two months and assessed all admitted patients whether there existed a treatment plan or not.* (Administrative consultant, Department B)	Extractability
	You can pull out lots of data from different reports …. There are also different possibilities of filtering to get specific data. Yet, for other reports, you can just click on the report, and you get the data you want, without needing to filter or anything. (Secretary, Department C)	
Data organization	*What we extract from* [the EHR system] *is one thing, and it's there you can see what's missing. It's in* [the EHR system] *we perform the records audit, but for the results of the audit … we have used* [information-processing tool]. *Simply for us to be able to have an overview of what we see.* (Senior quality advisor, Division)	Systematizability
Data presentation	*You must see if it's a trend … if these incidents and complaints are convergent over time. Do we see that same things are missing or multiple deficiencies? Then the point is to see things collectively and not just a random spike of something that doesn't say anything. To be able to do that you must extract* [data] *out of something* [the EHR system] *and put it into something else* [information-processing tool]. *For this reason, we use these tools.* (Senior quality advisor, Division)	Analyzability
	I just visualize it [the results of an audit]. *I think this is one way of doing it, and the response has been positive. When I showed them* [the unit managers] *the graphs, they said it seemed tidy, something I think they are concerned about. And I'll just try this out, until they tell me to do otherwise. If they don't like it, I might try something else, like making a report.* (Quality advisor, Department A)	Visualizability
	I got the results … on a list telling the number of patients, how many were supposed to have this document, and how many were not supposed to have this document. (Unit manager, Department B)	
Information comm.	*We work actively with the balanced scorecard in our management meetings. It is being presented once a month* [. . .] *with graphs and everything.* (Administrative consultant, Department B)	Communicability
	The unit managers bring information to the team manager meetings, which in turn brings the information to the teams. Or, she distributes the information to everyone working here. She also brings the information to staff meetings, or I email the information. (Team manager, Department C)	

Identified Affordances continued

Events	**Original text (examples)**	**Affordances**
Information use	[The balanced scorecard] *gives us a really good idea of how we are doing. Are we delivering on the parameters we are being measured on? And where are we not delivering. And then—if we see that we have a problem or a challenge—we can be concrete and focus on this.* (Department manager, Department B)	Prioritizability
	Based on the results at hand, we made a prioritized list of actions …. We all saw what we needed to prioritize. (Administrative manager, Department A)	
	We're all getting better at implementing changes …. We now do better assessments, and all of this started as an audit remark. (Psychiatrist, Department A)	Accountability

Appendix J: Summary of Case Analysis

Overall goal: Quality management of health care delivery

	Affordance	Technological features	Employee capabilities	Facilitating conditions	Conversion factors	Outcome
Information system affordances	**Extractability** *(enabling actors to extract EHR data)*	***IS artifact:*** *EHR system* *Health care delivery information storage (individual-level patient data); metadata (data creator, modifier, time, organizational affiliation, etc.); data extraction feature (patient records or reports)*	*EHR system report skills for extracting structured data; basic journal record extraction skills and clinical assessment skills for extracting unstructured data*	*Access to EHR system reports; access to patient records in EHR system*	*Data extraction criteria; effort; potential quality issues; identified IQ issues*	*Level of extracted data according to actor's goal*
	Systematizability *(enabling actors to systematize EHR data)*	***IS artifact:*** *Data-processing tool* *Customizable data entry; data storage*	*Basic EHR data extraction skills; basic data entry skills*	*Extracted EHR data; licensing policy*	*Predefined template; individual choice of data-processing tool*	*Level of systematized data according to actor's goal*
	Analyzability *(enabling actors to analyze EHR data)*	***IS artifacts:*** *EHR system; data-processing tool* *Descriptive statistics; filtering; ordering/pivoting; basic numeral operations*	*Analytic skills; tool know-how*	*Systematized data; licensing policy*	*Individual choice of data-analysis tool*	*Level of patterns detected according to actor's goal*
	Visualizability *(enabling actors to visualize emerging patterns)*	***IS artifacts:*** *EHR system; data-processing tool* *Print option; descriptive statistics; diagram and chart operations; output report generator*	*Analytic skills; tool know-how*	*Analyzed data; licensing policy*	*Target audience; individual choice of data-visualization tool*	*Level of visualized data according to actor's goal*

Summary of Case Analysis continued

	Overall goal: Quality management of health care delivery					
	Affordance	**Technological features**	**Employee capabilities**	**Facilitating conditions**	**Conversion factors**	**Outcome**
Information affordances	**Communicability** *(enabling actors to communicate quality management information)*	***IS artifacts:*** *Communication and presentation tools; quality management information* *Information presentation and communication features*	*Communicative and rhetorical skills*	*Visualized EHR data*	*E.g., meeting structure; mode of communication; manager discretion*	*Level of shared understanding reached*
	Prioritizability *(enabling actors to prioritize actions)*	***IS artifact:*** *Quality management information* *Information properties*	*Organizational knowledge*	*Action possibilities communicated; shared understanding*	*E.g., top management support; delegation of decisions; existing workload*	*Level of reached agreement on action(s)*
	Accountability *(enabling actors to be accountable for prioritized actions)*	***IS artifact:*** *Quality management information* *Information properties*	*Commitment*	*Action possibilities and priority communicated*	*E.g., clinical autonomy; system loyalty; perspectives of quality*	*Level of intention to commit to decided actions*

