THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Method Usefulness for Quality Improvement in Care

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ABSTRACT

Complexity in care arises from several concurrent sources, such as siloed care organisations and complex care processes handled by several medical specialities. Due to factors including the ongoing development of personalised care and increasingly older populations suffering from multi-sickness, care complexity can only be expected to increase. Simultaneously, organisational efficiency needs to be increased alongside this growing complexity. To address these challenges, there is a need to understand care complexity in order to drive care improvement.

Quality improvement (QI) aims to develop health and social care. Methods are central for QI by describing the care and thereby support i) planning for future care, ii) acquisition of knowledge and understanding of the current practice, and iii) prediction of the future of care from historical data. Methods for QI generally display data in a simple, graphic way, so that they are easy for practitioners to understand; however, this strong focus on simplicity may limit the understanding of care complexity and thereby reduce the support provided for QI. As QI research with a focus on methods describing care complexity is scarce, the purpose of this thesis is to *explore the usefulness of methods describing care complexity for QI in care.*

To fulfil this purpose, two research questions guided the analysis of the five appended papers. The first research question (*What usefulness can visual methods describing care process complexity have for QI?*) addresses the need to identify new methods describing care complexity where current methods are lacking. Two methods are chosen, guided by visual analytics theory: Lexis diagram and process mining. Two case studies and a literature review explore the usefulness of Lexis diagrams and process mining through visualisation of process variations at a patient and a population level, across groups and over time. The second research question (*What usefulness can methods describing care organisation complexity have for QI in public procurement?*) expands and explores the use of current methods describing complexity into the public care procurement context. First, the current state of QI in public care procurement is explored through an archival study, and next, a case study is conducted to explore the use of business excellence models to support QI in public care procurement. The thesis is guided by a pragmatic approach, leading to a mixed-methods approach and domain expert collaboration.

This thesis makes three main contributions. First, each method's properties are connected to a set of evaluative and organisational benefits, revealing the possibility of and need for matching methods to the local contextual conditions and needs for QI. Subsequently, a framework for this task is presented. Second, the results on the explored methods describing care complexity yield additional understanding of variations and care systems across stakeholders compared to traditional methods

used for QI in each context. Methods describing care complexity may, therefore, be useful to support QI efforts. Third, when methods describe care complexity, stakeholders might be supported in driving local QI efforts, and as the new perspectives seem to challenge their mental models, they also seem to develop their understanding of QI.

The findings and conclusions of this thesis primarily contribute to the QI research field but can also inform other research on Lexis diagrams, process mining, and public care procurement.

Keywords: Quality improvement, methods, usefulness, care complexity, health care, social care

LIST OF APPENDED PAPERS

This thesis is based on the work contained in the following papers:

Paper I Dahlin, S. (2019). Exploring the usefulness of Lexis diagrams for quality improvement. *Submitted for a second round of review in an international, peer-reviewed journal*

Contributions: Single-authored paper.

Paper II Dahlin, S., Eriksson, H., and Raharjo, H. (2019). Process mining for quality improvement: propositions for practice and research. *Quality Management in Health Care*, Vol. 28, No. 1, pp. 8–14.

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

Paper III Dahlin, S. and Raharjo, H. (2019). Relationship between patient costs and patient pathways. *International Journal of Health Care Quality Assurance*, Vol. 32, No. 1, pp. 246–261.

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 analysed the data and drafted the paper. Raharjo further contributed with guidance and support for the analysis and improvement of the paper.

Paper IV Dahlin, S., Camén, C., and Eriksson, H. (2019). Exploring criteria for quality improvement in care procurement. *Submitted to an international, peer-reviewed journal.*

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 archival data, and conducted most of the analysis. Eriksson and Camén collected and analysed the interview data. Dahlin, Camén, and Eriksson contributed equally to the study design and writing of the paper.

Paper V Dahlin, S. and Camén, C. (2019). The use of business excellence models to foster quality improvement in public contractual relationships. *Submitted to an international, peer-reviewed journal.*

An extended abstract of this paper was presented at the Servsig conference in Paris, France, June 14–16 2018.

Contributions: Dahlin was the lead author and managed the data analysis. Dahlin and Camén contributed equally and jointly in the design of the study, data collection, and writing of the paper.

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My name is on this thesis, but it is the result of several people´s engagement and work. First of all, I want to thank my "dream team" of supervisors. Henrik Eriksson, my main supervisor, for all your 'strålande' input, support and openness towards my confused ideas, and for bringing structure to them. Hendry Raharjo, for sharing your quant knowledge and guiding my thoughts - always with key references. Carolina Camén, for all your engagement through hours of discussion and challenging questions, building both research competence and great friendship along the way. Henrik, Carolina and Hendry, I have also enjoyed writing with you and I have learned a lot from it! I here also want to thank Ida Gremyr, for being such as compassionate and engaged examiner and friend, far beyond your duties. Thank you all for believing in me from the start and helping me to the finishing line!

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Sara Dahlin

Gothenburg, November 2019

In loving memory of my mother Karin,

and my mother-in-law Christina.

Your love, support and inspiration continue to guide me.

TABLE OF CONTENT

ABBREVIATIONS:

BE	Business excellence
CHI	Centre for Healthcare Improvement
PDSA	Plan-Do-Study-Act
QI	Quality improvement
RCC	Regional Cancer Centre
SIQ	Swedish Institute for Quality

1. INTRODUCTION

The introduction starts with the identification of the challenges facing care, followed by an introduction to quality improvement (QI) and its methods. The following sections bring the reader towards a purpose, the presentation of that purpose, and the development of the research questions.

1.1 Care challenges

Healthcare is known for its complexity (Glouberman and Mintzberg, 2001), which arises from several sources. Not only are care organisations siloed and difficult to embrace (Glouberman and Mintzberg, 2001), patients today also have increasingly complex needs resulting from comorbidities (Humowiecki et al., 2018). Apart from being complex, care processes are ad hoc, dynamic, and multi-disciplinary (Rebuge and Ferreira, 2012), often spanning across several medical specialities (Plsek and Greenhalgh, 2001). Moreover, chronic diseases and multi-comorbidity have become more common (Christensen et al., 2009), and the combination of people being both older and sick, blurs the border between health and social care (Shier et al., 2013). This increases the complexity of care and creates new requirements for the care system. Moreover, care organisations require more efficient management because of a lack of resources, as the ratio of the number of people of a working age to that of older people has decreased (Christensen et al., 2009).

Paradoxically, upcoming challenges that need to be addressed arise partly from the positive movement of frontiers in health and medicine. Medical research is heading towards 'precision medicine' (Dolsten and Søgaard, 2012), with initiatives such as 'Cancer Moonshot', which aim to personalise treatment down to a genetic level to achieve successful treatment outcomes (Singer et al., 2016). Through increased personalisation with an abundance of care and treatment alternatives, care complexity can be expected to increase.

1.2 Quality improvement

QI aims to improve healthcare (Bergman et al., 2015) and social care (Neubeck, 2016). QI emerged as a research field around the millennial shift, as it was declared that preventable harm caused an estimated 98,000 deaths per year in the U.S. alone (IoM, 2001). QI is strongly influenced by quality management and based on a philosophy guided by the system of profound knowledge (Deming, 1994) and its four pillars: understanding variation, knowledge about the systems, psychology, and theory of knowledge (Bergman et al., 2015). QI 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)…' (Batalden and Davidoff, 2007, p.2). However, despite good efforts, it should be noted that 'Although all improvement involves change, not all changes are improvement' (Batalden and Davidoff,

2007, p. 2). Shojania and Grimshaw (2005) argued for the improvement of understanding of the problem (i.e., local knowledge acquisition), as a primary step in any QI effort; likewise, acquiring knowledge regarding the effects of an intervention is an important part of QI efforts, emphasizing the need for follow up in this regard (Kilo, 1998). This requires methods that describe the problem at hand and its changes over time. Since the start of QI, significant improvement has been achieved through the evaluation and development of care via the QI approach (see, e.g., Lifvergren, 2013; Pronovost et al., 2006). However, there is considerable waste in healthcare, which stems partly from variation in care processes based on the overuse of non-working procedures, underuse of procedures that might work, and misuse, i.e., making errors (Berwick, 2003). This waste is reflected in outcome measures (Berwick, 2003) and was estimated to cost 700 billion dollars per year in the U.S. a decade ago (Kelley, 2009). Despite all efforts, QI projects are rarely, if ever, total success stories (Berwick, 2012), and sub-optimal processes and systems continue to cause considerable preventable harm (Dixon-Woods, 2019), demonstrating the need for further development of QI and the methods used to understand care.

1.3 Methods for quality improvement

Methods for QI have been defined as 'the processes which are typically intended to support the implementation of a quality intervention' (Jones et al., 2014). Methods are central to QI, fulfilling several purposes including planning for future care (Trebble et al., 2010), introducing knowledge and understanding of current, local practice (Brandrud et al., 2017), and predicting the future of care from historical data (Provost, 2011). Well-chosen, rigorous methods are central to ensuring that the improvement of working practices is systematic and informed (Marshall et al., 2013). Methods for QI are diverse, but they commonly support the principles or values that guide QI or are connected to the pillars of the system of profound knowledge (see, e.g., Parry et al., 2013).

Several such methods already exist. For example, process mapping brings a systems perspective to care processes (Walley et al., 2006), control charts support understanding of process variation (Thor et al., 2007), and the use of business excellence (BE) models enables assessment of the quality maturity of an organisation and improvement of organisational performance (Naylor, 1999). The Plan-Do-Study-Act (PDSA) learning cycle provides a systematic way of working with improvement, including planning, measuring, and learning (Kilo, 1998), and has been used extensively in healthcare (Taylor et al., 2014).

To understand local complexity and thereby improve patient outcomes, it is important to combine profound knowledge with the professional knowledge of healthcare practitioners (Batalden and Stoltz, 1995), whereby methods based on profound knowledge should support learning via interaction with professional knowledge (Perla et al., 2013; Parry, 2014).

