THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Understanding quality improvement in care

The case of public care procurement and process mining

SARA DAHLIN

Department of Technology Management and Economics

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2017

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ISSN 1654-9732
Technical report no L2017:092

Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Printed by Chalmers Reproservice
Gothenburg, Sweden 2017

Understanding quality improvement in care

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SARA DAHLIN

Department of Technology Management and Economics, Chalmers University of Technology

Abstract

Healthcare is facing challenges of increased cost and complexity originating from factors such as new technology and diversified treatments, increased life expectancy, an ageing population, and multi-comorbidity, making the need for Quality Improvement (QI) in care highly relevant. This is, however, easier said than done, considering that healthcare is complex, dynamic, ad-hoc, and multidisciplinary. Additionally, despite efforts taken, improvement initiatives sometimes fail or could potentially be improved further.

QI in care has been defined as '...the combined and unceasing efforts of everyone – healthcare professionals, patients and their families, researchers, payers, planners and educators – to make changes that will lead to better patient outcomes (health), better system performance (care) and better professional development (learning)…'. To understand care and find new ways of further improving care, inspiration is sometimes taken from other research fields and subjects. This thesis continues that journey by identifying an existing context and methodology that may support and drive QI efforts. The purpose of this thesis is to explore how QI in care can be understood by expanding QI application into a new context and through the support of a new methodology.

Although a significant amount of care is handled through public procurement, there is little understanding of this system's potential for QI. To explore how QI applications can be expanded into the context of public care procurement, one study in the thesis analyzes procurement documents and performs interviews with municipalities. Identified QI criteria were statistically analyzed for correlation to procurement-specific statistics. Although legal requirements sometimes work against QI, such as through advocating static requirements rather than the flexibility necessary to QI, this thesis identified potential ways to support and drive QI through public care procurement.

One way to achieve QI is through a focus on process and a use of planned to-be care pathways. However, since as-is care pathways, based on documented patient data, are often highly variable, they are seldom possible to recognize through mainstream pathway analysis, e.g. process mapping. Therefore, care variation may need to be better understood to attain the desired improvement. Process mining is a recently developed methodology in which knowledge is extracted from event logs based on individual patient data to produce process maps including all pathway variation. Despite this method's aim of discovering, monitoring, and improving processes and its application in healthcare settings, improvement efforts are lacking, and few papers address the combination of QI and process mining. This thesis explores how QI may be understood by expanding QI applications into the methodology of process mining both theoretically and empirically.

This thesis further elaborates upon the effects public care procurement and process mining have on the theoretical knowledge domains of QI and the practice of QI in care.

Keywords: Quality improvement, public care procurement, context, process mining, methodology, care pathways, elderly care, cancer care

List of appended papers

Paper I

Developing criteria for quality improvement in care procurement

Dahlin, S., Eriksson, H., and Camén, C (2017)

Working paper

An extended abstract of this paper was presented at the Servsig conference in Maastricht, the Netherlands, 17-19 June 2016.

Contributions: Dahlin was the lead author, collected the secondary data, and conducted most of the analysis. Eriksson and Camén collected and analyzed the interview data. Dahlin, Eriksson, and Camén contributed equally to the study design and writing of the paper.

Paper II

Process mining for quality improvement: propositions for practice and research

Dahlin, S., Eriksson, H., and Raharjo, H. (2017)

Submitted for publication

Contributions: As the lead author, Dahlin initiated the study and collected and analyzed the data. Dahlin and Eriksson designed and wrote the paper. Raharjo contributed with guidance, support, and suggestions for improvement.

Paper III

Relationship between patient cost and patient pathways: the case of breast cancer care in hospitals in Sweden

Dahlin, S. and Raharjo, H. (2017)

Working paper

An earlier version of this paper was presented as a poster at the International Forum on Quality and Safety in Healthcare in Gothenburg, Sweden, 12-15 April 2016.

Contributions: Dahlin and Raharjo initiated and designed the study. Being the lead author, Dahlin collected and analyzed the data as well as drafted the paper. Raharjo further contributed with guidance and support for the analysis and with improvement of the paper.

Acknowledgements

It has been a meandering road to this licentiate thesis, not only the research itself but also the road leading to it. I have since 2013 gone from being sure of never pursuing PhD studies to discover this wonderful field of quality improvement and having a lot of fun while doing so. This would never have been possible without the support of several people, some of which I acknowledge here.

First, I would like to give a warm thank you to my main supervisor Henrik Eriksson and my co-supervisors Hendry Raharjo and, joining after some time, Carolina Camén. I cannot say how much I appreciate that your doors (or Skype) are always open for me. Also, you, of course, all have different strengths and knowledges, and together, you are a dream team for a PhD student!

A special thank you goes to my examiner Ida Gremyr, whose compassion and engagement has stretched far beyond her duties, and to Bo Bergman, who was for a while my examiner and has enlightened me by sharing his great experience in the quality improvement field. (You are also a very uncomplicated roommate.)

I would also like to thank the rest of my research group and collaborative partners; a special thanks to Jan Bröchner, whose door is also always open for me, and Rickard Garvare, for all you support and knowledge. Per Sjöli, Roger Olofsson Bagge and other domain experts, thank you for a great collaboration and for opening my eyes to the complexity of the healthcare reality. I am also grateful to Anna Genell, Katrin Gunnarsdottir, Nils Conradi and other staff at RCC West for interesting discussions and insights.

As for financial support, I am grateful to both FORTE and RCC West for the support given through Centre of Healthcare Improvement. Thank you for believing in these projects!

I am a lucky person, not only do I have an interesting job but I also have the fortune of being happy when walking through the doors to the office in the morning. That happiness is due to my dear colleagues at the division of Service Management and Logistics and Centre for Healthcare Improvement as well as the department of Technology Management and Economics – a warm thank you for being so welcoming, friendly and making my days fun! I look forward to another few years with you!

Gunilla Clancy, you are the one who changed my mind regarding PhD studies, I would never have had this, sometimes tough but mainly great, experience without you. Now I know where I belong, work-wise. Thank you for that!

In the end, I would like to thank my family. Andreas, my love, luckily you have already been through this and know the efforts it takes – thank you for all your understanding and support through these years, you are the steady rock in my life, my home. And last but also the most, my wonderful children Martin and Simon. Thank you for all the fun we have and that you make me focus on what is truly important in life!

Table of Contents

List of abbreviations

CPAM	Clinical Pathway Analysis Method
HIS	Health Information System
KPI	Key Performance Indicators
PDSA	Plan Do Study Act
QI	Quality Improvement

'Better understanding of the problem being addressed is an essential first step for any QI effort.'

Shojania and Grimshaw, 2005

1. Introduction

This thesis is about the emerging research field of Quality Improvement (QI) in care. It contributes to understanding QI in care today by exploring the potential expansion of QI application into the context of public care procurement and the methodology of process mining. The findings indicate that the proposed expansion of QI application could lead to an increased understanding of variation in care processes as well as a better understanding and adaptation of QI in the public care procurement context; the research thereby identifies new ways of working that could be useful to realize success in QI efforts.

1.1 Background

In the mid-19th century, Florence Nightingale realized the importance of measuring and understanding variations in care processes, including wanted variations due to patients having different needs and preferences and unwanted variations like if and how the doctors or nurses cleaned their hands, but also in outcomes, such as variations in survival rates and their correspondence with the above-mentioned care processes. Her improvement initiatives led to a decrease in the deaths of wounded soldiers from 42.7% before intervention to 2.2% four months after implementing a number of hygiene improvement efforts (Neuhauser, 2003). She is seen today as the founder of modern care (Neuhauser, 2003). Another pioneer was Ernest Codman, an American surgeon student in 1894 who began to hold records of patient measures to better understand the variations in treatment outcomes (Neuhauser, 1990). Today, well-known challenges face care: cost and complexity continue to increase due to new technology and diversified treatments (Weisz, 2013), increased life expectancy, an ageing population, and multi-comorbidity (WHO, 2000; Weisz, 2013). Such challenges make the need for QI in care highly relevant.

Despite these pioneer efforts in healthcare, the basis of QI lies in theories of quality management (Berwick et al., 1991), with Shewhart and Deming as main contributors of thought (Perla et al., 2013). Shewhart developed statistical methods to understand variation over time, and his work developed into the now commonly used Plan-Do-Study-Act (PDSA)-cycle for continuous improvement (Bergman et al., 2015). Deming was heavily influenced by Shewhart (Bergman and Klefsjö, 2010) and proposed the 'System of profound knowledge', where he emphasized the need for knowledge about the system, understanding variation, psychology, and the theory of knowledge to drive improvement.

Marshall et al. (2013, p. 419) state that 'QI is characterized by its large domain of interest, its applied nature, and its commitment to generation of practical learning that can be applied in real-life situations'. Healthcare is well known for its complexity (Glouberman and Mintzberg, 2001), but it is also ad-hoc, dynamic, and multi-disciplinary (Rebuge and Ferreira, 2012). To capture the local complexity and thereby achieve better patient outcomes, it is important to combine profound knowledge with the professional knowledge of healthcare practitioners (Batalden and Stoltz, 1995).

Perla et al. (2013) explicitly emphasize the importance of connecting practice with scientific principles. Additionally, Marshall et al. (2013) argue that QI in healthcare as a research field addresses the need for a

scientific approach to QI work rather than rushing into poorly planned improvement projects, thereby further pointing out the importance of combining theory and practical knowledge. It is evident that QI builds on a tight connection between theory and practice, but what is the state of the research field today?

1.2 Problem discussion

The research field of QI is still emerging (Bergman et al., 2015), said to be in a pre-paradigmatic phase (Marshall et al., 2013). For example, QI currently has no set definition (Hignett et al., 2015; Marshall et al., 2013; Kleinman and Dougherty, 2013); instead, several overlapping explanations and definitions exist. In this thesis, the definition by Batalden and Davidoff (2007, p. 2) will be used: '...the combined and unceasing efforts of everyone – healthcare professionals, patients and their families, researchers, payers, planners and educators – to make changes that will lead to better patient outcomes (health), better system performance (care) and better professional development (learning)…' since it highlights the complexity of care, the large domain of interest and the shared responsibility to continuously drive improvement.

Healthcare pioneers Nightingale and Codman shared another mindset, namely the need for new thinking to pursue improvement. New thinking, however, does not mean that no one else has had similar ideas. QI theory is constantly being developed by inspiration from other research fields, adopting or adapting their existing frameworks. For example, the integration of human factors and ergonomics evaluation has been argued to improve problem definition and analysis of QI efforts (Hignett et al., 2015; Gurses et al., 2011). To address the issue of how to implement improvement projects in healthcare, Wandersman et al. (2015) suggest the combination of implementation theory with QI.

Batalden et al. (2011) argue for the need to better understand the environment targeted for improvement. In line with this need, several scholars highlight context as important for the outcome of a social intervention, such as QI (Batalden and Davidoff, 2007; Pawson and Tilley, 1997; Kaplan et al., 2010). Context in healthcare can be defined as 'all factors that are not part of the QI intervention itself' (Øvretveit, 2011, p. i18) and can be divided into different levels of the care system; external (economic, political, and social), internal (e.g. structure, culture, and leadership), and individual (e.g. individual knowledge, motivation, and ethics) (Kaplan et al., 2010). Internal context can further be divided into organization and QI team level (Kaplan et al., 2012). Regulations, incentives, and different measures of competition have been identified as QI criteria, reflecting how QI is manifested externally such as through adoption of quality management (Kaplan et al., 2010), and as important drivers of QI (Taylor et al., 2011). However, other external context QI criteria are less understood, and Kaplan et al. (2010) stress the need for further research on how the external context affects QI.

Other studies focus on methods or methodologies[1] to understand healthcare and drive QI (Berwick, 2012; Thor et al., 2007; Wandersman et al., 2015). Unlike context, methodology can be identified as part of the QI

[1] Some use the word technique instead of methodology. In this thesis methodology is interpreted as being broader than method, meaning that a methodology can include several methods and is also connected to a certain mindset or purpose that is similar to all included methods. For example, process mapping can be performed using several methods, but all have the purpose of producing a process map.

intervention itself. Best practice intervention, as defined by Done et al. (2011, p. 500), is 'an activity designed to introduce new practices through a series of short focused activities in the organization'. The researchers further conclude that an intervention is generally performed in order to fulfil both the short-term objectives of performance improvement and long-term objectives, particularly when new and promising practices like methodologies are incorporated into the organization. This conclusion is well in line with Marshall et al. (2013), who state that a pragmatic standpoint is to be taken in QI when robust and well-established methods are chosen from the need to produce local improvement as well as transferable knowledge. Notably, this means that QI is not limited to a certain pre-defined set of methodologies, a notion also be seen in research by Berwick (2012), who embraces human curiosity and encourages an ever-ongoing quest of finding new methods to increase learning. This makes sense if one considers that knowledge and technology develop constantly, whereby new methods and methodologies emerge which may be useful alongside, or instead of, current methods or methodologies that support and drive QI.

As seen in the background and problem definition above, there is and has been continuous development in QI. Since the complexity of healthcare, and thereby the problems addressed through QI, are not yet fully understood, a need for further research regarding these issues persists to support and drive successful QI efforts (Shojania and Grimshaw, 2005). From the QI perspective, considering expanding the application of QI into further contexts and methodologies seems to be a way by which additional understanding of QI in care can be achieved.

1.3 Purpose

The purpose of this thesis is to explore how QI in care can be understood by expanding QI application into a new context and through the support of a new methodology.