Appendix K: Facilitating Conditions

Affordances	**Facilitating conditions**	**Explanations**
Extractability	Access to EHR system reports	To make extractability available, access to relevant reports is needed.
	Access to patient records in EHR system	To make extractability available, access to relevant patient records is needed.
Systematizability	Extracted EHR data	To make systematizability available, extractability should be actualized.
	Licensing policy	To make systematizability available, license for data-processing tool is needed.
Analyzability	Systematized EHR data in a data-processing tool	To make analyzability available, systematizability should be actualized.
	Licensing policy	To make analyzability available, license for data-analysis tool is needed.
Visualizability	Analyzed EHR data	To make visualizability available, analyzability should be actualized.
	Licensing policy	To make visualizability available, license for data-visualization tool is needed.
Communicability	Visualized EHR data	To make communicability available, visualizability should be actualized.
Prioritizability	Action possibilities communicated	To make prioritizability available, communicability should be actualized.
	Shared understanding of problem	To make accountability available, prioritizability should be actualized.
Accountability	Action possibilities and priority communicated	To make accountability available, prioritizability should be actualized.

Appendix L: Conversion Factors

Affordances	**Conversion factors**	**Explanations**
Extractability	Data extraction criteria	Clarity and consistency of data extraction criteria may affect the data extraction process and its outcome.
	Effort	The amount of effort it takes to extract data from the EHR system.
	Potential quality issues	Suspicions of quality issues may lead actors to extract EHR data for quality management.
	Identified IQ issues	Identified IQ issues can motivate actors to extract data at a more granular level.
Systematizability	Predefined template	Predefined templates for systematizing EHR data outside EHR system may affect consistency of the systematized data.
	Individual choice of data-processing tools	Individual selection of data-processing tool is based on individual preferences, abilities, and goals.
Analyzability	Individual choice of data-analysis tools	Individual selection of data-analysis tool is based on individual preferences, abilities, and goals.
Visualizability	Individual choice of data-visualization tools	Individual selection of data-visualization tool is based on individual preferences, abilities, and goals.
	Target audience	Visualizing information needs to be customized to the audience in question.
Communicability	Manager discretion	Managers individually decide what to communicate to subordinate managers and further to clinicians.
	Quality culture	When communicating results to managers, there is a culture of seeing possibilities, not just problems.
	Clarity of agenda	In communicating with clinicians, managers set the agenda of what is up for discussion.
	Communication style	The communication style influences the level of shared understanding.
	Communication quality	When communicating results to clinicians, CQ may affect the possibility of creating shared understanding.
	Mode of communication	The mode of communication (e.g., face-to-face, meetings, or email) influences the level of shared understanding.
	Management support and expectation	Managers expect subordinate managers to communicate and inspire clinicians.
	Line of management	A clear line of management facilitates communication to managers.
	Meeting structure	The meeting structure facilitates communication to managers and clinicians.

Conversion factors continued 1/2

Affordances	**Conversion factors**	**Explanations**
Prioritizability	Arena for open discussions	Arenas for open discussion provide inclusiveness in decision-making.
	Clear goals	Top management clarity of goals provides basis for prioritizing.
	Attentiveness to change	Unit management attentiveness to change facilitates prioritizing.
	Collective commitment	Collective commitment facilitates prioritizing.
	Top management support	To increase legitimacy of local priorities, top management support is needed.
	Existing workload	Existing workload may affect decisions regarding prioritizing.
	Information quality	IQ may affect the outcome of the decision-making process.
	Delegation of decisions	Decision rights are delegated to secure local ownership of the problem.
Accountability	Information quality	IQ may affect clinicians' accountability.
	Clinical autonomy	Clinical autonomy may affect clinicians' accountability.
	Clinicians' mindset	Clinicians' mindset may affect accountability.
	Fear of criticism	Clinicians' fear of criticism may affect accountability.
	Management mistrust	Clinicians' mistrust of management may affect accountability.
	Personal commitment	Clinicians' personal commitment may affect accountability.
	Personal health	Clinicians' personal health may affect accountability.
	Perspectives of quality	Clinicians' perspectives of what constitutes quality may affect accountability.
	Seeing the relevance	Clinicians' ability to see the relevance may affect accountability.
	System loyalty	Clinicians' loyalty to the system may affect accountability.
	Management demands	Management demands may affect clinicians' accountability.
	Quality culture	Quality culture may affect clinicians' accountability.
	Clinicians' involvement in discussions	Clinician involvement in discussions may affect accountability.
	Collective commitment	Collective commitment among clinicians may affect accountability.

Conversion factors continued 2/2

Affordances	**Conversion factors**	**Explanations**
Accountability	Information fatigue	The amount of information communicated to clinicians may affect accountability.
	Incentives	Incentives may affect clinicians' accountability.
	Manpower	Available resources may affect clinicians' accountability.
	Supportive administrative staff	Supportive administrative staff may facilitate clinicians' accountability.
	Supportive management	Supportive management may affect clinicians' accountability.
	Work environment	The work environment may affect clinicians' accountability.
	Workload	The amount of extra workload may affect clinicians' accountability.
	Individual responsibility	The amount of personal responsibility may affect accountability.
	Keeping it manageable	Keeping interventions manageable may affect accountability.

Index of Topics