Van Looy et al. (2011) acknowledged that a method could be used for assessment and improvement, as the identification of strengths and weaknesses through assessment becomes a basis of improvement. It is important to distinguish methods from work procedures, which could also be used for QI. Dixon-Woods (2019) clarified the distinction between methods that focus on the 'doing of improvement', to which the above-mentioned PDSA cycle and control charts belong, and work procedures constituting training programs, 'bundles' of evidence-based practices, protocols, checklists, and devices, to ensure evidence-based QI practice. Dixon-Woods (2019) further noted that some methods could be used to implement work procedures. The distinction between methods and work procedures is important in this thesis. The implementation of work procedures has attracted considerable research attention and has developed into an independent research field known as implementation science, which focuses on moving evidence into practice (Bauer et al., 2015). However, methods, which describe care and thereby develop local knowledge to support QI, are the focus of this thesis.

1.4 Towards a purpose

The information presented above has identified three particular aspects of QI for care. First, methods are used for acquiring knowledge to drive and support improvement. Second, despite the efforts made, sub-optimal processes and systems in care continue to create waste and harm, partly due to variation in how care is provided. Third, the complexity of care is high and increasing, which could imply that the gap between actual and understood complexity is increasing (Mans et al., 2009).

At a process level, many methods for QI are basic and focus on the presentation of a simple, graphical view to ensure that healthcare practitioners understand data easily and quickly (Plsek, 1999). However, too strong a focus on simplicity conceals some of the existing complexity in care (Kannampallil et al., 2011), which should also be understood to drive improvement (Rebuge and Ferreira, 2012). Therefore, the importance of ensuring that QI involves methods to describe relevant aspects of care complexity appears to have increased. This development is also implied in earlier research (see, e.g., Mans et al., 2008; Shneiderman et al., 2013; Berwick, 2012).

The increased care complexity may not only be identified at a care process level, i.e., as care process complexity but also at an overarching organisational level, i.e., care organisation complexity, in which care processes may be one part.

Although there is a paucity of methods describing care process complexity, methods for QI that aim to describe and identify connections between different aspects of care organisation complexity (e.g., linking processes to leadership and customer satisfaction) are available (Bergman et al., 2015; Eriksson et al., 2016). As QI is emerging into new contexts that have not been researched extensively (see, e.g., Neubeck, 2016; Bröchner et al., 2016), the available methods describing care organisation complexity could gain expanded use.

This reasoning yields the following two potential developments in QI with respect to methods and the understanding of care complexity: 1) To identify new methods describing care complexity in areas where current methods are lacking, and 2) to expand the use of current methods describing care complexity. Method choice should be driven by the local need for improvement (Marshall et al., 2013; Cantiello et al., 2016), and choosing seemingly appropriate methods in certain contexts and exploring their usefulness with domain experts would be an interesting means of expanding the collection and use of methods for QI.

Usefulness is defined as 'capable of being put to use; especially: serviceable for an end or purpose' (Merriam-Webster, 2019), where the purpose in this thesis is QI in care. Different variants of usefulness have been researched, such as expected usefulness, when users have no experience of the method (Salo and Abrahamsson, 2008), perceived usefulness, when users have experience of the method (Riley et al., 2009; Davis, 1989), and actual usefulness, reflecting the actual use of the method (Madden et al., 2007). This thesis also aims to identify usefulness based on patient data-driven analysis, which involves measurement rather than perception. In this thesis, no differentiation will be made between these variants; the term usefulness may include any of these variants.

In method development research, usefulness is foregone by the ease of use, i.e., a method could not be useful without first being easy to use in order to ensure user acceptance (Davis, 1989). However, in this thesis, it is assumed that a method may be difficult to use (at least for beginners) and still considered useful, for example by enabling additional and important contribution to QI compared to current methods. Moreover, as the term useful pertains to advantages, this thesis focuses mainly on identifying the benefits of each method. Still, consistent with earlier research involving QI or method development, method limitations will also be addressed (see, e.g., Carnevalli and Miguel, 2008; Thor et al., 2007; Godin et al., 2008).

1.5 Purpose

Based on the above, the purpose of this thesis is to *explore the usefulness of methods describing care complexity for QI in care.*

1.6 Development of research questions

1.6.1 Identifying new methods

Related to the identification of new methods, QI continues to be considered an emergent research field (Bergman et al., 2015; Marshall et al., 2013), and Berwick (2012) supported an ever-ongoing quest to develop new methods for improvement. With the demand for new methods, QI is not limited to a particular pre-defined set of methods. Marshall et al. (2013) stated that a pragmatic standpoint should be adopted in QI when robust and well-established methods are chosen. Borrowing from other fields, rather than developing new methods independently, reflects a principle of striving towards the efficient use of resources

(IoM, 2001), leading to a reluctance to 'reinvent the wheel' in QI. This indicates a continuation of the expansion of methods highlighted 20 years ago by Plsek (1999, p. 203), who stated that '[QI] is an eclectic collection of techniques borrowed from the fields of systems theory, statistics, engineering, psychology, and others. Many of these improvement methods have been in use in general industry for more than 50 years, and new techniques are constantly being developed'. There are several extant examples of the continued adoption or adaption of existing frameworks and methods from other research fields, to enhance understanding of care and drive QI (see, e.g., Berwick, 2012; Thor et al., 2007; Wandersman et al., 2015).

The Learning Health System is a promising driver in the identification of potential methods for QI from the perspective of the potential of digitalisation, computational power, and the use of electronic health records (Budrionis and Bellika, 2016; Friedman et al., 2017). It addresses the need to understand care complexity using a data-driven approach to care improvement (Nwaru et al., 2017), which aims to 'harness the power of data and analytics to learn from every patient, and feed the knowledge of "what works best" back to clinicians, public health professionals, and other stakeholders to create cycles of continuous improvement' (Friedman et al., 2014, p. 44).

The field of visual analytics appears to fulfil the aims of QI and the Learning Health System by focusing on data-driven visualisation, which enables people to interact with data, learn, and make better decisions (Keim et al., 2008). This demonstrates that data should be presented in a sufficiently simple manner to ensure that domain experts can understand those data and draw conclusions. However, the current methods for QI could be too simple to facilitate the understanding of some complex care problems. For example, data from domain experts are sometimes used, rather than data-driven visualisation of complexity, to identify root causes (Trebble et al., 2010; Thor et al., 2007). This approach is inherently subject to shortcomings, such as the limitations of human memory, proneness to bias (Kornell and Bjork, 2009; Peerally et al., 2017), and information deficiency due to time and personnel resource limitations (Peerally et al., 2017). Ultimately, this could reduce understanding of the care system and the complexity thereof.

Therefore, rather than overusing existing methods, new methods that allow the increased use of patient data to understand the care complexity for improvement purposes should be sought. Considering the evident complexity of care processes (see, e.g., Rebuge and Ferreira, 2012) and their centrality to QI (see, e.g., Bergman et al., 2015; Hellsten and Klefsjö, 2000), this thesis focuses on methods visualising care processes. This leads to the first research question:

RQ1. *What usefulness can visual methods describing care process complexity have for QI?*

1.6.2 Expanded use of current methods

Although there is hope in introducing new methods, there is no need to 'throw the baby out with the bathwater' with respect to the methods used currently. Rather, it could be possible to identify care contexts in which current methods for QI might be useful but remain unused. Specifically, regulations, incentives, and different means of competition are contextual factors that could be used to control QI from outside care organisations (Kaplan et al., 2010). Moreover, they have been shown to reflect the external manifestation of QI including issues such as advocating the adoption of quality management (Kaplan et al., 2010) and functioning as important drivers of QI (Taylor et al., 2011). However, a lack of consensus regarding the role that regulations, incentives, and different measures of competition play in QI remains (Kaplan et al., 2012), highlighting the need for further research in this field.

Public care procurement is one of the ways used to control QI through competition. The need to understand and ensure QI in care procurement becomes central considering the increasing trend in purchasing care (Waters et al., 2004; Malley et al., 2015), leading to the management of an increasing portion of care by private caregivers rather than the government (Øvretveit, 2003b; Bergman and Jordahl, 2014). In addition, the focus on quality has increased in care procurement (Bröchner et al., 2016), as has the focus on improvement (Entwistle and Martin, 2005). Specifically, successful and strategic procurement is considered key to improving healthcare (Figueras et al., 2005; Øvretveit, 2003b). However, care procurement includes specific challenges, as care is controlled via a contractual relationship between two parties, the buyer and the caregiver, and provided for a third party (Bröchner et al., 2016). The requirements for QI should be established in procurement documents and form the basis of the contract. This raises another challenge, as because of the dynamic and interactive care process, whereby care is co-produced with patients, it could be difficult to pre-define service quality and QI requirements (Camén, 2010; Grönroos, 2007). Bröchner et al. (2016) indicated that QI and public procurement are both advanced research fields but follow different logics and combined research is required to examine quality issues in care procurement. As care procurement is designed to control the care system for the entire organisation, describing care process complexity is insufficient. Rather, understanding from a system's perspective at an organisational level is required for care procurement to ensure, for example, patient-centredness (Camén, 2011), personnel competence development (Velasco-Garrido et al., 2005), and care outcomes, which are improved continuously as part of the dynamic, interactive care process (Camén, 2011).

The system's perspective of the organisation is addressed via several methods for QI. Bröchner et al. (2016) exemplified the use of BE models as a potential means of ensuring improvements in care procurement. The need to plan for overall organisational complexity in public care procurement leads us to the second research question:

RQ2. *What usefulness can methods describing care organisation complexity have for QI in public procurement?*

2. FRAME OF REFERENCE

The purpose of this thesis is to explore the usefulness of methods describing care complexity for QI in care. In the fulfilment of this purpose, the thesis takes the perspective of and aims to contribute primarily to QI. Therefore, this frame of reference chapter begins with QI, to establish an understanding of the research field and its relationship with methods. Guided by RQ1, the chapter focuses on care process complexity and current method collection before turning to visual analytics and proposing two future methods: the Lexis diagram and process mining. Care organisation complexity is then presented with a description of the potential benefits of using BE models in care procurement (RQ2).