1.4 Development of research questions

Batalden and Davidoff (2007) mention several responsible stakeholders in their definition of QI, including payers and planners. As argued by Kaplan et al. (2010), there is a need to further understand the role of external context in QI. One field, that fits into the external context is public care procurement, which can be used when care is to be purchased from an external care provider. Public procurement accounts for 14% of total government spending on average in OECD countries (OECD, 2017) or 15-20% of global GDP (Gross Domestic Product) (European Commission, 2017), and a significant amount of healthcare is handled through public procurement (OECD, 2017). Since the care given is based on a contract, which in turn is based on the procurement, including QI in the procurement is essential to assure QI efforts over the course of the contract. Care procurement, however, is a context in which QI efforts face special challenges. Public procurement is heavily regulated by law, following a logic different from QI (Bröchner et al., 2016), and QI is thereby at risk of being neglected. For example, due to legal requirements, there is usually a set end to a contract regardless of its quality and collaborative composition. Additionally, previous research has shown that the many static and detailed requirements of law can inhibit QI efforts (Camén, 2011).

Quality and procurement have been studied from different viewpoints, such as microeconomic theory (Bergman and Lundberg, 2013) and comparing quality outcomes between private and government-driven care (Bergman et al., 2012), but less progress has been made concerning QI in public care procurement (Bröchner et al., 2016; Neubeck, 2016). Waters et al. (2004, p. 365) researched quality-based purchases of care, which they define as a purchase that 'seeks to improve healthcare quality through the purchaser-provider relationship'. They conclude that i) most research on the subject comes from the US, being substantially different than and therefore less useful for understanding care procurement in other parts of world, and ii) there is a lack of documentation regarding quality-based purchasing initiatives, thereby necessitating more research on the subject. Taken together, Waters et al. (2004) argue for more research regarding quality-based purchasing outside of the US, such as in an EU setting. To achieve QI in public procured care, further understanding and expansion of QI applications in this context may be needed. This statement is the basis for the first research question:

RQ1: How can QI be understood by expanding QI application into the context of care procurement?

Quality management methodologies, originating from the 20th century, have informed and helped improve care during the last decades. However, although the development of digitization has increased the amount of documented data, healthcare still relies heavily on stand-alone process and result measures. These so-called Key Performance Indicators (KPIs) (Harvey et al., 2016; Marshall et al., 2014), or aggregated statistics, pair together with standard quality management methods such as process mapping (Trebble et al., 2010) for process analysis. Methods like process mapping, where an understanding of the processes comes from domain expert knowledge or selected patient observations, might have certain flaws; they may be biased from human misperceptions (Mans et al., 2015) or lack a full understanding of process variations. Even if they would represent reality at that point in time, the dynamic nature of healthcare, with issues like an ever-changing patient population (Provost, 2011), creates a need for more flexible methods of representation. Regarding methodology development, Provost (2011) advocates for the use of analytical, graphical methods with the potential to follow changes over time instead of using traditional statistics to understand and describe healthcare and drive improvement.

One graphical and dynamic methodology that has emerged during the last decade is process mining (van der Aalst, 2016), which has been shown to enrich the understanding of variations in healthcare (Mans et al., 2015) and thereby may enhance QI efforts. Despite its recent development, process mining is well researched in many fields, including healthcare (Mans et al., 2015; Rojas et al., 2016). Process mining aims to discover, monitor, and improve processes (van der Aalst, 2016), but its focus in healthcare has mainly been on the discovery phase (Partington et al., 2015), while less focus has been given to monitoring and especially improvement (Yang and Su, 2014). Yang and Su (2014)'s literature review seem to be the only one discussing improvement in process mining studies, and they conclude that root cause analysis, used to identify the root causes of problems to focus on in improvement effort, is always neglected, exemplifying the weak link between QI and process mining. Other healthcare reviews of process mining (Partington et al., 2015; Rojas et al., 2016) analyze previous literature

through, in total, 14 relevant factors, including process mining perspectives used, process mining tools used, geographic distribution of the studies, and medical field of case example. However, although improvement is stated as an intention of process mining, the aims are never considered as a factor for analysis and improvement focus, thereby becoming neglected in the analyses. In conclusion, despite the potential for increased understanding of variation, one of the four pillars in the system of profound knowledge, few papers address the combination of QI and process mining (Bergs et al., 2016; Fernández-Llatas et al., 2013; Caron et al., 2014). Thus there is a need for further research on how process mining can be explicitly used to drive and evaluate QI in healthcare. This leads to the second research question:

RQ2: How can QI be understood by expanding QI application into process mining methodology?

The two research questions were further developed into three papers whose respective purposes are presented in Figure 1.

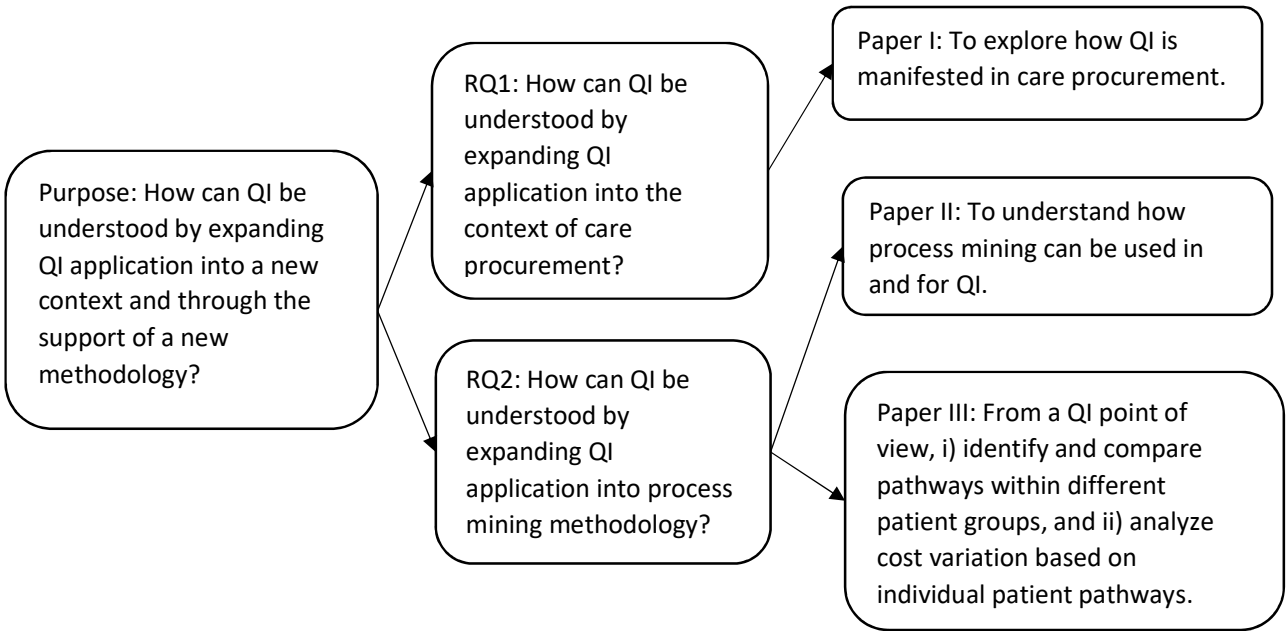

Figure 1. The connection between thesis purpose, study research questions, and paper purposes.

2. Frame of reference

In this chapter, the existing bodies of research surrounding the purpose and research questions are presented in more detail. The chapter begins by describing quality improvement, then care procurement as an external context, followed by healthcare processes, and finally process mining.

2.1. Quality improvement

Although being adopted by informed professionals starting near the end of the 1980s (Bergman et al., 2015), the QI movement did not gain momentum until the publication of the Institute of Medicine's "To err is human" (Kohn et al., 2000), wherein it was concluded that preventable harm to patients was one of the leading causes of death in the US (Kohn et al., 2000). This report moved the focus from improving medical treatment to being inclusive of care issues, such as the need for improved patient safety (Leape and Berwick, 2005). "To err is human" also explicitly stated that inspiration should be taken from other places such as the engineering industry and human factors (Kohn et al., 2000).

In 2001, the Institute of Medicine followed up on "To err is human" with "Crossing the quality chasm: a new health system for the 21st century" where six aims for improving healthcare were stated; safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity (Baker, 2001). These six aims should be reached by redesigning healthcare in three main ways; care should be knowledge-based, patient-centered and systems-minded (Baker, 2001), well in line with quality management (Bergman and Klefsjö, 2010). Healthcare has adopted these aims through different management concepts such as lean, six sigma, value-based healthcare, patient-centered healthcare, or a combination thereof. The six aims of improvement have reached beyond healthcare and is now also used as aims for social care (Lawrence and Lindelius, 2009).

Several scholars have explained and defined QI, but a consensus on its definition has not yet been reached (see for example Batalden and Davidoff, 2007; Lynn et al., 2007; Ogrinc et al., 2008). Lynn et al. (2007, p. 667) define QI as 'systematic, data-guided activities designed to bring about immediate improvements in healthcare delivery in particular settings', while Ogrinc et al. (2008, p. i13) claim that QI 'is fundamentally a process of change in human behavior, and is driven largely by experimental learning'. In this thesis, the definition by Batalden and Davidoff (2007, p 2) is used: '...the combined and unceasing efforts of everyone – healthcare professionals, patients and their families, researchers, payers, planners and educators – to make changes that will lead to better patient outcomes (health), better system performance (care) and better professional development (learning)…'. This definition reflects the need for QI to be knowledge-based, patient-centered, and systems-minded, as well as the responsibility of everyone involved and the complexity of the organization itself.

A combination of professional knowledge from healthcare with improvement knowledge from Deming (2000) is often the basis for QI. However, since the knowledge of the healthcare profession originates from positivism and objectivity, while improvement knowledge originates from a more pragmatic view, there is also an ongoing discussion around the epistemology of how to best achieve QI in healthcare, substantiated in two schools of thought (Berwick, 2008). One is based on engineering and socio-technical thinking stemming from Deming, while

the other is founded in medical research, focusing on evidence-based QI and aiming for e.g. increased use of randomized control trials when pursuing and validating care QI initiatives (Shojania and Grimshaw, 2005). Evidence-based QI predecessors argue that generalizable knowledge can be achieved in this way, thereby identifying criteria vital to QI success (Shojania and Grimshaw, 2005). However, evidence-based QI has also received critique, because although randomized control trials are very important for medical research, they are useful only for understanding what works, without addressing the important issues of the distribution and delivery of care (Leape et al., 2002). For this, the heritage from Deming´s system of profound knowledge is argued more appropriate, as behavioral and psychological understanding and knowledge are main components (Leape et al., 2002). This thesis is guided by engineering and socio-technical thinking.

Despite the ongoing debate regarding epistemology, QI has long been influenced by Deming's 'System of profound knowledge', sometimes called improvement knowledge, the four pillars of which are explained here. First, knowledge about the system is based on the view of the organization as a system of different interlocking parts and processes, emphasizing the importance of understanding the whole system. Second, there is a need to understand the variations within the processes of the system that are always present but which is a mix of different sources that can be divided into either unknown, random variation sources inherent in the system, or come from an identifiable source that lead to significant deviance from the normal process (Shewhart, 1931). The deviance can in turn be interpreted as both negative and unwanted, like a mistake leading to patient harm, or positive and wanted, like identifying a way to improve patient outcomes (Kahol et al., 2011). Variation can also be seen as synchronic (variation between items without taking time into account) or diachronic (variation over time) (Bergman et al., 2015). Third, Deming included two psychological perspectives; on one hand, the need for all employees to be intrinsically motivated, driven by human curiosity and a desire to learn and achieve goals, and on the other hand, the need for theories about change, such as knowledge about how different people react to changes in the organization. Fourth, the theory of knowledge also involves a focus on how knowledge and learning are achieved. This is the basis for the Plan-Do-Study-Act learning cycle, a practice where small changes are tested and evaluated for improvement (Batalden and Stoltz, 1995).

Perla et al. (2013) conclude that the system of profound knowledge (Deming, 1994), is important for healthcare since it clearly demonstrates the need not only for professional knowledge, but also improvement knowledge. Batalden and Stoltz (1995) put the system of profound knowledge into a healthcare framework by including professional knowledge of healthcare as another important factor (see Figure 2). They (Batalden and Stoltz, 1995) argue that it is by combining professional knowledge with improvement knowledge that a shared understanding is achieved in which diagnostics and treatment as well as processes and systems can be improved. In the end, this synergy could improve the outcome for the patient.

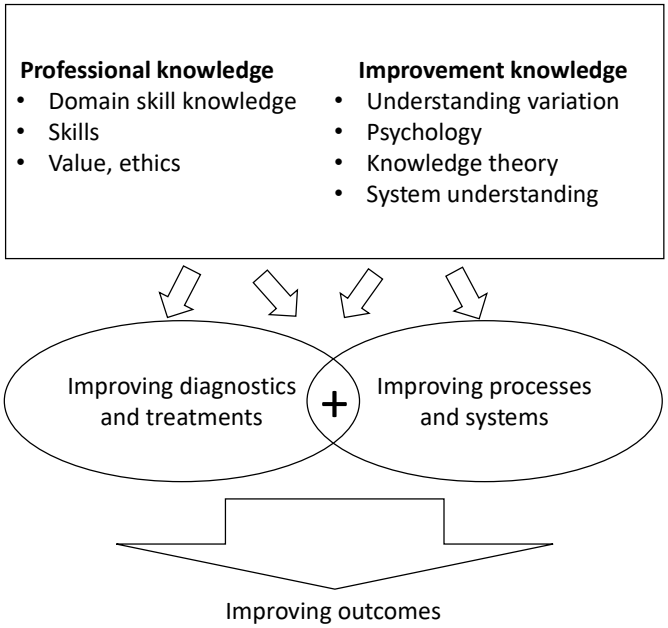

Figure 2. Batalden and Stoltz´s extended framework of Deming´s system of profound knowledge, interpreted by Bergman et al. (2015). The flowchart demonstrates how professional medical knowledge in combination with improvement knowledge could lead to improved healthcare outcomes.

Other attempts at putting forward QI frameworks have been made by Batalden and Splaine (2002), who present three types of processes they suggest are necessary for leaders to pursue QI; building knowledge, taking action, and reviewing and reflecting. To concrete these processes, they additionally present eight knowledge domains on which leaders should focus. Seven of these domains of interest are concreted even further by Batalden and Davidoff (2007), who include examples of methods and tools useful to achieve this knowledge (see Table 1).

Table 1. Seven domains of interest, as presented by Batalden and Davidoff (2007).

Domain of interest	**Helpful tools and methods**
Healthcare as processes within systems	Diagrams that illustrate flow, inter-relationships, and cause-effect; narrative descriptions; case examples
Variation and measurement	Data recorded over time and analyzed on run charts and control charts
Customer/beneficiary knowledge	Measurements of illness burden, functional status, quality of life; recipients´ assessment of the quality of their care
Leading, following, and making changes in healthcare	Building knowledge, taking initiative or adaptive action, reviewing and reflecting; developing both leadership and follower-ship skills
Collaboration	Managing conflict, building teams, and group learning; acquiring specific communication skills (eg. SBAR)
Social context and accountability	Documenting unwanted and unnecessary variation; widespread public sharing of information
Developing new, locally useful knowledge	Making small tests of change (PDSA cycle)

Batalden and Davidoff (2007) also created a formula for how to combine five knowledge systems to make QI happen (see Figure 3). The formula describes how measured performance improvement over time (3) is a result of using generalizable scientific knowledge (1) planned through evidence-based methods (4) while taking the context of the local care settings into account (2), followed by the proper and careful execution of the plan (5).

(1)		(2)		(3)
Generalizable scientific knowledge	+	Particular context	=>	Measured performance
	(4)		(5)	

Figure 3. Formula describing how to utilize the five knowledge systems to improve healthcare (Batalden and Davidoff, 2007).

Perla et al. (2013) draw on Deming's ideas to suggest seven propositions of QI, and, like Deming, they focus on both theory and epistemology. Parry (2014) summarized the resulting framework in a figure, presented here as Figure 4.

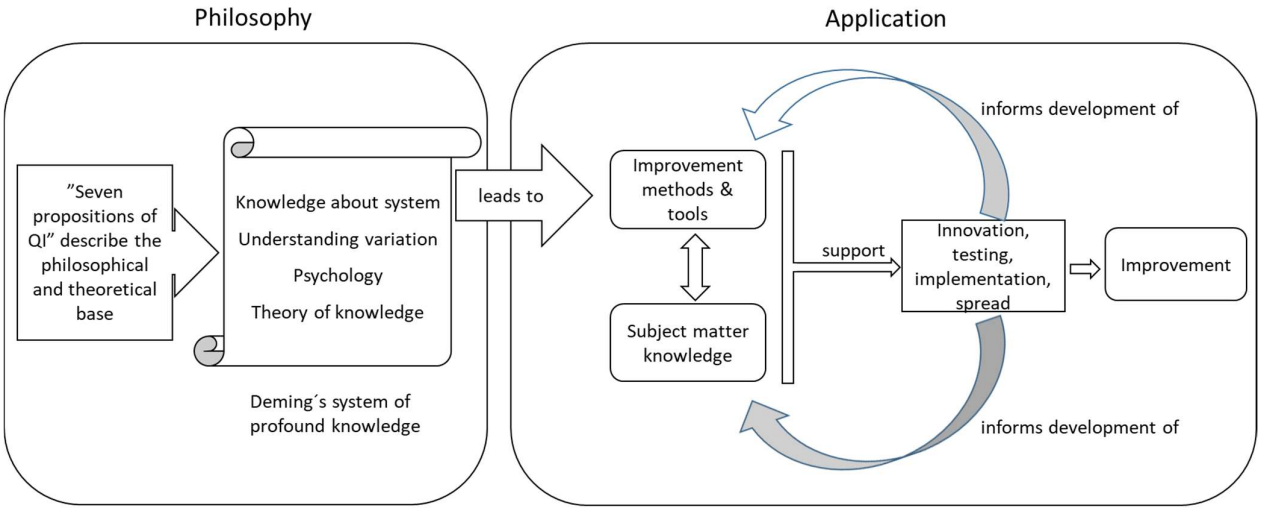

Figure 4. The seven propositions of QI (Perla et al., 2013), from Parry (2014).

The importance of improvement methods and tools is clearly shown in Figure 4, much as the need for planning using evidence-based methods (4) is expressed in the equation in Figure 3. Figure 3 also emphasizes the importance of the particular context, and Perla et al. (2013) argues for balancing justification, meaning the use of data through improvement methods and tools, with discovery and human creativity, being founded in subject matter knowledge. Although Perla et al. (2013), like Berwick (2012), encourage the development of new methods, and despite the recent technological developments and digitalization available for new applications, several QI methods have remained rather static. Some common QI methodologies that have to a large extent been used similarly for decades are Statistical Process Control (Shewhart, 1931), process mapping (Trebble et al., 2010), and the PDSA cycle (Batalden and Stoltz, 1995). However, new methods can be created or adopted into QI once they have been proven to be scientific and rigorous (Marshall et al., 2013).

Context is undoubtedly important in QI. However, different people define 'context' in different ways. While Lifvergren (2013) has a general view of context in the healthcare setting, seeing it as different parts of the care system, other researchers go into more detail. Kaplan et al. (2010) and Kaplan et al. (2012) divide healthcare into external, organizational, QI team, and individual contexts, while Batalden and Davidoff (2007) focus on local context, including processes, habits, and tradition. Pawson and Tilley (1997) explain context as the local conditions or relationships that make certain a mechanism has a causal effect, while Pettigrew (1987, p. 650) defines it as 'antecedent conditions of change'. Kaplan et al. (2010) clarifies that methods for intervention are not included in the notion of context. Context therefore seems to be most aspects that are not a direct part of the change intervention itself, with obvious importance placed on the setting in which the intervention will occur. Summarizing the above, context can be identified as encompassing different levels. Although local contexts, such as a department or hospital, can certainly have an impact on outcome, the system-wide context, such as in differences between healthcare and social care (Neubeck, 2016), is also important. Generally, the context of social care is somewhat neglected, as much quality improvement focus has been given to care within a healthcare setting.

In this thesis, 'context' is used to describe three levels (see Figure 5): i) the system level focuses on the type of care system, such as healthcare or social care; ii) the local level, as part of the system context, divides healthcare into external, organizational, QI team, and individual contexts (Kaplan et al., 2010; Kaplan et al., 2012). This local context affects care both directly but also indirectly, externally, such as through regulations or external sponsors. iii) The most detailed level of context describes QI criteria[2] in each of the local contexts but can also be directly connected to the systemic level (Ramadan and Arafeh, 2016). Some QI criteria can, in that sense, be connected to both the local and system levels. Examples thereof are QI skills, leadership, and QI culture (Kaplan et al., 2012), which have all been identified as important on more than one contextual level.

[2] Some use the word 'factor' instead of 'criterion'.

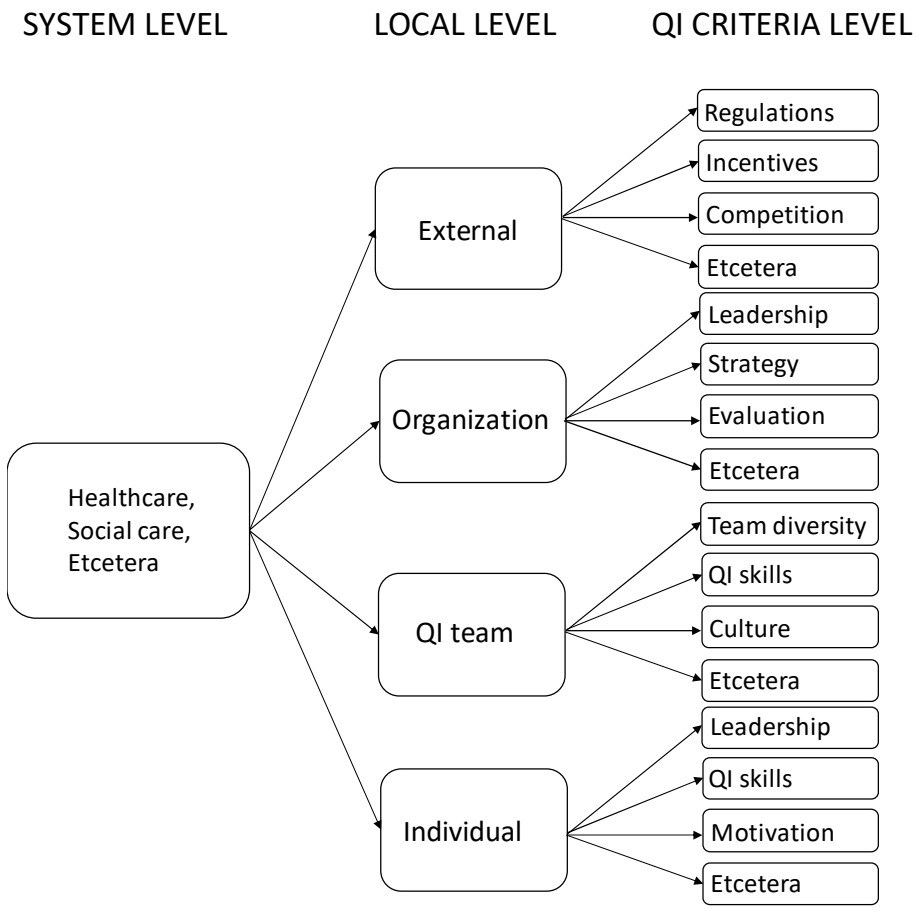

Figure 5. Context identified at three different levels. To the left is the system context, e.g. the healthcare context, while the middle boxes represent local contexts e.g. within a hospital setting. The rightmost contexts represent some examples of QI criteria specific to the each of the local contexts. The figure is the author's compilation of several papers focusing on QI context (Kaplan et al., 2010; Kaplan et al., 2012; Ramadan and Arafeh, 2016).

While context is often researched to understand what is needed for QI success (Kaplan et al., 2012), other studies focus on good and bad ways to conduct QI, identifying good examples or degree of QI development within a healthcare organization (Ramadan and Arafeh, 2016). Ramadan and Arafeh (2016) conclude that the execution or development of QI criteria varies both within and between hospitals.

In conclusion, QI is seen as an emerging research field in which development is ongoing, regarding both definition and, on a more detailed practice and methodological level, what is needed and how to work to achieve QI. In the former, a consensus is to be aimed for, while in the latter, an increase in methods is expected to allow researchers and practitioners to grasp the complex, ad-hoc, dynamic, and multi-disciplinary world of healthcare. At the same time, the QI context and how context affects QI are also expanding areas of research.

2.2 Care procurement as an external context

In their global review of quality-based healthcare, Waters et al. (2004) conclude that there is an increasing trend in purchasing care. This is in line with research by Øvretveit (2003b) and Bergman and Jordahl (2014), showing that care is increasingly handled by private caregivers instead of being government-driven. Waters et al. (2004) also identify a large variation in purchasing strategies between countries with different income levels, as well as

between the Unites States and the EU. Within the EU, however, common regulations make public procurement comparable.

Procurement is often mixed up with commissioning or purchasing, but Murray (2009) conclude that procurement includes purchasing as well as part of commissioning. Here, purchasing is therefore included in procurement following the explanation from Murray (2009, p. 200): 'a project-based approach to source the specific provider of the service'. In the case of public procurement, the government takes the role of the buyer (Bröchner et al., 2016), still being responsible for the care given. The care provider is, in accordance with the law, chosen through procurement. In the EU, public procurement was awarded under directive 2004/18/EC, given to either the lowest priced or the most economically advantageous tender, the latter including a tendering award evaluation based on quality requirements. In the more recent directive, 2014/14/EU, which repeal the earlier, only the most economically advantageous tender remains as an option. Quality can additionally be included in public procurement by prequalification requirements (Eadie et al., 2012) and through specified quality requirements in procurement documents (Kuypers and Gruppen, 2008; Enquist et al., 2011).

Previous research on procurement contracts concludes that contract formulation might affect future possibilities to manage quality (Camén, 2011). It is already difficult to formulate requirements for a care setting whose "soft" values hard to define (Stolt et al., 2011) – especially since procurement concerns care that should not be given to the buyer but to a third party – but legal restrictions create additional obstacles. Bröchner et al. (2016) identify problems in transferring quality methods to procurement due to legal restrictions like transparency, and they also state that buyers might be reluctant to include innovative requirements in procurement documents and instead may prefer more tested, simpler practices due to the risk of judicial complications. Earlier studies also show problems incorporating QI aspects into contracts due to the need for a set end date, regardless of the quality of the collaboration. Procurement legislation logic further leads to preference towards static requirements rather than flexible, which has been shown to restrict QI by reducing the contractors' possibility for customer-orientation (Camén, 2011). It is therefore not surprising that Bergman and Jordahl (2014) report a lack of relevant quality measures in healthcare procurement. In a report by Health Navigator (2013), authors argue for the need for less complicated procurements focused on results and incentives for QI during the contractual periods. Additionally, they point out the need to stress the importance of QI outside of the contract's demands.