2.1 Quality improvement

As a research field, QI gained momentum through the publication of the Institute of Medicine's (IoM's) 'To err is human' (Kohn et al., 2000), wherein preventable harm to patients was identified as one of the leading causes of death in the U.S., which resulted in an increased focus on improving care issues in healthcare (Leape and Berwick, 2005). Consequently, QI is 'characterised 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' (Marshall et al., 2013, p. 419). The IoM explicitly stated that inspiration for QI should be taken from other areas, such as the engineering industry and human factors (Kohn et al., 2000), and encouraged the uptake of knowledge from quality management. In 2001, the IoM published a follow-up document concluding that healthcare should be managed in the following three main ways: care should be knowledge-based, patient-centred, and systems-minded (IoM, 2001). This is consistent with quality management (Bergman and Klefsjö, 2010). Healthcare has since adopted these guidelines through various management concepts such as lean, six sigma, value-based healthcare, patient-centred healthcare, or a combination thereof (De Koning et al., 2006), including several quality management methods such as statistical process control (Thor et al., 2007), process mapping (Trebble et al., 2010), PDSA (Taylor et al., 2014), and the use of BE models (Naylor, 1999).

2.1.1 Guiding frameworks

Quality management, which exerts a strong influence on QI, is defined as a management approach or philosophy characterised by its principles, practices, and techniques (Dean and Bowen, 1994). The principles of quality management are implemented via practice (i.e., activities), which are in turn supported by a wide array of techniques (i.e., step-by-step methods) to increase the effectiveness of practice (Dean and Bowen, 1994). Therefore, the choice and use of methods are central to quality management in this definition and guided by a certain set of principles. Similar quality management principles, such as customer focus, continuous improvement, and teamwork (Dean and Bowen, 1994); customer satisfaction; and viewing the organisation as a system (Sitkin et al., 1994) have been suggested by different scholars. Moreover, Linderman et al. (2004) concluded that by

emphasising the systems perspective, Sitkin et al. (1994) highlighted the importance of the system of profound knowledge (Deming, 1994) and the need for knowledge acquisition in quality management.

The system of profound knowledge is central to both quality management and QI (Bergman et al., 2015; Deming, 1994) and consists of four pillars. First, *knowledge about the system* is based on the view of the organisation as a system of different interlocking parts and processes, emphasising the importance of understanding the entire system. Second, there is a need to *understand the variation* within the constantly present processes of the system, which originates from a combination of different sources. Based on the ideas proposed by Shewhart (1931), Deming focused on a variation that could be divided into either unknown, random variation sources inherent in the system or identifiable sources that lead to significant deviance from the normal process, and he argued that variation should be reduced (Bergman et al., 2015). Bergman et al. (2015) conclude that variation can be seen as synchronic (variation between items without taking time into account) or diachronic (variation over time). In addition, care research by Kahol et al. (2011) has shown that deviance can be interpreted as both negative and unwanted (e.g., a mistake leading to patient harm) or positive and wanted (e.g., identifying means of improving patient outcomes), consistent with Juran's (1986) position that connected diachronic variation deviance and improvement. Noteworthy, complexity in a care system depends on the number of components and their inter-relatedness (Kannampallil et al., 2011) as well as the system's non-linearity (Plsek, 1999). The inter-relatedness of components seems not to be covered by the definition of variation, and therefore, variation is in this thesis seen as a part of, but not covering, the notion of complexity. Third, Deming included two *psychological* perspectives: the need for all employees to be intrinsically motivated, which is driven by human curiosity and a desire to learn and achieve goals; and interaction between people, which affects motivation. Fourth, the *theory of knowledge* focuses on how knowledge and learning are achieved. This forms the basis of the PPDSA) learning cycle, a practice in which small changes are tested and evaluated systematically for continuous improvement (Batalden and Stoltz, 1995). Perla et al. (2013) drew on Deming's ideas to suggest seven propositions for QI, and the resultant framework was summarised in a figure produced by Parry (2014), here presented as Figure 2.1. The system of profound knowledge is often called improvement knowledge in QI (Batalden and Stoltz, 1995), guiding practical application (Parry, 2014; Perla et al., 2013) including method choice and use (Figure 2.1).

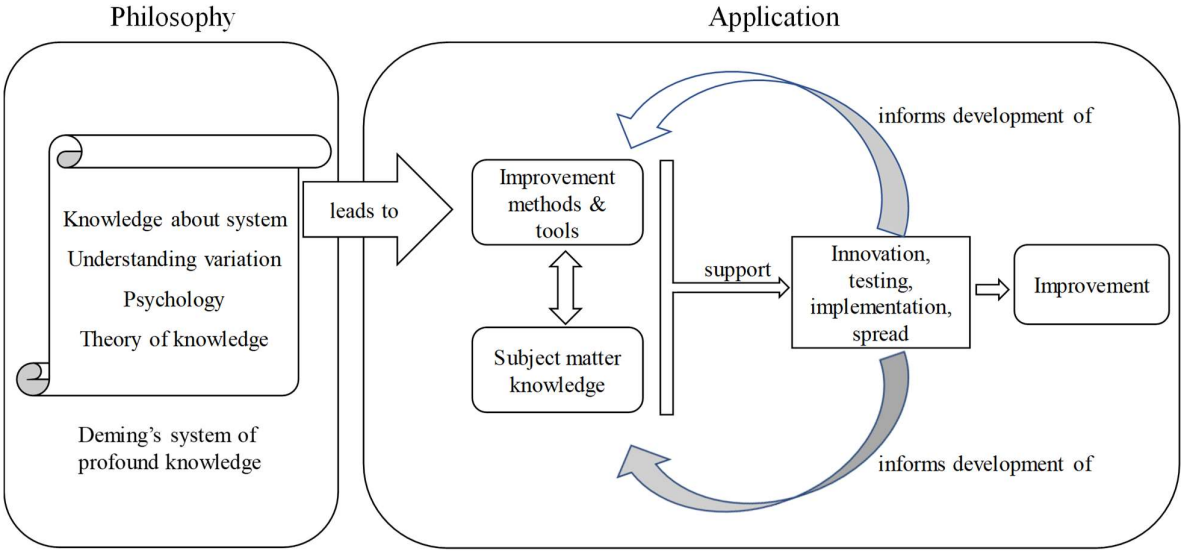

Figure 2.1. The seven propositions of quality improvement (Perla et al., 2013), adopted from Parry (2014).

Perla et al. (2013) argued for balancing justification, which refers to the use of data through methods for QI, with discovery and human creativity founded in domain experts' subject matter knowledge including understanding of the care context. When used with subject-matter knowledge, these methods facilitate innovation, testing, implementation, and dissemination to drive care improvement (Parry, 2014). Additionally, using data feedback, a learning cycle may be established to understand whether and how improvement occurs (Parry, 2014). Batalden and Stoltz (1995) did not focus on methods specifically; rather, they linked professional and improvement knowledge (Figure 2.2) and proposed that these two knowledge fields combined, led to shared understanding within which diagnostics, treatment, processes, and systems could be improved. Ultimately, this synergy could improve patient outcomes. Considering the frameworks proposed by Batalden and Stoltz (1995) and Parry (2014) together, the combination of methods, improvement knowledge, and subject matter knowledge, could be considered to drive learning cycles, leading to QI.

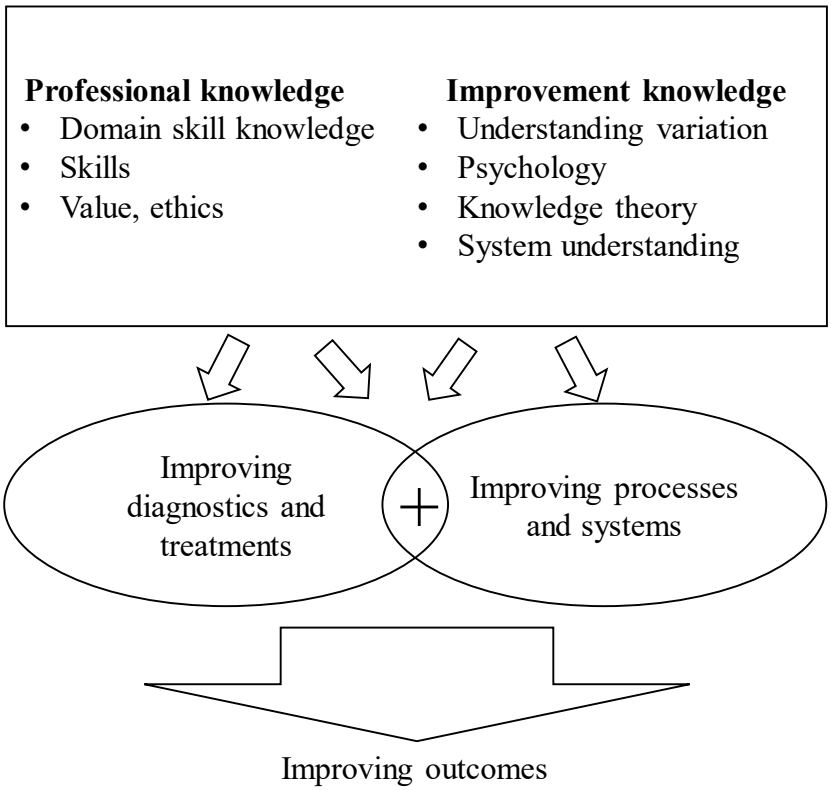

Figure 2.2 Batalden and Stoltz's (1995) extended framework for Deming's system of profound knowledge. The figure is inspired by Bergman et al. (2015). The flowchart demonstrates how professional medical knowledge combined with improvement knowledge could lead to improved care outcomes.

Several scholars have explained and defined QI, but consensus has not been reached regarding its definition (see, e.g., Lynn et al., 2007; Ogrinc et al., 2008; Batalden and Davidoff, 2007). Lynn et al. (2007) defined QI as 'systematic, data-guided activities designed to bring about immediate improvements in healthcare delivery in particular settings', while Ogrinc et al. (2008) claimed that QI 'is fundamentally a process of change in human behaviour, and is driven largely by experimental learning'. However, the definition proposed by Batalden and Davidoff (2007, p.2), '...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)…' is used in this thesis. This definition was chosen, as I find it reflects the need for QI to be knowledge-based, patient-centred, and systems-minded and highlights both the responsibility of everyone involved and the complexity of the organisation itself.