Care procurement could be connected to QI theory in other ways than as an external context. In the 4C model of different healthcare worlds (care, cure, control, and community) by Glouberman and Mintzberg (2001), care procurement can be linked to the control and community worlds. Care procurement could be part of control, since government is ultimately responsible for the care, while it could also part of community, since the responsible government is situated outside of the care itself but is part of the community. Care procurement may also be connected to the definition of QI as stated by Batalden and Davidoff (2007), since it highlights planners' and payers' responsibility to drive QI efforts.

2.3 Healthcare processes

By focusing on care processes, some research has argued that organizational silos can be overcome (Glouberman and Mintzberg, 2001) and that healthcare processes reduce costs (Porter et al., 2000). Care processes are mainly managed by measuring KPIs (Mainz, 2003), sometimes connected to a process map, usually developed through process mapping (Trebble et al., 2010).

On a patient level, process-focus can be achieved through care pathways (Vanhaecht et al., 2007). The European Pathway Association defines care pathways as 'a methodology for the mutual decision making and organization of care for a well-defined group of patients during a well-defined period' (Vanhaecht et al., 2007). Care pathways were introduced to improve quality of care and lower costs and should be developed through evidence-based protocols (Every et al., 2000), resulting in to-be process models guiding care. However, with care pathways physicians sometimes feel they lose autonomy and are forced to follow the standardized 'cook-book medicine' given to them, thereby inhibiting personalized care (Every et al., 2000).

Bergman (1999) concludes that care pathways are mainly a result of expert clinical panels rather than randomized control trials. Additionally, Mans et al. (2013) claim that process execution is viewed subjectively, indicating that personal assumptions or experiences are part of care pathway creation. This inclusion implies that care pathways might not always be in line with best practices, hence echoing the physicians´ concerns stated above. However, one must remember that not all patients are expected to follow the care pathway as long as deviations are properly motivated and do not exceed a certain threshold (Polite et al., 2016). By explaining the reasons for deviations, learning can be achieved; a deviation itself might reveal even better ways of working (Kahol et al., 2011). To gain the best possible outcomes from a focus on the patient process, it is therefore of great importance not only to create a care pathway and assume that the implemented to-be care pathway is followed to the extent intended, but also to understand the resulting as-is care pathways.

2.4 Process mining

A huge amount of data is recorded every day in care settings such as hospitals, and information exists with varying degrees of detail regarding several different kinds of processes. Digitalization and increased documentation have led to new ways of understanding processes, enabling the use of bottom-up approaches. Process mining is a methodology developed about a decade ago that aims to discover, monitor, and improve processes (Van Der Aalst et al., 2012). As a result, patient and performance data is now directly connected to processes (van der Aalst, 2016). By merging the fields of data mining and process management, process mining is used to extract process knowledge from event logs (van der Aalst, 2016). Event logs are ordered data where a case, such as a patient, is connected to well-defined activities, such as a doctor visit or blood test. Time-stamps and other additional attribute information are sometimes included. A health information system (HIS) is one example of so-called process-aware information systems, which can be used to handle the data kept in such event logs. Two specific examples of HIS are electronic health records and quality registers (Coorevits et al., 2013). Van Der Aalst et al. (2012, p.172) argue that process mining as a methodology enables systems such as

Quality Management and Six Sigma, offering more rigorous compliance checks and 'acertain[ing] the validity and reliability of information about an organization´s core processes'.

Process mining has already been used in healthcare (Rojas et al., 2016), but as a methodology it originates from the field of computer science (Ghasemi and Amyot, 2016), which might be the reason for the lack of research on the connection between QI and process mining. Process mining is typically used for three different purposes: discovery, conformance, and enhancement (van der Aalst, 2016). Discovery is about identifying the order of events resulting in, e.g., a process map, while conformance considers whether the reality conforms to a pre-defined process model such as a care pathway. Lastly, enhancement is used for developing the existing models by using data to more closely match reality or to include additional information in the model, such as adding time stamps for a bottleneck analysis. For each of these purposes, one can use one of three different orthogonal perspectives: control-flow, performance, and organization (Mans et al., 2009). The control-flow perspective requires ordered data and answers the question "How?", producing end-to-end process models similar to but more detailed than models achieved with process mapping. The performance perspective connects the pathway and the process models with additional data: timestamps for identifying bottlenecks, for example, or other attribute data such as costs or chosen medical treatments. Connected to cases, the performance perspective answers the question "What?" (Mans, 2011). The organization perspective focuses on identifying collaborations between groups such as physicians or wards and answers the question of "Who?" (Mans, 2011).

The Process Mining Manifesto, which was written to introduce process mining to a larger audience, introduced the L* lifecycle model in order to guide process mining practitioners (Van Der Aalst et al., 2012). Different models have since then been developed for healthcare; the L* lifecycle model has been adapted for parallel analysis of data from different data records (Helm and Küng, 2016), and the Clinical Pathway Analysis Model (CPAM) has been developed with a focus on care processes (Caron et al., 2014). A clear connection between process mining and QI can be seen by comparing the process mining models with the PDSA cycle. All models can be compared to a PDSA cycle as shown in Table 2. This cycle, in turn, can be part of a larger PDSA cycle covering the full improvement project cycle. The connection to the PDSA cycle highlights the systematic and potentially iterative mindset with a focus on improvement that is shared between QI and process mining.

Table 2. Comparison of PDSA, L-lifecycle model, Extended L*-lifecycle model, and CPAM.*

<table>
<tr><th>PDSA</th><th>L*-lifecycle model</th><th>Extended L*-lifecycle model</th><th>CPAM</th></tr>
<tr><td>Plan</td><td>Plan and justify</td><td>Plan and justify</td><td rowspan="2">Project definition and event log extraction</td></tr>
<tr><td rowspan="3">Do</td><td rowspan="2">Extract</td><td rowspan="2">Multiple extract (compare and align)</td></tr>
<tr><td>Event log pre-processing</td></tr>
<tr><td rowspan="3">Create control-flow and connect event log</td><td rowspan="3">Create multiple control-flows and connect event log</td><td>Perspective selection</td></tr>
<tr><td rowspan="2">Exploratory pathway analysis</td></tr>
<tr><td rowspan="3">Study</td></tr>
<tr><td rowspan="2">Create integrated process model</td><td rowspan="2">Create multiple integrated process models</td><td>Medical confirmation</td></tr>
<tr><td>Advanced pathway analysis</td></tr>
<tr><td>Act</td><td>Operational support</td><td>Operational support</td><td>Improvement of pathway</td></tr>
</table>

Interestingly, although few papers connect QI and process mining, Vaitsis et al. (2016) include process mining when they analyze the use of big data and analytics in QI. They use the equation from Batalden and Davidoff (2007, presented in Figure 3), calling 'general scientific knowledge' 'actionable intelligence' instead, and argue that the actionable knowledge can be drawn from raw data through the use of process mining.

2.5 Summary of theoretical framework

Quality improvement of care deals with the challenges of driving improvement in complex, ad-hoc, dynamic, and multi-disciplinary settings (Rebuge and Ferreira, 2012), all with their own local contexts affecting care and improvement efforts. On a philosophical level, QI is guided by the system of profound knowledge (Perla et al., 2013), which, together with the professional knowledge of healthcare personnel and other stakeholders, can produce better patient outcomes (Batalden and Stoltz, 1995). To grasp this complexity, many studies present various perspectives and methods focused on different areas of interest to understand how QI can be applied, driven, and supported. Some researchers focus on context, i.e. everything but the improvement intervention itself (Kaplan et al., 2010; Øvretveit, 2011), while others focus on the implementation of improvement efforts through new methodologies (Done et al., 2011; Berwick, 2012). Many researchers and practitioners find inspiration from other research fields or theories (Baker, 2001; Batalden et al., 2015; Hignett et al., 2015).

Despite the many papers written about QI, improvement efforts still fail or need further improvement (Berwick, 2012). One reason for this inadequacy might be that certain parts of QI are yet not fully understood. To further understand QI, it may be useful to expand QI application into new and un- or under-explored areas with the

potential to shed new light on QI efforts. One such area is public care procurement, which has rarely been studied within the QI field despite its potential to drive QI and overcome challenges. Public care procurement's main challenge for gaining a QI focus is procurement legislation logic, which heavily influences care procurement requirements with its sometimes contradictory nature. QI aims for flexibility while care procurement requirements are often static (Camén, 2011). Public care procurement can be identified as an external context in the QI context framework presented in Figure 5, and further understanding of the subject is needed regarding both how QI is manifested and the procurements' subsequent effects on QI. This thesis's contributions to the framework are highlighted in Figure 6.

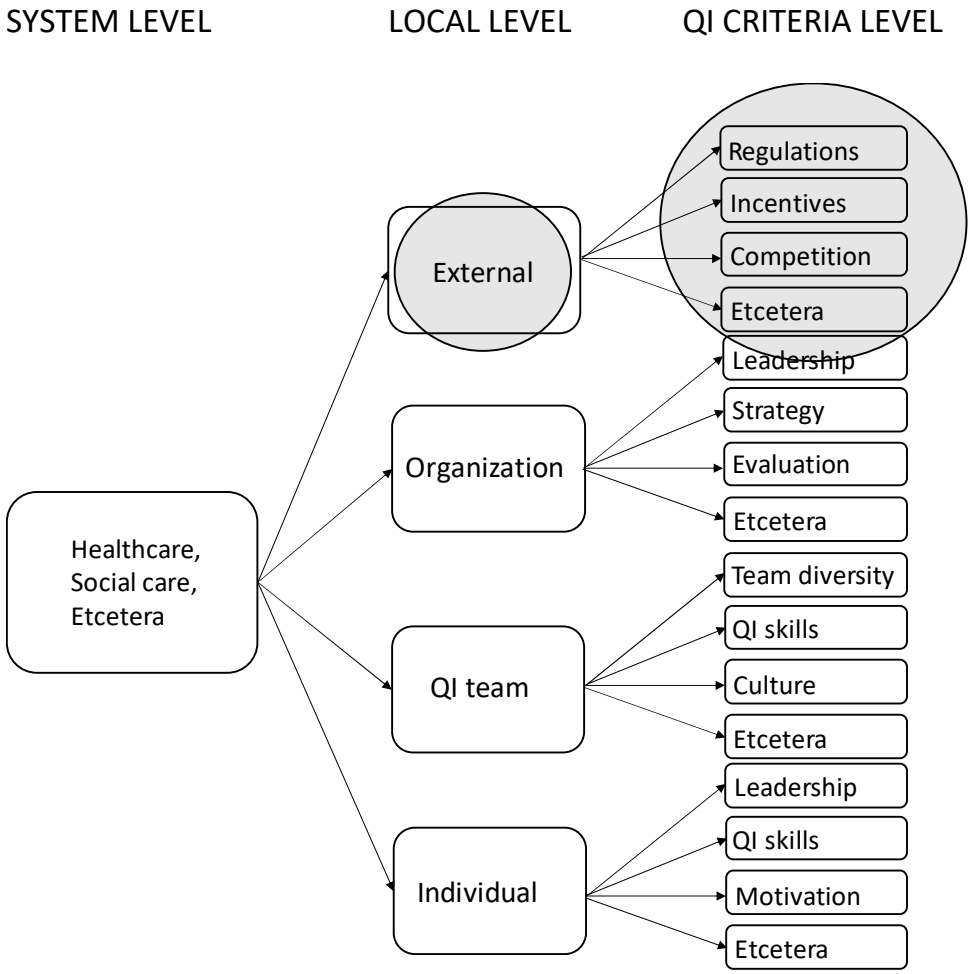

Figure 6. The conceptual model presented in Figure 5, with areas of contribution from this thesis circled. The figure is the author's compilation of several papers focusing on QI context (Kaplan et al., 2010; Kaplan et al., 2012; Ramadan and Arafeh, 2016).

Focus on care process is one way to pursue QI, and it can be argued that standardization through successful implementation of to-be care pathways improves quality and reduces cost. However, to-be care pathways may not reflect reality (Mans et al., 2015) and may not always be based on evidence. Additionally, physicians sometimes feel restricted by what they call 'cook-book medicine' with limited possibilities to individualize care (Every et al., 2000). One way to shift the focus from to-be care pathways and instead support and drive QI through an increased understanding of reality is by using the existing methodology of process mining, where

knowledge is extracted from event logs by identifying and analyzing as-is processes. Process mining aims to discover, monitor, and improve processes and has been used in healthcare settings for years, but mainly only to discover as-is care pathways with little to no focus on quality improvement.

In conclusion, Figure 7 shows a conceptual framework explaining this thesis's view of how QI can be understood by the research field, exploring the expansion of QI application into the context of care procurement and by using process mining methodology. The dashed line in Figure 7 represent this expansion. This paper's main contribution to the field is presumed to be along the solid arrows, showing that care procurement and process mining can support and drive QI efforts, leading to QI being better understood. There may also be potential contributions in the opposite direction, as indicated by the dotted arrows; QI may contribute to the research fields of public care procurement and process mining.

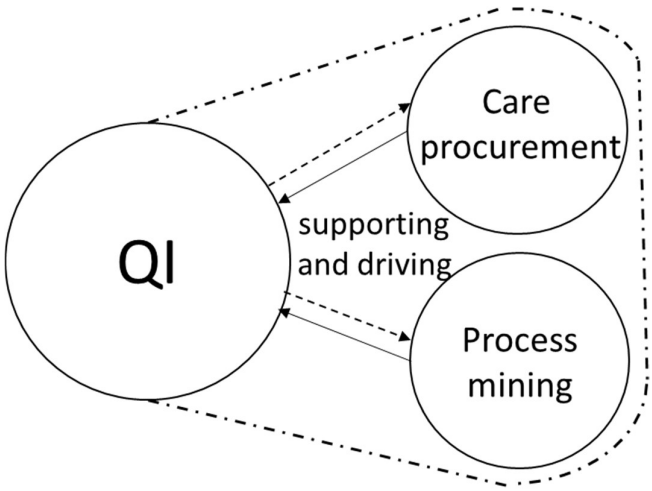

Figure 7. Conceptual framework of how support and drive for QI work may be achieved through the extension of QI application into care procurement and process mining.