2.1.2 Methods for QI

As mentioned above, methods for QI have various purposes: planning for future care (Trebble et al., 2010), enhancing knowledge and understanding of current practice (Brandrud et al., 2017), and predicting the future of care (Provost, 2011). Many methods

are inherited from quality management after a long history in the industry including process mapping (Hines and Rich, 1997) and the seven quality control tools (Bergman and Klefsjö, 2010) including the almost 100-year-old control chart (Shewhart, 1931). Methods for QI should include a simple, graphical display to facilitate understanding for practitioners (Plsek, 1999), highlighting its use in learning and supporting QI. Specific to the methods used to analyse quantitative data for QI is the analytical approach, whereby timely feedback is central to understanding the mechanisms of processes and interventions for QI (Provost, 2011). However, many healthcare data are not analysed according to the analytical approach but are aggregated to ensure the statistical significance of key variables (Provost, 2011; Burke and Shojania, 2018).

This thesis presents an argument for adding further requirements for methods for QI. Even when the guidelines for the analytical approach are followed, such as plotting data over time, the focus on simplicity in traditional methods could reduce their usefulness in describing care complexity. The complexity of care affects variation in care processes (Perla et al., 2013), and levels of system complexity depend on the number of components involved and their inter-relatedness (Kannampallil et al., 2011). Moreover, non-linearity characterises complex system behaviour (Plsek and Greenhalgh, 2001). For methods to be useful in understanding complexity, they may need to describe more of the complexity. Specifically, despite the abundant information currently available in, for example, health information systems, commonly used methods for QI often rely on subject-matter knowledge, to enhance understanding of variation. This is the case in process mapping, which results in an overview of main processes (Trebble et al., 2010) and in root cause analysis of adverse events, where adverse effects are associated with the environment, people, or measures (Plsek, 1999) that are used for control charts, for example (Benneyan et al., 2003). Although subject-matter knowledge is important for identifying relevant data and making sense of care data, the human brain is less effective at correctly memorising specific data. As human memory is prone to bias (Mans et al., 2008; Peerally et al., 2017), it could lead to a reduced or false understanding of complexity. Therefore we should aim to use correct, objective data rather than rely on human memory (Mans et al., 2015).

Different scholars (see, e.g., Hellsten and Klefsjö, 2000; Dean and Bowen, 1994) have connected methods for QI to general quality management practices or management concepts and the core principles guiding quality management such as customer focus, continuous improvement, and teamwork (Dean and Bowen, 1994). In accordance with the core principles of quality management and four pillars of improvement knowledge, Bergman et al. (2015) suggested the following core principles for QI: focus on processes, improve continually, use intelligence, support inner motivation, and take the perspectives of the ones for whom the value is created (i.e., customers, patients, stakeholders, or citizens). These five principles are supported by improvement leadership and taking a system's perspective. The core principles thereby highlight important method focus areas, leading to centrality in understanding care processes.

Complexity may be described within a process, including variation between groups or changes in process-related measures over time. It could also be described within the broader perspective of care, including not only processes but also e.g. leadership, information management, people's perspectives and engagement, and continuous improvement (Bergman et al., 2015; Eriksson et al., 2016). Describing complexity at the relevant level could lead to an understanding of local needs (Marshall et al., 2013; Cantiello et al., 2016), which is central to guiding QI efforts (Perla and Parry, 2011).

2.2 Care process complexity and current methods

The centrality of methods describing care process complexity for QI is the focus of RQ1. Focusing on care processes, some researchers have argued that organisational silos can be overcome (Glouberman and Mintzberg, 2001), while others have claimed that the standardisation of healthcare processes reduces costs (Porter et al., 2000).

A focus on processes allows for the planning of work at different organisational levels. At a patient level, this focus could be achieved through care pathways (Vanhaecht et al., 2007). The European Pathway Association defined care pathways as 'a methodology for the mutual decision making and organisation of care for a well-defined group of patients during a well-defined period' (Vanhaecht et al., 2007, p. 8). Care pathways were introduced to improve care quality and reduce costs and should be developed via evidence-based protocols (Every et al., 2000), resulting in to-be process models to guide care. However, within care pathways, physicians sometimes experience a loss of autonomy and feel that they are forced to provide standardised 'cook-book medicine', inhibiting personalised care (Every et al., 2000).

Bergman (1999) concluded that care pathways result mainly from expert clinical panels rather than randomised control trials. In addition, Mans et al. (2013) claimed that process execution is subjective, indicating that personal assumptions or experiences are part of the creation of care pathways. This inclusion implies that care pathways might not always be consistent with best practice, which echoes the above-mentioned concerns expressed by physicians. Moreover, it should be noted that not all patients are expected to follow care pathways, as long as deviations are underpinned by appropriate motivation and do not exceed a certain threshold (Polite et al., 2016). Explanation of the reasons for deviations could lead to learning, and deviation could reveal better ways of working (Kahol et al., 2011). Therefore, to achieve the best possible outcomes from a focus on the patient process, it is important to not only to create and implement a to-be care pathway and assume that it is followed to the extent intended but also evaluate variation in the resultant as-is care pathway. This becomes clear when considering that care is complex, multi-disciplinary, ad hoc, and dynamic (Rebuge and Ferreira, 2012).

However, thus far, care processes have been evaluated and managed mainly by measuring specific key performance indices (KPIs) reflecting care structures, processes, and outcomes separately (Mainz, 2003; Donabedian, 1966). Moreover, before and after measures of a

single KPI, such as patient survival, have been used to assess the effects of efforts to provide QI (Dahm-Kähler et al., 2016; Kristoffersen et al., 2015). However, before and after measures have been criticised because of the potentially erroneous assumption that other factors are static when they vary (Provost, 2011; Burke and Shojania, 2018). In other instances, the evaluation is supported by certain methods, such as a run chart (Perla et al., 2011) or control chart (Thor et al., 2007), to analyse KPI variations over time. KPI analysis of care processes is sometimes connected to process maps, which are usually developed via process mapping (Trebble et al., 2010). When considering the magnitude of current care process complexity, which is expected to increase, it may be problematic to rely on current methods to support learning to the extent required to drive QI.

2.3 Developmental trends for QI regarding care process complexity

As explained by Plsek (1999), QI is based on several different theories and research fields. Bergman et al. (2015) noted the need for other research fields to contribute to the further development of QI and pinpoint the need for an enhanced understanding of complexity. However, although complexity is often highlighted as problematic in healthcare, and the Learning Health System has been launched, the development of methods describing complexity at a process level remains limited. However, there are several weak but specific connections between QI and methods describing care process complexity in other research fields. Specifically, Shneiderman et al. (2013) argue for interactive visualisation to understand and improve QI. The use of visual analytics could both complement the Learning Health System and encourage the use of graphical displays in QI.

2.3.1 Visual analytics

Digitalisation and increased documentation have led to new ways of understanding processes, facilitating the use of bottom-up approaches to managing the considerable amount of data recorded daily in healthcare. Visual analytics methods are used to 'visually represent the information, allowing the human to directly interact with the information, to gain insight, to draw conclusions, and to ultimately make better decisions' (Keim et al., 2008, p. 77), thus, data visualisation may be used for exploring, making sense of, and communicating data (Few, 2014).

The field of visual analytics is in the early developmental stage, and several healthcare-related challenges have been identified (Shneiderman et al., 2013; Keim et al., 2008). These challenges include the facilitation of team decision-making, which is implemented when several stakeholders collaborate in, for example, multidisciplinary teams. Therefore, data should be understandable by everyone involved (Shneiderman et al., 2013), and this could be supported by graphical excellence, which 'gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space…telling the truth about the data' (Tufte, 2001, p. 51). Facilitating the provision of timely information in a usable format is another challenge and is particularly important to busy clinicians during ongoing practice or for feedback purposes in the advancement of situational awareness and

improvement efforts (Shneiderman et al., 2013). Accordingly, visualisation to evaluate improvement efforts and methods has been identified as another challenge in data visualisation in healthcare. Keim et al. (2008) emphasised the need for data quality and the understanding of uncertainty to avoid issues including the risk of misinterpretation of data collected for another purpose. User acceptability is a further challenge highlighted by Keim et al. (2008), as many visualisation methods have been developed but never implemented in daily routines because of initial usage barriers such as knowledge gaps. Therefore, a clear understanding of the usefulness of visual analytics is required, and perhaps QI and visual analytics could be developed jointly by identifying new visualisation methods guided by QI requirements and the challenges listed above.

Epidemiology and computer science are two research fields in which potential visual methods for QI are observed. Howland and Decker (1992) highlighted similarities between QI and epidemiology decades ago, introducing the use of epidemiological methods to understand variation. The Lexis diagram is such an epidemiology method and has been shown to be useful in QI for monitoring lead times in care (Santos et al., 2014). Extending earlier research involving Lexis diagram visualisation of multiple factors in life event histories (Francis and Fuller, 1996), the Lexis diagram could be useful in describing different types of care process complexity such as connecting patient data about, for example, diagnosis, different surgeries, or relapse.

Process mining, which originates from computer science, is another method with the potential to support understanding of care process complexity (Van der Aalst, 2016; Ghasemi and Amyot, 2016). Process mining has been applied in healthcare (Mans et al., 2015; Rojas et al., 2016) but used mainly for the discovery of real, or 'as-is', care processes (Partington et al., 2015), while less attention has been paid to care process monitoring or improvement (Yang and Su, 2014). In addition, few studies have addressed the combination of QI and process mining (see, e.g., Bergs et al., 2016; Fernández-Llatas et al., 2013; Caron et al., 2014). Therefore, there is a need for further research to determine how process mining can be used to drive and evaluate QI in healthcare. Both methods are presented in further detail below.

2.3.1.1 Lexis diagram

The Lexis diagram originates from demography and epidemiology, and depicts individual lifelines along two time axes: calendar time on the x-axis and age or year since diagnosis on the y-axis (Keiding, 1990; Wolkewitz et al., 2016; Jewell, 2016); for an example, see Figure 5.1B. The Lexis diagram is a versatile method, whereby additional event information can be added or highlighted using colouring and markings along individual lifelines (Francis and Pritchard, 2000; Carstensen et al., 2008), enhancing the understanding of the visualisation (Francis and Fuller, 1996). The Lexis diagram has been developed in several ways, such as, for the advanced graphical display of individual life histories (Francis and Pritchard, 2000) and population-level mortality dynamics (Rau et al.,

2017). With increased care complexity, potentially resulting in small patient sample sizes (Lowy and Collins, 2016), it is impossible to pursue traditional statistical analysis in a timely manner. Therefore, visualisation via the Lexis diagram provides potential support in driving and understanding QI.

2.3.1.2 Process mining

Process mining is a graphical, dynamic methodology developed approximately ten years ago and aims to discover, monitor, and improve processes (Van der Aalst et al., 2012); for an example, see Figure 5.1D. By merging the data mining and process management fields, process mining is used to extract process knowledge from event logs (Van der Aalst, 2016). As a result, patient and performance data can be directly connected to processes (Van der Aalst, 2016), enhancing understanding of care variation.

Event logs involve ordered data, whereby a case, such as a patient, is connected to well-defined activities, such as blood tests or consultations with a doctor. In addition, timestamps and information regarding other additional attributes are sometimes included. A health information system is an example of a process-aware information system, which can be used to handle the data kept in event logs. Two specific examples of health information systems are electronic health records and quality registers (Coorevits et al., 2013). Van der Aalst et al. (2012) posited that process mining allows quality management to perform more rigorous compliance checks and 'ascertain the validity and reliability of information about an organisation's core processes' (p. 172).

Process mining has been used in healthcare (Rojas et al., 2016), but as a method, it originates from the field of computer science (Ghasemi and Amyot, 2016; Van der Aalst, 2016). Process mining is typically used for three different purposes: discovery, conformance, and enhancement (Van der Aalst, 2016). Discovery involves identifying the order of events, with outcomes such as process maps. Conformance considers whether reality conforms to a pre-defined process model, such as a care pathway. Enhancement is used to develop existing models, using data to match models to reality or include additional information in the model (e.g., adding timestamps for bottleneck analysis). For each of these purposes, one can use three different orthogonal perspectives (control-flow, performance, and organisation) to answer the questions of how, what, and who, respectively (Mans et al., 2009; Mans, 2011).

The Process Mining Manifesto, written to introduce process mining to a larger audience, introduced the L* lifecycle model to guide process mining practitioners (Van der Aalst et al., 2012). Different models have since been developed for healthcare; specifically, the L* lifecycle model has been extended to perform parallel analysis of data from different data records (Helm and Küng, 2016), and the clinical pathway analysis model has been developed with a focus on care processes (Caron et al., 2014). A clear connection between process mining and QI learning cycles can be observed when comparing process mining models with the PDSA cycle (see Table 2.1), highlighting a common systematic and

potentially iterative mindset with a focus on improvement. However, the steps in each model, which are separated by horizontal lines in each column of Table 2.1, do not completely coincide. For example, the 'Do' step in the PDSA cycle overlaps with the first four steps in the clinical pathway analysis model.

Table 2.1 Comparison of the PDSA cycle, L*-lifecycle model, Extended L*-lifecycle model, and Clinical Pathway Analysis Model.

<table>
<tr><th>PDSA cycle</th><th>L*-lifecycle model</th><th>Extended L*-lifecycle model</th><th>Clinical Pathway Analysis Model</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 extracts (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 an 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>

2.4 Care organisation complexity and current methods

Shifting focus from care processes, RQ2 explores the usefulness of methods describing care organisation complexity for QI in public procurement. As described in section 2.1.1, Deming (1994) defined the system of profound knowledge as one of different interlocking parts and processes and posited that the entire system should be understood. Although the system is often understood by focusing on processes and process measures spanning across the different parts (Gemmel et al., 2008; Adair et al., 2006), which is exemplified in the previous section, a wider perspective on care complexity could be adopted, whereby the system of the entire care organisation is considered. Plsek and Greenhalgh (2001) argued that it is possible to view healthcare as a complex adaptive system that is understandable but unpredictable. However, this lack of predictability was criticised by Paley (2007), who concluded that different rules guide individuals in the system, affecting their behaviour. Moreover, Höög et al. (2016) concluded that complex systems require not only methods for analysing data but also a wide array of competencies, perspectives, and communication strategies, while Braithwaite et al. (2017) highlighted collective, dynamic behaviour in care

organisation complexity. System-based thinking has long guided knowledge acquisition and learning for improvement purposes (Senge and Sterman, 1992), and a wide variety of system-wide approaches and methods, such as lean, six sigma, ISO 9001, balanced scorecards, and BE models, are available to assess or improve care (Mohammad et al., 2010).

These approaches and methods are similar in many ways (see, e.g., Eriksson et al., 2016; Andersson et al., 2006; Wongrassamee et al., 2003) but each has a specific focus. Lean has a strong focus on identifying and reducing waste and controlling resources to fulfil customer needs, while six sigma focuses on reducing variation to satisfy customers (Andersson et al., 2006). Balanced scorecards include four measures: customer satisfaction, internal business processes, learning and growth, and financial measures, to facilitate the strategic vision of an organisation (Wongrassamee et al., 2003). ISO 9001 is a standard based on quality management principles, to ensure that customers get consistent, good quality services and products, which leads to business benefits (ISO, 2019). BE models focus on assessment of the quality maturity of organisations according to a number of criteria covering important areas of organisations, identified via the analysis of successful organisations (Raharjo and Eriksson, 2017), and are used to both drive organisational improvement and assess the quality maturity of organisations (Dahlgaard et al., 2013).

2.5 Potential developmental trends for QI regarding care organisation complexity

Concerning the expanded use of current methods, in the introduction (section 1.6.2), public care procurement was identified as an important context within which to understand and ensure QI. Further, the need to adopt the system's perspective on the entire organisation, including patient-centredness and leadership perspectives, was demonstrated. Therefore, care organisation complexity should be addressed within the context of public care procurement.

In addition, as noted in section 1.3, methods for QI fulfil several purposes. While visual analytics present historical data and thereby bridge knowledge and understanding of current practice (Brandrud et al., 2017) and support prediction of future care through historical data (Provost, 2011), care procurement requires methods that support the planning of future care.

2.5.1 Care procurement and care organisation complexity

Regarding care procurement, it should be noted that procurement is often confused with commissioning or purchasing, but Murray (2009) concluded that procurement both includes purchasing and forms part of commissioning. Therefore, purchasing is included in procurement, which is considered 'a project-based approach to source the specific provider of the services' (Murray, 2009, p. 200). In public procurement, the government plays the role of the buyer (Bröchner et al., 2016) while remaining responsible for the care provided. In accordance with the law, the care provider is chosen through public

procurement according to a number of requirements reflecting the ways in which the care organisation should deliver care. In the EU, under directive 2004/18/EC, public procurement was awarded to either the lowest priced or most economically advantageous tender, and the latter included a tendering award evaluation based on quality requirements. In the more recent directive, 2014/14/EU, which repealed the earlier directive, only the most economically advantageous tender remains an option. Further, quality can also be included in public procurement via pre-qualification requirements (Eadie et al., 2012) and specified quality requirements in procurement documents (Kuypers and Gruppen, 2008; Enquist et al., 2011).

Public procurement faces certain challenges in describing QI. Previous research examining procurement contracts demonstrated that contract formulation could affect the future possibility of managing quality (Camén, 2011). Moreover, it is difficult to formulate requirements in a care setting with 'soft' values that are difficult to define (Stolt et al., 2011), particularly as procurement concerns care that should be provided to a third party rather than the buyer (Bröchner et al., 2016). Further, legal restrictions create additional obstacles. Procurement legislation logic leads to a preference for static, rather than flexible, requirements, which have been shown to restrict QI by reducing the possibility for contractors to provide customer-oriented services (Camén, 2011). In addition, Bröchner et al. (2016) argued that it could be difficult to transfer quality methods to procurement because of legal restrictions such as transparency. They also stated that buyers could be reluctant to include innovative requirements in procurement documents, because of the risk of judicial complications, and prefer well-tested, simple practices. Moreover, earlier studies demonstrated problems incorporating aspects of QI into contracts, because of the need for a set end date, regardless of collaboration quality (Bröchner et al., 2016). Therefore it is not surprising that Bergman and Jordahl (2014) reported a lack of relevant quality measures in healthcare procurement. In a report provided by Health Navigator (2013) regarding the procurement of elderly care in Sweden, the authors demonstrated the necessity for less complicated procurement focused on QI results and incentives during contractual periods, and the need to stress the importance of QI outside of contractual demand.

In conclusion, procurement addresses the ways in which care should be provided during contractual time. Considering the static view of quality in public care procurement, which lacks the incentive for improvement during contractual time, there could be a need for a method that drives a dynamic view of quality. As care procurement addresses the complexity of the organisation from the caretaker's perspective, the method ought to adopt a system-wide organisational perspective of QI. In addition, a method that allows for the comparison of tenders according to QI competence would be advantageous, to ensure that procurement awarding could establish a focus on QI. Bröchner et al. (2016) specifically suggested the use of quality models, such as BE models, to assess and drive QI at an organisational level. The use of BE models is elaborated upon in the following section.

2.5.1.1 BE models for care procurement

An important advantage of the use of BE models, rather than ISO 9001 and balanced scorecards, is that assessment provides a score reflecting the organisation's QI maturity. This score allows comparison between organisations, although they might work with QI in different ways (Eriksson, 2003b), and using BE models is one of the most common methods used to assess the current state of QI in care (Xiong et al., 2016). The possibility of comparing QI maturity between organisations makes the use of BE models interesting in the tendering process. Decades ago, BE models were demonstrated as being able to identify the successful application of quality management (Hendricks and Singhal, 1997), and recent research has shown that they remain valid for addressing current organisational QI challenges (Eriksson et al., 2016). In adopting a holistic approach for the performance of the entire organisation across organisational plans, processes, people, decisions, actions, and results (Xiong et al., 2016), BE accounts for overall care organisation complexity.