To understand the effects of expanding the application of QI into the context of care procurement and through the support of process mining methodology, the results in this thesis will be analyzed and discussed through the seven knowledge domains presented in Batalden and Splaine (2002) and Batalden and Davidoff (2007). These knowledge domains are useful in driving actions in healthcare to achieve QI (Batalden and Splaine, 2002) and can therefore be seen as an overarching framework of QI. It can thereby be assumed that expansion of QI applications resulting in further drive and support for QI may affect the knowledge domains presented by Batalden and Davidoff (2007).

3. Research methodology

The research methodology has largely been inspired by the mindset of QI. It aims for continuous, iterative learning through collaboration, a use of rigorous research methods, and a pragmatic standpoint, together with a large amount of curiosity.

3.1 Research design

The purpose of a research design is to give an overall blueprint of how a study is to be conducted to answer the research question (Flick, 2014). Maxwell (2012) identified five key components for a qualitative research design: goal, conceptual framework, methods, validity, and research question. The goal, the conceptual framework, the methods, and the validity are developed not only in the planning phase but also during ongoing research, in interplay with the research question as it is refined based on new insights. This goes along with the iterative approach in both QI and this thesis.

3.1.1 Mixed methods

As research becomes increasingly interdisciplinary, there is a need to combine quantitative and qualitative methodologies to gain a systematic view. This combination is very much in line with how research in the field of QI is conducted. The following quote from a colloquium on improving healthcare highlights the need to capture both quantitatively measurable and underlying qualitative social knowledge in healthcare (Batalden et al., 2011, p. i103): "Even at its most scientific and technical moments, the provision of healthcare is always—always—a social act."

Flick (2014) claims the combination of qualitative and quantitative methods is the third methodological movement, the first being when quantitative methodology was introduced and the second introducing qualitative research methodology. He concludes that mixed-methods research is in line with a pragmatic view and that, by not putting a hierarchy between these two methodologies, he is able to end the 'paradigm wars' over which methodology is best.

Qualitative and quantitative approaches can be combined in different ways, according to Miles and Huberman (1984): continuous collection can use both types of data, connecting waves of quantitative research with continuous collection of qualitative data, or linearly, going either from qualitative research to quantitative or the other way around. Due to the differences in scope between the three papers, different methodological approaches have been taken (see more in Figure 8 as well as thesis sections 3.3 and 3.4).

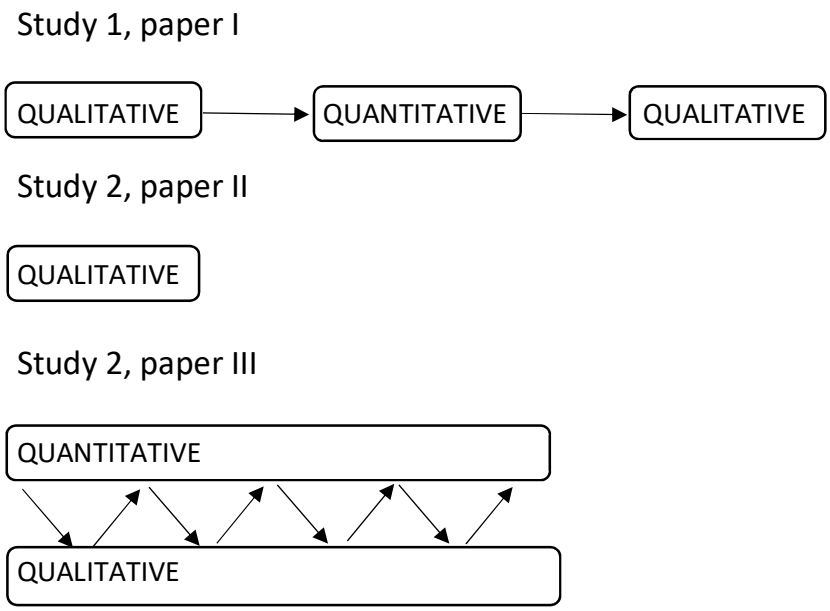

Figure 8. Methodological approaches used in each of the three papers. Mixed methods were used in study 1 and study 2, paper III.

An overview of the research methodology is shown in Table 3 and further elaborated upon in sections 3.3 and 3.4.

Table 3. Methodological design.

	Paper I	**Paper II**	**Paper III**
Research design	Mixed method comparative study	Narrative review	Mixed method case study
Data collection	Procurement documents, Semi-structured interviews	Literature review of process mining in healthcare papers	Patient event data, Semi-structured expert interviews, Expert collaboration
Data analysis	Document and interview analysis using constant comparison method, Correlation analysis	Comparative analysis between QI and process mining	Process mining, Descriptive statistics, Nonparametric tests

3.2 Empirical setting

Empirical studies require a setting in which data can be collected and analyzed. In these studies, Swedish settings have been chosen for several reasons (other than the researchers being situated in Sweden). Sweden is considered a forerunner in healthcare organization, with good medical outcomes, costs close to mean among both European and OECD countries (OECD, 2013), and well-developed documentation of welfare measures through for example quality registers. It is, therefore, an interesting country to learn from. Still, like many other countries, Sweden faces organizational problems with a lack of resources and an ageing population, together with the fact that patients' expectation of healthcare is increasing (OECD, 2013). Sweden still needs improvements to achieve timely and efficient care (Arvidsson, 2007) as well as better ways to use existing data

more comprehensibly, to gain a full picture of individual care patterns, and to communicate this data between care groups (OECD, 2013). OECD (2013) concluded that, although Sweden has an advanced quality management system in healthcare, this system needs further development, especially in social care sectors such as elderly care. Sweden is also particularly relevant to this study because of its abundant and relatively accessible data. Qualitative data collection was facilitated by a well-developed collaboration and trust between the university and healthcare organizations.

3.2.1 Study 1

Study 1 was set in elderly residential homes for three main reasons. First, the setting needed to allow for the collection of a rather large amount of comparable procurement documents, which are the basis for contracts upon which the care is later designed. Second, the systematic and robust measures of quality in Sweden (OECD, 2013) can be assumed to have resulted in some improvement (Marshall et al., 2013) useful for international learning. Third, the quality of publicly procured elderly care is important for several reasons: i) it is a hot topic in Swedish media as well as in other international media since bad examples have been highlighted, pushing the need for QI. ii) Since elderly care is increasingly handled by private caregivers, in contrast to municipality-driven care (Øvretveit, 2003a; Bergman and Jordahl, 2014), public procured care has become increasingly important to QI in care.

However, elderly care is part of social care, not healthcare, which is the domain of QI. However, QI has been used in social care settings in other research (Neubeck, 2016). There is also a close connection between healthcare and social care since healthcare services are sometimes a part of social care. This might be especially true for people living in elderly care homes, being often both old and sick, often with multiple conditions. Elderly care thereby combines medical care and care for the person, which puts additional requirements on the quality of care given to the elderly today. In Sweden, the National Board of Health and Welfare, responsible for national care guidelines, has also adopted the six aims for improvement stated in the Institute of Medicine´s report "Crossing the quality chasm", under the name of "God vård" (Good care), thereby clearly linking social care and QI.

In 2010, a five-year long, nation-wide QI initiative was launched by the Swedish Association of Local Authorities and Regions. This initiative's aim was the sickest elderly people receiving municipality-driven care (Awes et al., 2015), and it was driven by well-known problems of elderly care such as bad continuity, many different and/or ill-suited medications, and lack of improvement work. As it is mainly the sickest elderly living in residential care homes, this population became central in this initiative. It was concluded that new ways of working, strong leadership, engaged elderly, and the use of quality registries contributed to the success story (Awes et al., 2015), and it is of great interest to see if the municipalities reflect the QI initiatives in their procurement as well.

3.2.2 Study 2

For analyzing the use of process mining, the study analyzes breast cancer patients in Western Sweden for several reasons. Breast cancer treatment has well-developed clinical guidelines; evidence-based best practices exist to

guide the care, which was assumed to result in a reasonable amount of similar as-is care pathways to the extent that most frequent pathways could be identified. Breast cancer is the most common type of cancer among women and counts for 12% of all new cancer cases in the world and for 25% of all female cancer diagnoses (International, 2017). The quality of breast cancer care has been researched from many angles, for example by comparing specific parts of given care (Malin et al., 2002), timeliness (Li et al., 2013), cost and case-mix (Taplin et al., 1995), or results (Malin et al., 2002; Walters et al., 2013). Other studies evaluate specific hospitals (Ishizaki et al., 2002; Akhtar and Nadrah, 2005), highlight inequalities of care, or develop algorithms to identify patient pathways (Defossez et al., 2014). Still lacking is the connection between patient pathway variations and cost. Since breast cancer treatment is not only common but also very costly (Carlson, 2009), this patient group is especially interesting.

3.3 Data collection

Qualitative case research studies commonly collect primary data through interviews, focus groups, and observations, while for quantitative research a structured variant of interviews or questionnaires can be useful (Bryman and Bell, 2011). Secondary data, on the other hand, can consist of documents or archive data. Every method has pros and cons, and Flick (2014) emphasizes the need to choose a method appropriate for the research question. In this thesis, the research questions regard i) care procurement and ii) process mining, and in both cases, secondary data has been used as the main data source, sometimes in combination with primary data for validation and enrichment purposes. Further details and reasoning will be elaborated upon for each study below.

3.3.1 Study 1

The research question for study 1 is “How can QI be understood by expanding QI application into the context of care procurement?”. To answer this question, one must first understand the content of care procurement, and this can be done either through interviewing those working with care procurement or through reading the actual procurement documents. With the general aim of understanding QI, the researchers tried to be as objective as possible and thus chose to analyze procurement documents, i.e. secondary data. Procurement documents were collected from the database Visma opic, which is said to be the most comprehensive database for Swedish procurement documents (www.visma.com). It was a purposive sampling of all possible care procurement both by choosing Swedish procurements and by focusing on the relatively homogenous group of elderly residential care procurements. This is in line with the guidelines by Flick (2014), who emphasizes the need to keep non-interesting variables constant to allow for a good comparison. Using elderly care procurement allowed for a rather large sample of 71 procurements from 2013 to June 2015. This amount was large enough to reach saturation (Strauss, 1987) and therefore enable comparison across the sample population.

In addition to the procurement documents, information was collected regarding contract length as well as municipality size per citizen in 2014 (Statistics Sweden, 2015) and year of procurement. These three aspects were chosen since they were presumed to correlate with the QI criteria.

However, the study did not want to rely entirely on secondary data. Alongside document reading, eleven semi-structured expert interviews (Flick, 2014) were conducted with seven different municipalities. The interviews were performed in order to triangulate data during criteria identification (Patton 2002, Yin 2013). Interviewees were chosen from the municipalities present in the sample and were further purposively chosen according to geographical convenience (Flick, 2014) when a personal interview was possible. Some of the interviews were conducted using telephone, eliminating the need for purposive sampling due to geographic location. All the interviews followed the same guide, lasting 45-100 minutes, and were recorded and transcribed verbatim. One possible limitation of the interviews is that some of the procurements discussed were a few years old, and although each interview was aimed at a certain procurement, the experts might have been biased by more recent cases. Since this study's focus was on identifying the current state of elderly care procurement, this was not seen as an important limitation.

3.3.2 Study 2

Study 2 aims at answering the question "How can QI be understood by expanding QI application into process mining methodology?". Process mining is based on extracting knowledge from event data, which is typically stored in electronic information systems. In an empirical setting, secondary data from electronic health information systems was thus implied. Still, it is possible to answer the question either by studying earlier research about process mining and QI or by performing a process mining study of event data. In study 2, both techniques have been performed, leading to papers II and III. Paper II emphasizes theory building, and paper III emphasizes empirical data.

3.3.2.1 Paper II

Paper II is written as a narrative literature review. Frank et al. (2014) conclude that "narrative literature reviews are appropriate for describing the history or development of a problem and its solution" (p. 99). A systematic review, being the other choice, was not possible due to the many weak and complex connections between process mining and QI, making a structured literature search extremely difficult to pursue. Data was therefore collected through an extensive snowballing literature review, which ensured a comprehensive understanding of the field.

3.3.2.2 Paper III

For paper III, purposive sampling was used. Through the Centre for Healthcare Improvement, Chalmers has a well-developed collaboration with Regional Cancer Centre West (RCC West), one of six cancer centers founded in 2009, with the purpose of developing and implementing more patient-centered, equal, and efficient cancer care processes in Sweden (von Knorring and Zetterström, 2016). RCC is also responsible for the cancer quality registries in Sweden from which this paper's data was taken. Västra Götalandsregionen (Region Västra Götaland) contributed additional data around the real patient cost per care visit through their case-costing system (Eklind et al., 2015). In this way, a rich dataset was produced, making it possible to combine data about patient pathways and cost.

From an ethical point of view, access to patient data is highly restricted, and ethical approval was given on the grounds that the data be made anonymous prior to access. All national quality registries (in this case breast cancer) are quality validated by monitors at RCC using medical journals, and the case-costing data was validated using invoice inspections. Domain experts therefore rate the quality of this secondary data as high. Data was also collected through interviews with the expert preparing the event log, the regional process owner responsible for the breast cancer process in the region, as well as local process owners at each hospital to understand and validate the results.