Several models, such as the Malcolm Baldridge National Quality Award (MNBQA) model, the European Foundation for Quality Management (EFQM) excellence model, and the Swedish Institute for Quality (SIQ) model (Eriksson et al., 2016) are used by both public and private organisations (Raharjo and Eriksson, 2017) to assess the quality maturity of an organisation or drive QI. Organisational assessment is pursued through internal self-assessment (Samuelsson and Nilsson, 2002) performed by external consultants, or external assessment connected to excellence awards (Tickle et al., 2016). In turn, this assessment supports the understanding of an organisation's ability to succeed in QI (Eriksson et al., 2016).

BE models have been used extensively in healthcare (Xiong et al., 2016) but for purposes other than public care procurement. However, a BE model (SIQ, 2015) has recently been adapted for use in procurement awarding. The BE procurement model (henceforth called the BE model) consists of several questions used as part of the requirements for procurement concerning processes, planning, information and analysis, leadership, customers, personnel, and results (SIQ, 2015). Similar to the SIQ model, it is based on three principles: i) A systematic means of asking questions leading to insight, ii) a clear structure implemented through a template of questions, and iii) contribution involving a culture of values guiding decisions and action (SIQ, 2015; SIQ, 2018). Through these principles and a focus on important areas of the organisation, the BE model could be expected to both support identification of QI-mature care providers and facilitate the flexibility and change required to adapt to care organisation complexity and its dynamics during the contractual period (SIQ, 2015). However, its usefulness in public care procurement has not been researched thus far.

2.6 Final comments on the frame of reference

The main frame of reference guiding this thesis is QI, as an emerging research field, which continues to take inspiration for further development from other fields. Based on the need

to understand care complexity, this thesis explores the usefulness of visualisation of care processes complexity through the Lexis diagram and process mining. In addition, the current use of methods is explored using a BE model as a means of planning for and understanding care organisation complexity in public care procurement.

3. RESEARCH METHODOLOGY

This chapter begins by presenting the research strategy, followed by an overview of the research design. Then, a reflection on the research process is followed by a presentation of the study settings and processes for each paper. Last, the data collection and data analysis are followed by a section on research quality.

3.1 Research strategy

Flick (2014) contended that the research question of a study should guide the choice of method and approach—i.e., quantitative, qualitative, or mixed-method (Doyle et al., 2009). In contrast, Morgan (2007) argued that the paradigm (i.e., beliefs or world view) the researcher subscribes to, will influence the questions posed and the methods chosen to answer them. I believe that these perspectives are interconnected; the approaches and research questions depend on your interest and world view, which in turn informs the choice of methods and approaches. Additionally, theoretical choices, in my case QI, may also guide which approaches are adopted (Doyle et al., 2009). I call the set of approaches the 'research strategy', as together they constitute the overarching strategic foundation guiding the hands-on research study design, such as the method choices and how to integrate them. The research strategy, thus, establishes the possible parameters in the design of each study. The method and design choices are consequently shaped by the pursuit of addressing the research questions within those parameters and fulfilling the purpose of the thesis.

3.1.1 Explorative approach

The purpose of this thesis is to *explore the usefulness of methods describing care complexity for QI in care*. The thesis thereby sheds light on the importance of methods that describe complexity in care and the need to understand their usefulness for QI, which has received scant attention in earlier literature. This thesis includes studies on both methods from fields independent of QI and methods already established in the method collection for QI, but here used in a new context; each particular combination of method and context centred on QI has not been studied before. As prior knowledge on the usefulness of methods may not apply to novel contexts (Parry et al., 2013), their usefulness still needs to be evaluated in the chosen contexts. As such, an *explorative* approach, which is particularly open to the emergence of novel unanticipated insights, was adopted. The explorative approach has enabled the accumulation of empirical knowledge over time on usefulness, methods, and contexts. Exploration during data analysis was supported and guided by theoretical QI knowledge to ensure a focus on QI.

3.1.2 Pragmatism and mixed methods

This thesis is guided by pragmatism, as is QI generally (Brock et al., 1998). This means emphasising the importance of using the knowledge on how care is provided to drive improvement (Baker, 2006), including documented data and subject-matter knowledge.

The role of knowledge in this thesis, and in QI, is in line with pragmatism, which conceptualises the world as being both real and constructed (Johnson and Onwuegbuzie, 2004); i.e., one reality exists but is experienced and interpreted differently by diverse individuals (Morgan, 2007). Morgan (2007) further argued that pragmatism is guided by intersubjectivity, where people with different views create and share knowledge through joint action. The combined new knowledge may, in turn, update the a priori views that people hold, i.e., learning is achieved through action (Perla et al., 2013; Bergman et al., 2015).

The need to understand care in QI requires understanding the interplay between the quantitatively measurable and tacit qualitative social knowledge in healthcare, epitomised by Batalden et al. (2011, p. i103), who argued: 'Even at its most scientific and technical moments, the provision of healthcare is always—always—a social act'. Similarly, pragmatism is often connected to a pluralist methodology, that utilises mixed methods (Scott and Briggs, 2009). This approach also aligns well with the socio-technical systems view, which by using human cognition to analyse complex data, is central to the aim of developing a Learning Healthcare System (Friedman et al., 2017) and guiding attempts to answer RQ1. Importantly, the implementation of mixed methods research for QI should maximise the strengths and minimise the weaknesses of qualitative and quantitative methods, respectively (Doyle et al., 2009; Kleinman and Dougherty, 2013). Indeed, Doyle et al. (2009) and Miles and Huberman (1984) have noted numerous ways that quantitative and qualitative research methods can be integrated. In this thesis, mixed methods have been implemented, as seen appropriate in the different studies for formulating a comprehensive view of the problem, and thereby, answer the research questions posed, and this is further elaborated upon in the data collection and analysis sections (3.5 and 3.6). Overall, while quantitative research methods were used to present and analyse the quantified data (e.g., patient data), qualitative methods were used to develop a rich understanding of the contexts and actions (Miles and Huberman, 1984).

3.1.3 Abductive approach

The abductive approach, which alternates between induction and deduction (Morgan, 2007), requires a balance between deliberation and serendipity, engaging with and detaching from data, and knowing and not knowing (Langley et al., 2013). This approach develops theoretical ideas and generates new insights (Langley et al., 2013), facilitated through action (Morgan, 2007). In this thesis, abduction was used by alternating between empirical data through methodological exploration (e.g., patient and other documented data, subject matter knowledge, and observation) and theory (primarily on methods and QI, but also care procurement). To strike an appropriate balance in this abductive approach, a balance between planning and safeguarding openness to the unexpected (serendipity) has been strived for, where joint knowledge, rather than individual knowledge, holds the answers.

3.1.4 Collaborative approach

The abductive approach in this thesis relied upon collaboration with domain experts that contributed with subject-matter knowledge. Collaboration is central to QI (Batalden and Davidoff, 2007) and collaboration with domain experts may lead to a better understanding of the environment targeted for improvement (Batalden et al., 2011). Considering the complexity and multidisciplinary nature of care combined with the need for both improvement and subject-matter knowledge, presented in section 2.1.1, several fields of knowledge will need to be integrated to achieve QI. The need to combine multiple disciplines through collaboration, which has also been emphasised by several QI scholars, creates a paradigm (Kleinman and Dougherty, 2013) that highlights diverse perspectives on problems (Perla et al., 2013) and enables team building and co-learning (Batalden and Davidoff, 2007) that are particularly important in understanding complex phenomena (Nyström et al., 2018). As Kleinman and Dougherty (2013, p. S117) concluded 'quality and QI research require the collaboration of excellent listeners, sophisticated methodologists, and conceptual and analytic thinkers, all coming together with open minds that are informed but not bound by theory.' Marshall et al. (2013) specified that the combined knowledge of domain experts (i.e., subject-matter knowledge) and QI researchers might support the development of new boundaries for traditional health services research and create synergies that foster rigour and leverage creativity. Collaboration has also been shown to be essential for data analysis (Mans et al., 2008) and method development (Perimal-Lewis, 2014).

Open minds are necessary when integrating different subject-matter knowledges as some stakeholders possess different mental models that originate from prior experiences that affect their perception and interpretation of the world (Perla et al., 2013) or participate in professions that are based on different theoretical presuppositions or logic (see, e.g., Bröchner et al., 2016). Even professions within healthcare possess distinct logic, as illustrated by Glouberman and Mintzberg's (2001) 4C model, where four different 'worlds' of healthcare represent the professional logic of nurses (care), doctors (cure), management (control), and trustees (community). Although individuals' mental models are liable to change when faced with conflicting expectations and experiences (Perla et al., 2013), and there have been attempts to bridge their different logic (Burke and Shojania, 2018), it is arguably wise to be conscious of the likely risk of clashes that may emerge during interdisciplinary collaboration. These clashes could be mediated with the help of a facilitator (Reed et al., 2018), and when mental models do change, there is the potential for sustained improvement in care (Hovlid et al., 2012). The abductive approach, with its capacity to engage with expert perceptions and openness to novelty, guided this research towards the identification of potential changes in mental models.

3.2 Study design

This thesis sets out to answer two research questions; RQ1: '*What usefulness can visual methods describing care process complexity have for QI?'* and RQ2: '*What usefulness can*

methods describing care organisation complexity have for QI in public procurement?' These research questions are answered in three studies. Two studies address RQ1 by focusing on distinct visual methods—i.e., the Lexis diagram and process mining; while RQ2 was addressed by focusing on the use of BE models for QI in public care procurement (see Table 3.1). The choice to conduct three studies was based on the three 'novelties', so to speak, in QI; that is, the use of Lexis diagram and process mining to describe care process complexity, and the use of the BE model to describe care organisation complexity in public care procurement.

Table 3.1 The connection between the papers, studies and research questions, as well as to QI 'novelty', setting, study type, research methods, and collaboration.

Paper	**I**	**II**	**III**	**IV**	**V**
Thesis study	1	2	2	3	3
Research question	RQ1	RQ1	RQ1	RQ2	RQ2
QI 'novelty'	Lexis diagram for care processes	Process mining for care processes	Process mining for care processes	Public care procurement	Business excellence for public care procurement
Setting	Gynaecological cancer in Western Sweden	All care settings included	Breast cancer in Western Sweden	Elderly care homes in Sweden	A single elderly care home in Sweden
Study type	Single case	Literature review	Single case	Archival	Single case
Research methods	Qualitative + Quantitative	Qualitative	Qualitative + Quantitative	Qualitative + Quantitative	Qualitative
External collaboration	Yes	No	Yes	No	Yes

Further, five papers were included in the three studies conducted, and each paper has its own design (see Table 3.1). Notably, all three studies included a case study (Papers I, III, and V). Yin (2013) noted that case studies are often appropriate when asking how and why questions but may also be used for exploratory what-questions such as RQ1 and RQ2. Although the research questions are rather general and may not be enough to exclude the use of other study types (Yin, 2013), the novelty of exploring the usefulness of diverse methods in new contexts served as the basis for conducting case studies. Case studies are suited to developing an in-depth and rich understanding of the phenomena of interest (Eisenhardt and Graebner, 2007) ; that is, the methods in context. Further, Voss (2002) identified exploration as one of the uses of conducting case studies, aside from theory building, theory testing, and extension/refinement. In addition, Parry et al. (2013) have argued that case studies are suited to evaluating new methods for QI. An important part of

each of the three case studies has been the use of a collaborative approach with different stakeholders to produce joint knowledge.

Paper II and IV aimed to acquire general overviews and were, thus, based on numerous papers and documents, respectively. Paper II is a narrative literature review (Frank et al., 2014) based on qualitative data. It explores the general overlap between QI and process mining in healthcare and identifies possibilities of process mining in QI. Paper IV is primarily an archival study (Yin, 2013), based on the official public care procurement and statistics available online. The archival study was based on both qualitative and quantitative data. This study design was selected because it was necessary to develop an understanding of how QI currently manifests in public care procurement.

3.3 Reflection on my research process

The research process leading to this thesis started in April 2014. The initiation of the project started earlier as my PhD student position was based on two existing research projects. One project was financed by the Regional Cancer Centre (RCC) West and explored the possibilities of advancing the use of patient data for QI (resulting in Paper I and III). The other project was a part of a larger project financed by the Swedish Research Council for Health, Working Life, and Welfare (FORTE) on quality in care procurement (leading to Paper IV).

While researching health and social care, I was asked several times whether I had any education or work experience within care. While I hold a Master of Science in bioengineering with a focus on medicine and environment, and I later supplemented this education by studying business administration, I do not have any work experience in care. However, I applied for the PhD position due to my increasing interest in improving care and learning more about quality in care, as a result of my diverse work experience. I believe my background, engineering knowledge, limited care knowledge, and a strong interest in improving care has had an impact on the research process. My engineering knowledge provided a good basis for understanding and learning the different methods used in this thesis, all of which were new to me, while the medically orientated courses of my education fostered an understanding of medical discourse that supported my discussions with domain experts. However, due to my limited knowledge and practical experience in care, which is necessary for understanding the respective contexts and settings under investigation, collaboration with domain experts was vital.

The RCC West project was built upon a long-term collaboration between the Centre for Healthcare Improvement (CHI) at Chalmers and RCC West, the latter being part of the healthcare Region Västra Götaland, Sweden. CHI is a research and education centre focusing on improvement innovation and the transformation of healthcare. CHI has had an ongoing collaboration with RCC West almost since the 2009 opening of six RCCs in Sweden, aimed at facilitating knowledge transfer through research and education. The collaboration advances research and practice through the synergy of engineering, QI, and

method knowledge (i.e., improvement knowledge) at Chalmers with the subject-matter knowledge from care process owners and other clinical experts affiliated with RCC West. In this thesis, two projects focusing on different methods were initiated and developed in parallel from the collaboration with RCC West: control charts to analyse survival data when death is a rare event (Study 1) and process mining to understand variations in care processes and their association with patient costs (Study 2; see Figure 3.1). Fortunately, and as presented below, the projects were flexible in focus, enabling me to explore and adapt the research objectives and studied methods, as the research progressed with data collection and analysis.

My thesis work spanned from April 2014 until the end of 2019, as presented in Figure 3.1. 2014 was mainly dedicated to courses, building up knowledge about research and QI, but also included taking initial steps towards the collaboration in Study 1 and the data collection and analysis in Study 3 (i.e., Paper IV). Notably, I had no former knowledge of the context of these studies, which supported the process of exploration and openness in this study. Paper IV contributed to the theory, and enabled me to develop my knowledge on procurement in general and care procurement in particular, a field which was also completely new to me. As a result of a preliminary data analysis, the focus of Paper IV changed from quality to QI.

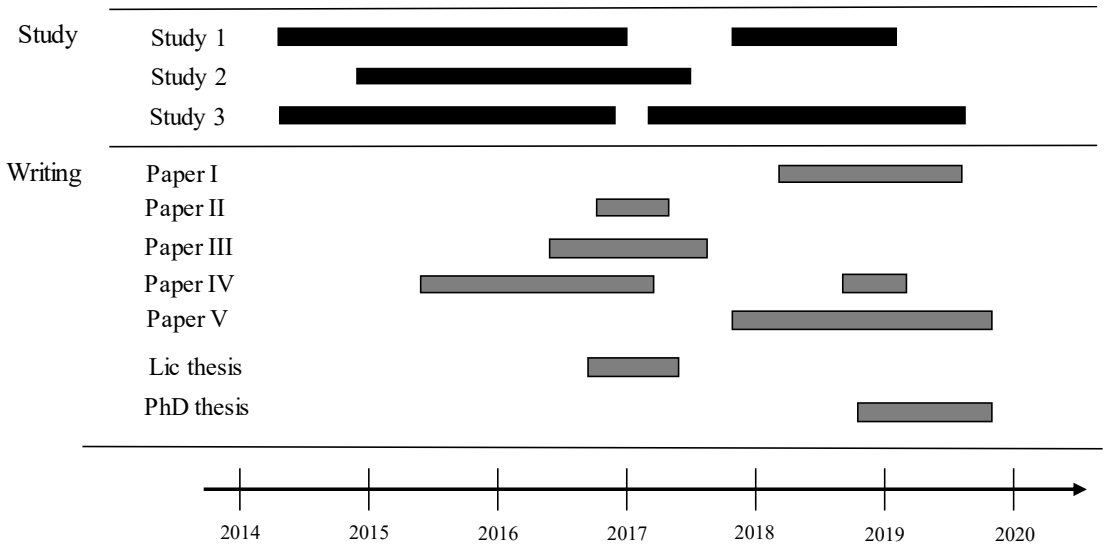

Figure 3.1 The research process timeline, starting in April 2014, ending in December 2019. 'Study' refers to time from study design through method education and data collection to data analysis. 'Writing' refers to the writing process of papers and theses. Notably, paper IV was substantially updated post licentiate thesis.

In 2015, the second collaboration with RCC West on process mining, which resulted in Paper III, was initiated, and data was collected and analysed. All three projects continued throughout 2016. However, during that year, the insights derived from Paper III resulted in Paper II. Due to time constraints from writing Paper II and as the research process

approached licentiate thesis writing and seminar, Study 1 was put on hold. However, before being put on hold, the method focus in Study 1 changed from control charts to Lexis diagram, as control charts do not visualise the associated care process complexity that the domain experts considered necessary for facilitating clinical understanding. Study 3 proceeded with writing up Paper IV. In 2017, Study 2 was completed while Study 3 resulted in Paper IV. The licentiate seminar was held in August 2017. In early 2017, three-year funding from the Swedish Quality Management Academy (SQMA) enabled a continuation of Study 3, encompassing research following the first-ever use of a BE model in a public care procurement setting (Paper V). Data collection resumed throughout 2018 until January 2019 for Paper I, and continued until April 2019 for Paper V; 2019 thereby involved an integrated data collection and analysis process as well as paper and doctoral thesis writing.

This doctoral thesis primarily contributes to QI by introducing novel insights to a research field already based on numerous theories. The intersection and addition of new methods and contexts formed the basis of the thesis, and the process of learning about such diverse subjects has represented a personal challenge. The focus on methods has resulted in a somewhat different emphasis on the appended papers in the thesis, with a lesser focus on Paper IV. However, Paper IV was essential for forming the contextual understanding necessary for Paper V.

The RCC West research projects could not have been possible without the collaboration of domain experts and the division of responsibility and labour within these collaborations. Both projects were designed so that I could learn the proposed methods and relevant software and manage all of the data analysis, including visualising data as per the request of the process owners and data expert, who possessed in-depth knowledge of the care processes and data sets. My engagement with the methods also ensured adequate time to test the methods and thoroughly scrutinise the data, which the various healthcare stakeholders did not have time to do. As the initiator of these projects, I also drove the process forward. This is important because time is a known limiting factor in collaboration and knowledge development settings (see, e.g., Brandrud et al., 2017; Nyström et al., 2018). Although joint ownership and research is encouraged in a collaborative research approach, such as interactive research that strives for collective ownership throughout the research project (Svensson et al., 2007), it was impossible to ensure equal collaboration in these projects as the domain experts were very busy and data analysis and method testing are time intensive. This division of labour (in this collaborative research) may be useful as a 'good enough' choice as it still fostered synergistic effects and mutual learning by integrating research and practice, which previous research has indicated is positive (Rowley et al., 2012; Marshall et al., 2013).

3.4 Study settings and study processes per paper

Four of the five papers included empirical data. Their study settings and processes are presented here. Note that Paper II had no specific study setting guiding the sampling due

to the scarce availability of papers regarding process mining in care. Further, the study process of the conceptual Paper II is presented in section 3.5.6 (the Literature review).