3.4 Data analysis

3.4.1 Study 1

Each of the procurements was written somewhat differently from the others, both regarding design and wording, which complicated the analysis. It was necessary to carefully read all procurement documents and, with the expertise built up over time, interpret the content. A qualitative research method was therefore essential. If this had not been the case, a quantitative study using evidence such as word counts could have been considered, but that would not be appropriate due to heterogeneity of the language used in the care procurements.

There are many methods and models available for sorting qualitative data into categories. Grounded theory is one overarching method with an inductive approach which can have criteria development as an end result. Debate is ongoing regarding the interpretation of grounded theory, as can be illustrated by the paper 'What grounded theory is not' (Suddaby, 2006), where Suddaby questions the assumption that one should begin research without prior theoretical knowledge. The constant comparative method (Glaser and Strauss, 2009) is a kind of grounded theory in which data is constantly compared with each other and with identified criterion to re-evaluate them in an iterative manner (Flick, 2014). Because the present study accepts earlier theoretical knowledge, since without any prior knowledge about QI it is impossible to identify QI criteria, this research was inspired by the constant comparison method. However, the researchers had no prior knowledge regarding the content of care procurement, and it was further assumed that using an existing framework developed for QI in healthcare a priori would restrict the possibilities of identifying new, unexpected criteria, being specific for (elderly home) care procurement. Criteria were instead developed over the course of the analysis of the procurement documents and interviews by constantly comparing them to the literature and to the researchers´ prior knowledge of QI.

Procurement document content was initially categorized depending closely on the initial procurement document's wording, but later these criteria became more general, like already identified QI criteria (see Figure 5). This generality encourages comparison for increased understanding of QI. To strengthen the document analysis, interview data analysis was used to validate the results. Similar QI criteria as in the procurement document analysis were also identified in this data set, validating the results. Additionally, several interviewees highlighted the need for leadership in QI, which was not identified in the procurement analysis. Upon re-

analyzing the procurement documents, leadership for QI was indeed emphasized in a few procurements, and was therefore added as an eleventh QI criterion. Nvivo 10 was used for all data analysis in this study.

Since different procurements highlighted different parts of QI to different extents, the study continued by grading each criterion in each procurement on a four-level scale from weak to very clear connection to QI. Clear definitions of the evaluating grades were set and presented together with illustrative quotes exemplifying the lowest and highest grades. All procurements were then evaluated by one researcher in an iterative way along with the development of criteria and refinement of evaluation definitions. The co-authors subsequently evaluated five procurements to assess the definitions. Additionally, in case of uncertainty, discussions were held within the research group to improve the definitions and find unanimity. The research approach has thus been iterative not only when identifying criteria but also during the evaluation and definition of evaluation levels to ensure consensus and separation of potential sub-groups for each criterion.

After the graded levels were quantified, it was then possible to analyze correlations (Fenton and Neil, 2007), showing how the criteria are connected to potentially dependent variables (contract length, municipality size and contract year). Bryman and Bell (2011) state that the quantification of qualitative data can bring about increased possibilities to uncover the generality of phenomena, but there is then also a need for the researcher to communicate that the quantification is based on his/her own understanding of the social world. It should thus be noted that, despite efforts taken to ensure research rigor, the quantitative data results might be biased by the subjective interpretation of the researchers.

3.4.2 Study 2

3.4.2.1 Paper II

The literature collected for paper II has been read at least once and sometimes multiple times. To gain a deeper understanding of process mining in healthcare, all papers identified in the review by Rojas et al. (2016) as well as more recent papers found in an additional literature search were analyzed using a number of questions: what has been done, whether there is any QI connection, whether healthcare collaboration is included, and why each paper is or is not important for the study. After several dead ends of laying this jigsaw puzzle of complexity originating from both QI and process mining, the effort to achieve a structured literature review was abandoned, mainly due to the weak connection between QI and process mining in the reviewed papers. Although performed primarily to identify cases for the paper, this analysis proved very useful both to gain an overview of the field but also in discussions among the researchers to grasp the complexity of the topic. However, two process mining cases were identified as having a clear connection to QI, and these were used to exemplify synchronic and diachronic variation of healthcare processes, highlighting the potential both for longitudinal studies and for comparison between factors like hospitals' ensuring equity of care.

3.4.2.1 Paper III

All analysis of the data for paper III was based on the breast cancer patient data, following the exploratory data analysis method (de Mast and Trip, 2007) as well as the process mining model CPAM (Caron et al., 2014), with the adaptation of iterating back to earlier steps when necessary as presented by Lismont et al. (2016).

Exploratory data analysis was chosen because there was little prior knowledge about process mining together with having a rich data set, which opened the study up for several different analysis approaches. CPAM, which focuses on process mining of clinical pathways and ensures contextual understanding through collaboration, seemed to have a closer fit to the QI mindset and method approach than alternative process mining analysis models. Several different software programs were used, each of which had different strengths and weaknesses. Main analysis programs were Disco (www.fluxicon.com) for process mining, SAS JMP 13 for data pre-processing and statistical analysis, and MS Excel for changing file format.

At times of decision-making, a close collaboration with both the data expert and the process owner, who is also a breast cancer physician, was ensured. The data expert pre-processed the data into an event database, and the process owner identified relevant patient groups, based on surgery and treatment mixes. The analysis originated from surgery hospital and identified patient groups. Within each patient group, the most frequent, less frequent, and unique pathways were identified. Cost distribution was analyzed in JMP 13 for each group.

During the analysis, several other decisions were made concerning system boundaries. For example, the patient pathways were limited to 14 months, which made comparison between groups and within and between the hospitals possible. The data aggregation level was set to include only visits directly affecting decision making in the overall medical treatment process. This aggregation level resembles general process mapping at hospitals, allowing for comparison. Further details on the analysis decisions can be found in paper III.

As the event log mainly included structure, process, and fiscal data, such as hospital and patient information, time stamps, and cost, this data became the basis of analysis. Although it was possible to calculate one-year survival rates, survival was overall very high and therefore did not affect the results. Patient reported outcome measures (PROMs) would have been interesting to include, but were not measured for breast cancer until more recently and were therefore lacking in the event log.

After the analysis of all patient pathways, the results were discussed with the data expert and the regional and local process owners at each of the four hospitals included in the study. Their domain expertize were used to validated the results and for understanding of identified unexpected factors.

3.5 Research quality

Note that instead of handling the research quality as a separate section, it is included as part of the other research methodology sections, reflecting the link between method selection and research quality (Maxwell, 2012). Traditionally, research quality is measured by reliability and validity. Validity, though, assumes objectivity and measurability of the social reality (Bryman and Bell, 2011), and thereby does not take the complexity of context into full account. Guba and Lincoln (1989) instead emphasize the use of the term trustworthiness when conducting qualitative research.

Since qualitative and quantitative methods are included as a mix in both studies, it is not self-evident whether the research should seek to utilize validity and reliability or trustworthiness. Going to the core of the research,

it could be argued that even though there are quantitative pieces of the studies and regardless of efforts taken to be objective, the researchers' and even the domain experts' interpretations color the results in different ways. This means that another researcher (possibly in collaboration with other domain experts) might come up with somewhat different conclusions. Additionally, the empirical studies themselves are highly context-dependent. These reasons affect validity negatively, but are not limiting trustworthiness similarly. Therefore, trustworthiness is used in the present study instead of reliability and validity. Trustworthiness is comprised of four criteria: credibility, transferability, dependability, and confirmability. These will be explained and elaborated upon below.

Similarly to internal validity, credibility depends on whether the researcher's results and conclusions align with the construct of the respondent. This means that the researcher should have the same understanding as the respondent, which can be achieved by methods such as the confirmation of domain experts or triangulation (Bryman and Bell, 2011). In study 1, an investigator triangulated the data in order to address the study's credibility (Flick, 2014). Investigator triangulation was also used to reduce researcher bias during the identification of QI criteria and the evaluation of procurement documents, while interviews with municipalities were used to confirm and extend the criteria identified during secondary data analysis. Further credibility might have resulted from reading the tender documents as well, since some parts of the procurement documents themselves do not give much information about the QI level per se. One example is 'describe your quality management system'. If that is defined as having a well-written description of a well-developed quality management system with a thorough analysis by the municipality, it could have been considered good. However, without this information, it is difficult for an outside researcher to evaluate the requirement. This problem was handled by focusing on the clarity and reasoning around the requirement in the procurement documents, and good examples were identified where factors such as quality management system requirements were further elaborated upon. In study 2, close collaboration with domain experts throughout research helps to ensure the credibility of the results.

Like external validity, transferability concerns whether the results can be converted into generalizable claims, meaning if they can be transferred to another setting or context. Yin (2013) presents two kinds of generalization (similar to transferability): statistical generalization, where the results are generalized to a larger population, and analytic generalization, meaning that the focus is not on that specific population but rather highlighting a certain theoretical concept or principle. Both studies in this thesis regard analytic generalization, since the samples are either too small or represent a population too context-based and dynamic for statistical generalizability. Study 1 is about understanding how QI is manifested in care procurement and is therefore not assumed to be transferable outside of the public care procurement context and possibly not for countries outside of the EU. The QI criteria are likely transferable to other care procurement contexts since the criteria are general. The good and bad examples, however, might be less transferable. The transferability of QI in a procurement context outside care will be left to other researchers and domain experts to judge, as is ultimately any transferability. Study 2, especially paper II, could be highly transferable within the field of QI, regardless of

context. What is necessary for transferability of process mining is the existence of event data concerning the process of interest. Paper III focuses on a specific empirical setting, but it can be assumed that similar results regarding as-is care pathways and cost variations can be found at other hospitals. Further research on each specific setting is necessary, but these results can be used as a starting point. The dynamic nature of care settings should be noted and time might change the transferability of these results (Lincoln and Guba, 1985).

Dependability is sometimes called trackability, and is similar to reliability, because another researcher should be able to track the research process and the shifts within it. Dependability can be ensured by keeping complete records of the research process so that auditing can be performed. In study 1, dependability has been addressed by saving all documents, performing the analysis on Nvivo 10 together with field notes in MS Excel for things such as details of categorization, quotes, and comments on the documents. All interviews were transcribed verbatim. Due to the exploratory approach, not all twists and turns can be followed, but all meetings were documented to ensure trackability. Study 2, paper III, has been even more explorative since the analysis was much less set from the start. After publication, all data including patient information need to be deleted as part of the ethical approval agreement, but detailed step-by-step descriptions have been written so that future researchers may follow the final analysis.

Confirmability, like objectivity, concerns the question of whether the researcher has acted in good faith, remained objective as far as possible, and not attempted to bias the results. Confirmability is a potential problem in study 1 despite the researchers' attempts to act in good faith, since some level of subjectivity was involved in criteria identification and the grading of procurement. The research group discussed criteria definitions, graded, and reached a consensus to avoid bias and address confirmability. Study 2, on the other hand, is about encouraging objectivity. Leaving all decisions to domain experts reduced the risk of researcher bias.

3.5.1 Ethical consideration

Ethical approval has been given for the use of patient data in the empirical study in paper III. Ethical considerations have otherwise followed standard research ethics, such as voluntary participation in interviews, with the option to resign at any time.

3.6 A reflection on the research process

Reflection and learning are crucial to QI work. Lifvergren and Bergman (2012) added this final step in a learning circle to highlight the need for learning and reflection as part of an improvement cycle. Writing this thesis, I am closing my first 'research learning circles', going from primary insights about QI to getting to know the data and context to writing the papers and thesis.

The explorative approach used in papers I and III has been both rewarding and challenging. Using different angles to really understanding things takes time and effort, but without the explorative approach of paper III, the idea for paper II would probably not have been born. It has, however, resulted in lengthy studies, meaning the major parts of the papers have all been written quite late in the research process, as presented in Figure 9. This process has had both pros and cons, but hopefully the papers and the final thesis are richer and more useful as a result.

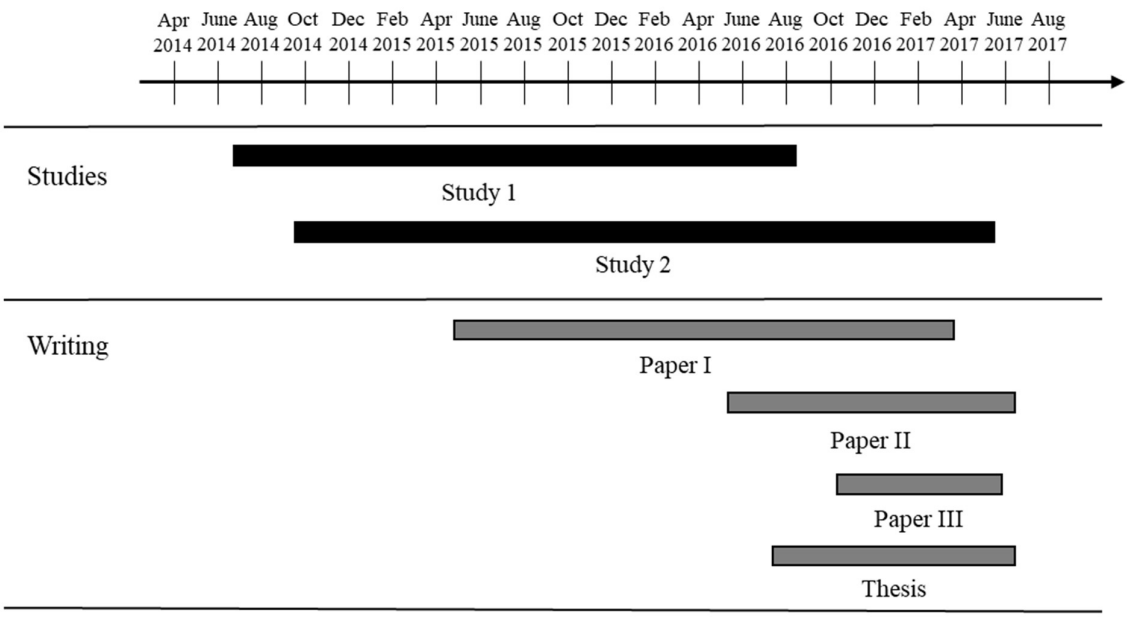

Figure 9. Research process timeline.

4. Summary of appended papers

This licentiate thesis includes three papers, and the following chapter gives a summary of the results and conclusions of each of the three papers.

4.1. Paper I: "Developing criteria for quality improvement in care procurement"

The purpose of this paper was to explore how QI is manifested in care procurement. The contribution of this paper is three-fold. First, eleven QI criteria were identified in the procurement: internal evaluation, external evaluation, tender evaluation model, incentives, use of quality registries, QI aim, cooperation, workforce training, evidence-based care, new thinking, and leadership. The eleven criteria were additionally summarized into a model that can be used as a starting point by buyers and providers aiming for QI of care procurement. Second, classification of the procurement criteria in five levels revealed large variations regarding how municipalities include QI both within and between different procurements, whereby good and bad examples were identified as illustrative for each QI criteria. It was thereby argued that public care procurement needs a stronger focus on the QI criteria often found in low levels, such as leadership and tender evaluation, without reducing focus on the more well-developed QI criteria, like external evaluation and use of quality registries. Third, the statistical analysis revealed a correlation between factors like contract length, new thinking, and total score; the longer the contract length was, the larger the likelihood for new thinking by the care provider as well as the overall inclusion of QI criteria, as represented by the 'total score', showing an aim for continuous QI during long contractual time.

An extended abstract of this paper was presented at the international conference SERVSIG in Maastricht, Netherlands, June 17-19 2016.

4.2 Paper II: "Process mining for quality improvement: propositions for practice and research"

The purpose of this paper is to understand how process mining can be used in and for QI. This paper compares the understanding of variation using process mapping and KPIs against the effects of complementing process mapping with process mining. Process mapping is exemplified as being an integral part of the healthcare redesign framework, which is used in several healthcare settings to reduce variation and improve public satisfaction.

Process mapping and process mining methodologies are explained, and differences in factors like goal, nature of data, role of staff, and the frameworks of both methodologies are presented together with their main advantages and limitations. For example, process mapping enables discussion and understanding between the collaborating domain experts during process identification, but this knowledge can also be achievedby validating the automatically mined processes, in which domain expert knowledge is also crucial. Two cases exemplifying how process mining can be used to identify synchronic and diachronic variation are presented, as is a step-by-step model for pursuing process mining. Four propositions to practice of how to include process mining in quality improvement work are presented: i) build commitment for and knowledge on process mining; ii) integrate and use process mining in new or already existing quality improvement initiatives; iii) find ways to improve data

quality; and iv) Learn and reflect from process mining interventions. Three propositions for needed research in quality improvement are also suggested: i) on how process mining can be integrated into quality improvement of patient pathways and healthcare processes; ii) on how HIS in general, and process mining in particular, can be used for developing measurement systems that can be used for quality improvement purposes; and iii) on how process mining and clinical knowledge can be combined with patient experience in order to facilitate quality improvement of patient pathways (and for reality-check purposes) in a resource-efficient way. The aim of the propositions is to support healthcare so that it can adopt process mining in a systematic way and to encourage further research to develop the potential for using process mining in QI.

It is argued in the paper that process mining should be incorporated into QI as a complement to process mapping following healthcare digitalization to support the work of researchers and practitioners by driving QI through visualization and understanding of processes. Additionally, this paper may support data scientists from the process mining research field in identifying more effective ways to implement process mining and thereby improve care quality.

4.3 Paper III: "Relationship between patient cost and patient pathways: the case of breast cancer care in hospitals in Sweden"

This paper explores the use of process mining in understanding the relationship between patient pathway and patient cost variations with the two-fold purpose of: i) identifying and comparing pathways within different patient groups; and ii) analyzing the cost variations based on the individual patient groups and their pathways. To ensure results relevant for healthcare, the analysis was performed in collaboration with domain experts.

Standardization of to-be care pathways is, in earlier studies, argued to lower costs, although without taking the high variation of as-is care pathways into account. Identification of as-is care pathway types (most frequent, less frequent and unique pathways) through process mining, based on four patient groups retrieving different medical treatment and their relation to patient cost revealed several insights. Unique pathways were overall most expensive when significant difference between pathway types could be identified. Earlier studies were confirmed for mastectomy patients since most frequent pathways had lower cost, whereas contracting and inconclusive results emerged for partial mastectomy patient groups. This result implies that factors other than the standardization of to-be pathways affect the cost pattern, such as treatment outcome priorities. Moreover, other rationales for standardization may be prevalent; the hospital with the strongest focus on their to-be care pathway had the largest percentage of patients following the most frequent pathway as well as few patients following unique pathways. Although this hospital was not overall the cheapest, it had a much shorter median lead time between diagnosis and surgery, potentially due to the organization of a one-stop-shop clinic.

This paper is a development of a poster presented at International Forum on Quality and Safety in Healthcare, in Gothenburg, April 2016.

5. Analysis and discussion

QI is philosophically guided by the system of profound knowledge together with professional domain knowledge (Batalden and Stoltz, 1995). To substantiate this, QI in care has long been understood and developed through inspiration from other research fields, such as quality management (Kohn et al., 2000), service management (Batalden et al., 2015), and human factors (Hignett et al., 2015). The findings in this thesis shows that QI can be further developed in this way through expanding the application of QI into the context of public care procurement and through the support of process mining methodology.

5.1 Seven domains of interest

Batalden and Davidoff (2007) presented seven knowledge domains of interest in which healthcare could drive improvement, elaborated upon in more detail in Batalden and Splaine (2002). As these overarching knowledge domains are considered important for supporting and driving QI efforts, they could be useful for analyzing and discussing the purpose of this thesis: to understand QI by expanding QI application into a new context and through the support of a new methodology. The findings in this thesis and the seven knowledge domains are discussed below.

5.1.1 Healthcare as processes or systems

Batalden and Splaine (2002) see healthcare processes or systems being the stakeholders, procedures, technologies, and activities of caregiving that interact independently in order to meet the needs of individuals or communities.

Expanding QI application to include the context of care procurement and the methodology of process mining seems to enable a broader and deeper perspective on the processes and systems within care. Public care procurement can broaden the system boundaries of QI by being added to the external QI context and thereby bringing new perspectives through which the care system may be understood. Paper I highlights the added complexity of care that is given through this new public care procurement perspective, in which stakeholders and procedures interact as presented by Batalden and Splaine (2002); however, procurement must meet the sometimes contradicting aims of individual patients and the procurement legislation of the community. One may also conclude that, although it is necessary to set the requirements for QI before the start of the care itself, these requirements as systems need to be aligned with the different and potentially changing needs of the caretakers. To achieve this end, there may be a need for further collaboration between patient, caregiver, and procurer. Paper I also identifies QI criteria that may be helpful to support and drive QI. Some of these criteria, such as leadership, have been shown to be important in organizational, QI team, and individual contexts (Kaplan et al., 2012). Thus, public care procurement fits into the QI care system, but based on the results of paper I, there is also a need to increase the system perspective in care procurement, so that all parts of QI are included in the procurement document. If not, the consequence may be that the subsequent contract discourages potential improvement – why seek or put forth the effort of improving the system if the improvement is not demanded in the contract? The identified QI criterion 'tender evaluation' in paper I highlights the potential for the care procurer to select a care provider with focus on QI, thereby laying the foundation for future QI efforts.

While public care procurement may help to broaden system-wide thinking in QI, paper II showed that process mining has the potential to also deepen the understanding of systems and processes. This understanding comes from visualizing processes ranging from individual patient to inter-organizational pathways. Using attributes connected to identified pathways, such as hospital or physician name, as in paper III, may help future researchers and practitioners see the interaction between stakeholders and activities in new perspectives. Additionally, paper III showed that analyzing important KPIs based on identified pathway types within a process may bring a more nuanced picture of a process or system compared to methods like connecting KPIs to the to-be care pathway. In total, these results show that process mining may be a useful methodology to better understand the interdependent interactions between stakeholders, procedures, activities, and technologies through process evaluation based on event logs.

5.1.2 Variation and measurement

In their 2002 paper, Batalden and Splaine argue for the use of measurement to understand variation in processes and systems in order to design or redesign care.

Indirect methods are often used to measure variation in processes and systems; for example, the KPIs reflecting the process can be measured synchronically or diachronically (Bergman et al., 2015) to identify whether the variation has random or assignable causes (Shewhart, 1931) or is wanted or unwanted (Kahol et al., 2011). As Batalden and Davidoff (2007) point out, run charts or control charts could be useful tools for measuring this variation. These methods can also be used for healthcare processes in combination with process mapping (Sedlack, 2010; Riley et al., 2009). Although such methodologies are highly useful in many settings, papers II and III show that process mining contributes to QI by revealing the variation of pathways within the process itself. The advantage that QI may gain through a process mining methodology is the possibility of a more objective and dynamic view of care that can be gained by understanding the variations within a process, ranging from individual pathways to general process overviews (papers II and III), and regardless of the variation perspective used (synchronic/diachronic, wanted/unwanted). This advantage includes the possibility to perform different KPI analyses for different identified pathway types (paper III) leading to a more nuanced picture of these measures. Future consequences of understanding variation through process mining in QI could be more process-specific allocation of resources (as presented in paper III) or, if used in real-time (paper II), gaining this understanding in a timelier manner. Therefore, paper II argues that process mining is useful as a complement to process mapping to visualize and better understand variations in QI.

One should not forget that variation in care can also be measured qualitatively. The document analysis in combination with the interviews in paper I revealed variations in how QI was manifested in public care procurement, identifying some QI criteria that were more developed than others. This variation within how far QI criteria were developed could be identified both within and between procurement. These results could bring further focus on understanding the effects of variations within QI criteria and how they may help to drive QI in

public care procurement by ensuring both that all relevant criteria are represented in care procurement and that they are well-developed.

5.1.3 Customer/beneficiary knowledge

Customer/beneficiary knowledge includes the identification of the person, group, or people for which care is provided followed by an assessment of their needs and preferences and how these needs and preferences relate to the care (Batalden and Splaine, 2002).

The focus on knowledge about the customer and beneficiary (including relatives) became very apparent when analyzing the procurement documents for paper I, where patient focus in general permeated the identified QI criteria. Several procurement documents included the requirement of working in a salutogenic way. Salutogenic means focus is shifted from the sickness, or pathogenesis, to also include health and wellbeing (Pelikan, 2017). This mindset is steadily becoming more prevalent in healthcare, such as through increased focus on patient value and rehabilitation. Individual care plans have been used in healthcare for at least two decades (Rudd et al., 1997), but Pelikan (2017) argues that salutogenic methods still needs to be included in healthcare philosophy and management. Expanding QI application to include the context of public care procurement, and thereby include good examples of a salutogenic way of working, may allow other parts of the care system to focus even further on patients' health and wellbeing. Such an outcome is becoming increasingly more important when more and more diseases become chronic, and therefore care should address patients´ everyday lives, just like the requirements of residential care home procurement should reflect the needs of the everyday lives of the elderly.

Paper II argues that process mining contributes to customer and beneficiary knowledge by identifying individual pathways and thereby giving an overview of the patient process. This may in turn lead to more patient-centered care by reflecting patient perspectives and needs, like insights about how care is or could be improved for certain patient groups by identifying positive deviations (Kahol et al., 2011) or as visual support during discussions between patients, relatives, and caregivers (Mans et al., 2008).

5.1.4 Leading, following, and making changes in healthcare

Batalden and Splaine (2002) add three perspectives to this domain of knowledge. First, they emphasize the need for methods and skills to enable leaders to make changes in complex settings. Second, they emphasize the strategic management of persons and their work in care on a general level, including understanding financing, information technology, and roles. Third, they focus on culture by aiming to develop an intra-organizational climate that supports working, learning, and caring.

This thesis's contribution to methods and skills that can change complex settings comes primarily from process mining. Instead of a focus on the bits and pieces making up the system, a system-wide view is needed to make changes in complex settings (Plsek and Wilson, 2001). Provost (2011) argues that graphical methods are preferable to understand care for QI purposes, and visualization of process mining has proven to be helpful in increasing motivation (Mans et al., 2008), which is needed for improvement. Process mining visualization gives

processes transparency, which, it has been suggested, reduces the culture of blame (Quaglini, 2008) that can be connected to the development of working, learning, and caring.

Regarding the need to understand the strategic management in the care organization, Batalden and Splaine (2002) claim that a skilled chief executive officer would see the benefits of aligning strategies organizing operation, improvement, professional development, and financing. Strategic management may to some extent be understood through KPI measures. As shown in paper III, analyzing KPIs that are based on identified as-is pathways may reveal a more nuanced picture of how the KPIs are related to the given care. Thus, following Batalden and Splaine (2002), if the chief executive officer uses process mining to understand patient pathways and potentially also their related KPIs, (s)he may realize connections between factors like operations and financing that would otherwise have been unknown. With proper interpretation, this in turn could lead to improved alignment of strategies, to accomplish things like using resources in a more efficient way or identifying the need for the professional development of a certain group of personnel. The correlations between QI criteria and contract length, municipality size, and procurement year in paper I may have revealed another way of understanding strategic management, in this case in a public care procurement context. One example is that municipalities working with longer contractual times also seem to focus more on quality improvement, new thinking, and use of incentives.

Batalden and Splaine (2002) argue that leaders need to understand how to strategically manage people and their care work in the organization, and this understanding may also be used to drive new strategies. Public care procurement might be a way to affect the strategic management aims of an organization, like an elderly care home, if the caregiver is required to ensure QI focus. However, to ensure that the buyer´s strategic aims are understood, it may be necessary to include further definitions of expressions and concepts in care procurement. In paper I, it was sometimes necessary to interpret what was meant with certain expressions and concepts, since they were seldom defined or thoroughly explained. Not only did this make the procurements difficult to analyze in the study, but could also cause one to question the motivations behind the procurements. While some procurement documents included elaborations on the QI implementation, such as using results for continuous improvement and learning among all staff in every stage of the organization, others included exact wordings as legally required by the National Board of Health and Welfare without further elaboration. Zbaracki (1998) discusses two reasons for implementing quality initiatives: technical, or honest, reasons aim to make a real change in the operations, while rhetorical is made up of words only and might be used primarily to establish legitimacy. When using the exact wording as in the legal requirements, one may therefore be unsure if the municipality included QI in an honest way or merely to gain legitimacy. Also, if they only briefly stated that there should be a focus on quality improvement, it is difficult for the care provider to understand what the buyer means by this expression. In both cases, it may mean the procurer's QI ambitions are not put into practice by the care provider.

5.1.5 Collaboration

With the collaboration domain, Batalden and Splaine (2002) emphasize the need for knowledge, methods, and skills to understand and value both the responsibilities and perspectives of others as well as to spread that capacity to others.

The need to understand others' responsibilities and perspectives is discussed by Glouberman and Mintzberg (2001), who identify four worlds of care, the 4Cs (care, cure, control, and community). Process mining has already been suggested to facilitate collaboration between several stakeholders (Mans et al., 2008), noted in paper II, and in line with this reasoning, visualization of patient processes using process mining could potentially be used as a platform for physicians (representing the world of cure), nurses (representing the world of care), and managers (representing the world of control), among others, to discuss their perspectives on the process and thereby better understand each other's perspectives.

Despite having different focuses, papers I and III both identified variations between organizations. The results of paper I revealed a variation in how QI was manifested by the buyer organizations, and paper III identified a variation in as-is pathways and their related cost. These variations might be useful as a basis for learning and collaboration between organizations to spread the QI capacity to others, but also for reflecting within an organization, potentially leading to better understanding of roles and responsibilities.

5.1.6 Social context and accountability

In social context and accountability, Batalden and Splaine (2002) included the understanding of social context at local, regional, national, and global levels and the explicit expectations being raised from them. These researchers further emphasize the need to understand the impact on financial and cost changes in care.

Paper I suggested that a focus on QI differs between procurements, based on variation between development levels of QI criteria. In paper III, it was shown that process mining might be used to gain a more nuanced picture of the organizational context and care costs by connecting cost to the as-is care pathways. Drawing on the need to understand social context, these findings may represent different reflections on the context and expectations within the care buyer or healthcare organization such as attitudes towards QI, standardization, and professional autonomy.

5.1.7 Develop new and locally useful knowledge

This last domain of knowledge focuses on recognition of the need for and skills to develop new knowledge of professional healthcare practice through empiric testing (Batalden and Splaine, 2002).

As discussed by Done et al. (2011), implementation of new methodologies has the purpose of fulfilling both short-term objectives of quick performance improvement and long-term objectives of adopting and spreading the new methodology across the organization. Paper II contributes by suggesting the inclusion of process mining as a QI methodology, and since process mining visualizes as-is care pathways based on actual patient event logs, this methodology is an example of new knowledge building through empirical testing. Further, paper II argues for building commitment to and knowledge about process mining within the organization, which is in line with

Done's long-term objective of adopting and spreading a new methodology across the organization. This, however, might require some effort; one insight from working with domain experts in paper III was that process mining, including visualization of as-is pathways, is a change in mindset for the domain experts, who are accustomed to process analysis methods such as process mapping.

5.1.8 Digitalization as an additional domain of interest

The seven domains of knowledge presented by Batalden and Davidoff (2007) were recognized by the Institute of Healthcare Improvement in 1998 (Batalden and Splaine, 2002). The domains are thus almost 20 years old, and since then, there has been an increased focus on digitalization within care (Agarwal et al., 2010), opening up great potential for improvement (Solomon, 2007). The use of electronically stored documents, as discussed in paper I, or quality registries and case-costing systems, as in paper III, with the potential of automated analyses of event logs, as for process mining presented in both paper II and III, are but a few examples of digitalization in and around care, where options like ICT solutions are spreading at an accelerated rate (Juciute, 2009). Although opening up great potential benefits in care, papers I and III also reveal that digitalization can be accompanied by data quality issues, a problem especially profound when data is manually documented (van der Aalst et al., 2012). The effects of bad data quality might not have been so clear before data was used to the extent it is today, in complex and sometimes automated analyses. To highlight both potentials and problems arising for QI with the rise of digitalization in care, it could be beneficial to add digitalization as an additional QI knowledge domain.

Since data quality problems were identified in papers I and III, this is here elaborated upon in more detail. It is, as noted by van der Aalst et al. (2012), important that data is documented in a comprehensive and correct way. Suriadi et al. (2017) discuss event log data imperfections as being problematic in process mining. Among others, one of their examples of data quality issues in event logs is a labelling problem called homonymous labels, which was identified in paper III. Homonymous labels occur when the same label is used for activities that could otherwise have been interpreted differently. In paper III, due to a lack of information about procedures performed during a doctor visit, the homonymous label 'doctor visit' had to be used, although this activity label used in process mining probably included different procedures during the visits. If details of procedures had existed, they might have been used as activity labels instead, whereby more variation may have been revealed, leading to further understanding of the processes.

Through working with secondary data in paper I, the importance of consensus in the use of words and expressions also became evident. The apparent lack of a unified language within public care procurement meant researchers needed to identify the different parlance used in procurement documents, making the analysis time-consuming. Although thorough reading increased the understanding so that the QI criteria could be identified, a similar problem in the process mining's automated analysis would have been even more problematic. If identified, it would have required time-consuming pre-processing of data. In conclusion, a clear parlance and

use of definitions are important both to reduce confusion by other readers or users and to improve the data's usability for automated QI analyses.

5.2 QI definition

Although the main contribution of this thesis has been on expanding QI application into a new context and through the support of a new methodology, it could also have implications on the definition of QI. So far this thesis has used the definition of QI as stated by Batalden and Davidoff (2007). Although one can argue that this definition reflects much of what QI is and stands for, it lacks certain aspects relevant for QI of care today. The definition of QI by Lynn et al. (2007) highlights that QI efforts should be systematic and data-guided. It could be argued that explicitly emphasizing systematic and data-guided efforts, especially with the increasing digitalization in care, would strengthen the case for Batalden and Davidoff's definition. Moreover, the definition aims towards healthcare, thereby excluding other contexts. Through paper I, it could be argued that the definition also works for social care, at least in an elderly care setting, which actually includes healthcare due to the degree of sickness among the elderly. Additionally, the definition has been used for higher education, mainly within healthcare education, although then excluding the notion of healthcare. Like healthcare, social care and education are collaborative, complex systems with a high degree of professionalism, so it is not strange that they also face similar QI challenges and could benefit from the same QI definition. A development of the Batalden and Davidoff (2007) QI definition is suggested: '...the combined and unceasing efforts of everyone – care professionals, patients and their families, researchers, payers, planners and educators – to make systematic, data-guided changes that will lead to better patient outcomes (health), better system performance (care) and better professional development (learning)…'.

6. Conclusions and future research

After summarizing the theoretical contributions and managerial implications given by the papers and the thesis discussion, this section will continue with suggestions on future research.

6.1 Theoretical contributions

By understanding how QI is manifested in public care procurement, paper I sheds light on the external context, which has to some extent been lacking. Paper I identifies eleven QI criteria that may support and drive QI in care, as well as a model summarizing these criteria into three overlapping domains: evidence-based practice, improvements, and evaluation. Further, paper I classifies the levels of development of the procurements regarding QI based on identified criteria, revealing variation of QI focus both within and between procurement, and furthermore identifies correlations between the development of QI criteria and procurement-specific information: municipality size, contract length, and year of procurement.

Paper II suggests that process mining methodology can be connected to existing concepts and methodologies such as lean or value-based healthcare, gaining an enriched understanding of patient processes using event data already existing in health information systems. Process mining may thereby expand the possibility to achieve a process- and patient-centered care by facilitating the integration of care processes across settings.

Theoretical contributions from paper III include empirical data analysis showing that a changed focus could be necessary to understand QI in care. This understanding requires moving away from identifying and evaluating QI efforts using only to-be care pathways and KPIs, and instead gaining further understanding of as-is care pathway variations through complementing analysis with process mining. Paper III also contributed with an empirical example showing that analyzing process-related KPIs based on the identified pathway types may reveal further insights about the KPI variations, which may also be useful to drive and support QI efforts in a more nuanced manner, such as not relying on implementation of to-be care pathways alone to reduce cost.

Building on an existing QI framework, the seven domains of interest for building knowledge for QI (Batalden and Davidoff, 2007), this thesis suggests that expanding QI application into the context of public care procurement and the methodology of process mining could contribute to all seven of these domains. Through this contribution, QI in care may be more thoroughly understood, which in turn may support and drive QI towards further improvements. The most explicit contribution is presumed to arise from the potential for both deeper and broader insights regarding systems and processes in care as well as for an increased and sometimes more nuanced understanding of variations of care. These contributions in turn may lead to leadership support and drive of QI and a more efficient use of resources through patient- and process-centeredness, enhanced collaboration, and increased motivation.

Additionally, digitalization is suggested as an additional knowledge domain to highlight its newfound prevalence in care, its potential to use data from sources like HIS, and its challenges, such as poor data quality. These insights led to a suggestion for an updated version of the QI definition by Batalden and Davidoff (2007).

6.2 Managerial implications

This thesis has shown that expanding QI applications into the context of care procurement and the methodology of process mining has the potential to support and drive improvements in care. Paper I has identified eleven QI criteria, including good examples and a summarizing model, which may be used as a starting point for managers aiming to improve public care procurement. Variations within and between procurements highlight the need to focus more on both the under-developed criteria, without dropping the well-developed criteria, and on the learning potential that exists between buyers of care. Additionally, it was concluded that there is a need for more focus on leadership and evidence of QI skills. Further consideration of the patients' and employees' perspective might also drive improvement.

Papers II and III suggest using process mining as a complement to process mapping for further understanding of patient pathway variation, which may help drive and support QI efforts. Paper II presents a model for process mining and proposes four practices for those beginning to use process mining for QI in care. There is a need first for knowledge building concerning process mining within care, followed by the incorporation of process mining into new or existing QI efforts. There is also an overall need to improve data quality (which needs to be addressed in qualitative data as well). Lastly, as emphasized in QI interventions, it is important to reflect and learn from efforts made. These propositions were moreover identified as important during the empirical study in paper III. Paper II additionally suggests that QI practitioners may help process mining practitioners focus further on the improvement aim of process mining.

The expansion of QI applications may, however, require changed mindsets within the care system; not only is there a need for new knowledge building but also for increased collaboration over system boundaries and an larger focus on understanding variation.

6.3 Future research

This thesis may be used as a starting point for further research regarding how expanding QI application into public care procurement and process mining can support and drive QI efforts. Some future directions for research are presented below.

- Kaplan et al. (2010, p. 500) conclude that '[f]uture research should focus on identifying and developing measures of context tied to a conceptual model that examines context across all levels of the health care system and explores the relationships among various aspects of context.' The model presented in this thesis (Figure 5, with the identified QI criteria inserted) could be a starting point for developing such a conceptual model.
- Despite the good intentions of collaborating with healthcare, community, patients, and relatives in care procurement, more can be done. Future research should consider developing partnerships of procurement between municipalities and care providers, which is possible within regulations but seldom acted upon.

- Although good examples were identified in procurement documents, very few procurements included definitions of what they mean by terms like quality or new thinking. Similar problems exist in process mining – if definitions are not well defined, different interpretations might lead to wrong conclusions and documentation and, in the end, failed QI efforts. This can be further researched, from the viewpoint of both care procurement and quality of data documentation in health information systems.
- The correlations identified in study 1 are either moderate or weak, showing the need for further research with a larger sample size.
- There are several ongoing process mining research initiatives, such as real-time process mining and process mining based on indoor location systems, which can be connected to lean thinking. Improvement knowledge, however, seems to be weak or lacking in these projects, and future research can aim at strengthening this connection.
- Since April 2016, Sweden has introduced standardized diagnostic processes for several cancer diseases. It is assumed that lead times thereby are shortened and cancer care processes are streamlined. It would be interesting to evaluate this initiative by following up paper III with a similar analysis covering the years after 2016.
- Although process mining is conclusively useful in QI, there is today no connection between the variation of the mined processes and identification of assignable causes of variation in relevant process-related KPI, answering the question of when process variation leads to significant deviance of relevant KPIs. Statistical process control is already used for identification of assignable causes of KPI variation within healthcare (Thor et al., 2007) and future research should address the potential to combine this with process variations identified through process mining.

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