Swedish settings were selected in this research for several reasons (aside from the researchers being situated in Sweden). Sweden is considered a forerunner in healthcare organisation, with good medical outcomes, costs close to mean among both European and OECD countries (OECD, 2013), and well-developed documentation of welfare measures (e.g., quality registers). It is, therefore, an interesting country to learn from. Still, like many other countries, Sweden faces organisational problems with scarce resources and an ageing population, as well as increasing expectations from patients in healthcare (OECD, 2013). Sweden still requires further improvement to achieve timely and efficient care (Arvidsson, 2007) and more effective ways to utilise existing data more comprehensible, to produce a complete picture of individual care patterns and communicate this information between care groups (OECD, 2013). OECD (2013) concluded that, although Sweden has an advanced quality management system in healthcare, this system needs further development, particularly in social care sectors such as elderly care. Sweden is also particularly relevant to this study because of its abundant and relatively accessible data, collected in the national quality registers.

3.4.1 Study 1: Lexis diagram

Paper I

Study 1 was set in Western Sweden and focused on gynaecological cancer. Gynaecological cancer is a group of diagnoses that strike approximately 2,800 women annually in Sweden. The mortality is, except for ovarian cancer, relatively low for these diagnoses, making death a rare event. Gynaecological cancer was selected for several reasons. First, the gynaecological cancer care process owners are engaged and interested in collaborations involving innovative methods. Second, gynaecological cancer sub-diagnoses (ovarian, cervix, and corpus) exhibit low incidence and/or high survival, limiting timeliness in traditional statistical analyses. Third, the three diagnostic subgroups undergo different care processes and possess different patient characteristics, allowing a more comprehensive evaluation of the usefulness of Lexis diagrams in broader more diverse populations relative to analysing a single homogeneous group. Fourth, the completeness of the gynaecology cancer quality registry in Western Sweden is estimated at 100%, minimising the risk of bias from missing data.

Although being initiated and driven by the researchers, the collaboration between RCC West and CHI enabled joint knowledge acquisition between the healthcare domain expertise and academia. The domain experts contributed primarily with medical knowledge and experience within their fields, while along with colleague researchers from CHI, I contributed with methodological and engineering-based knowledge. All of the stakeholders possessed QI knowledge. The collaborative group consisted of four gynaecological cancer process owners (three surgeons and one oncologist) providing knowledge on all sub-groups

and the researcher. The process owners are active clinicians and are responsible for the care process and its development for the specific cancer diagnoses. To maximise their interpretability of the data, patient data known to the domain experts was used. In addition, to understand the structure of the patient data, the statistician responsible for the data extraction answered questions during a meeting, and on a few occasions, a co-researcher of mine joined the discussion.

The collaboration was mainly used for two purposes. First, to identify clinically relevant data and patient sub-groups, such as stratification on different uterine corpus sarcomas, and for guidance on data quality. Second, to discuss the usefulness of the Lexis diagram, evaluating both its strengths and limitations. The collaborative research process was similar to earlier research on method development (Street et al., 2007; see figure 3.2). During the data identification phase, the researcher studied the method while the process owners identified the relevant data. The data visualisation and analysis phases included several iterations, where the researcher visualised the data followed by meetings with the process owners who interpreted the graphics and identified potential ways to update and adjust the visualisations to enhance their clinical relevance and usefulness. Qualitative data was collected through dialogue during the analysis of the visualised quantitative patient data. The final result of the process was to produce context-specific, clinically relevant, and useful Lexis diagrams.

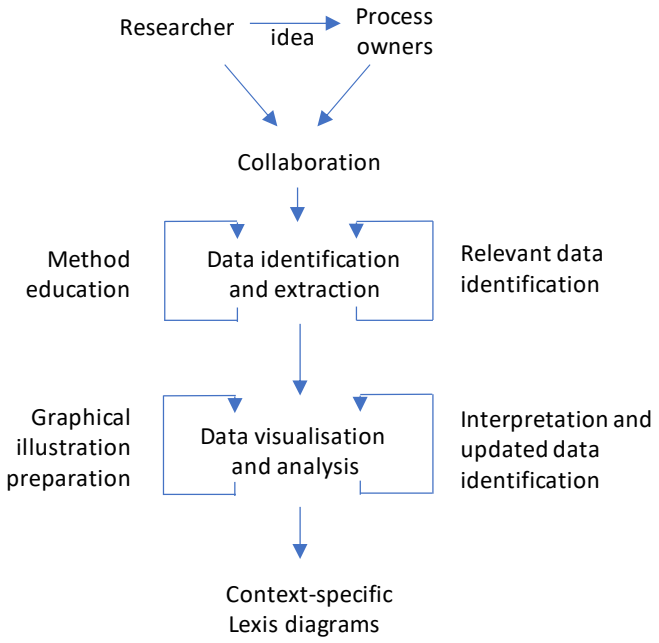

Figure 3.2. The research process in Study 1, Paper I, reflecting the collaboration, patient data identification, visualisation, and analysis. Note that the researcher's main contributions are stated on the left-hand side of the process, while the process owners' main contributions are stated on the right-hand side.

3.4.2 Study 2: Process mining

Paper III

This single case study aimed to explore the usefulness of process mining and focused on breast cancer patients for several reasons. First, breast cancer treatment has well-developed clinical guidelines; evidence-based best practices exist to guide care, which were assumed to result in identifying a reasonable amount of existing care pathways to the extent that the most frequent pathways could be identified and compared to existing process maps. Second, breast cancer is the most common type of cancer among women, representing 12% of new cancer cases globally and 25% of female cancer diagnoses (World Cancer Research Fund International, 2017). Third, the quality of breast cancer care has been researched from numerous angles, for example by comparing specific parts of care provision (Malin et al., 2002), timeliness (Li et al., 2013), costs, case-mix (Taplin et al., 1995), and outcomes (Malin et al., 2002; Walters et al., 2013). Other studies evaluate specific hospitals (Akhtar and Nadrah, 2005; Ishizaki et al., 2002), highlight inequalities in care, and have developed algorithms to identify patient pathways (Defossez et al., 2014). Despite this, there is still scare research on the connection between patient pathway variations and costs. As such, given that breast cancer treatment is common and highly expensive (Carlson, 2009), this patient group is especially interesting.

The collaboration group primarily consisted of a regional care process owner/active clinician, a data expert, and the researchers. The research process followed Phase I to VI of a slightly moderated version of the Clinical Pathway Analysis Model (CPAM; Caron et al., 2014) in line with Lismont et al. (2016; see Figure 3.3). Phase VII was excluded as improvement of pathways was beyond the scope of the paper.

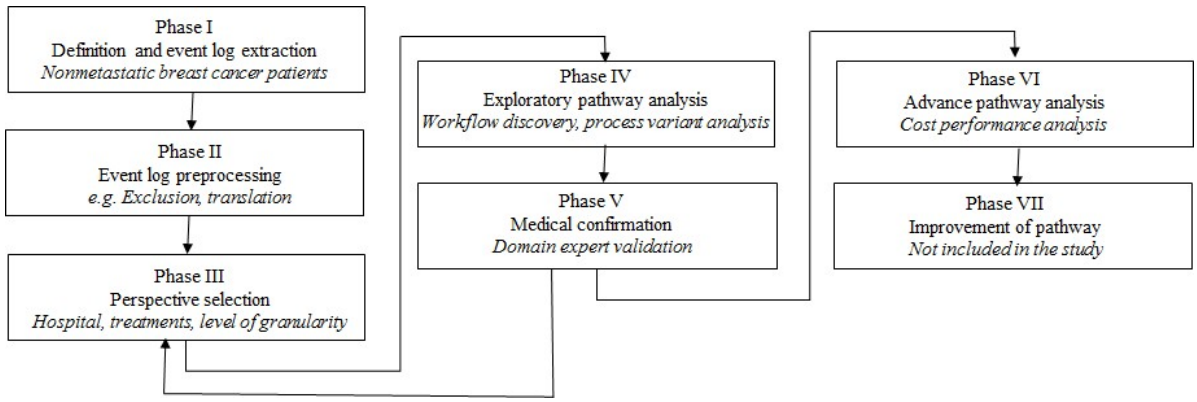

Figure 3.3. The research process in Study 2, Paper III. Inspired by Caron et al. (2014) and Lismont et al. (2016).

The healthcare stakeholders directed the data collection, provided feedback on the analysis, validated the results, and suggested possibilities to further the analysis. The researchers contributed by mining processes, performing the statistical analysis, and by joining the analysis discussion. Other healthcare stakeholders, such as local process owners, medical doctors, and nurses from the hospitals, contributed local process maps of their care

processes for comparison with the mined processes and to provide a contextual understanding of local hospital procedures, as well as, validate the results.

During the analysis, several decisions were made regarding system boundaries. For example, the patient pathways were limited to 14 months, which made comparisons between groups and within and between hospitals possible. Further information on the analytic decisions is reported in the appended Paper III.

3.4.3 Study 3: BE in public care procurement

Of the several care procurement settings that could have been selected for Paper IV, elderly residential homes were selected for three main reasons. First, it was necessary that the setting allowed the collection of a large number of comparable procurement documents, which form the basis of the contracts upon which 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) and therefore may be arguably valuable for informing international literature and practices. Third, the quality of publicly procured elderly care is important because i) it is a reoccurring topic in Swedish and international media after numerous bad examples have been highlighted, pushing the need for QI and ii) elderly care is increasingly handled by private caregivers, in contrast to municipality-driven care (Bergman and Jordahl, 2014; Øvretveit, 2003a). In recent years, approximately 14% of European Union GDP was assigned to public procurement (EU, 2017) and 7–8% GDP was spent on elderly care in the OECD (Ortiz-Ospina and Roser, 2019).

Significantly, the choice of elderly care implicates two relatively unexplored contexts in QI; public care procurement and social care. Social care is increasingly being explored in QI (Neubeck, 2016; Øvretveit and Klazinga, 2013) and features of QI specifically associated with social care have been identified (Neubeck et al., 2014). The gap between QI in health and social care is diminishing due to the increasing prevalence of multi-sick older people (Shier et al., 2013), and the fact that social care has adopted similar aims to those formulated in healthcare (IoM, 2001; Lawrence and Lindelius, 2009), in line with the needs identified by the OECD (2013).

Paper IV

Relative to the other empirical papers, the general research process was rather straightforward for Paper IV, although the focus changed from how quality is manifested in care procurement to how QI is manifested in care procurement. Procurement documents were predominantly collected, first, followed by a qualitative data analysis. After that, interviews were performed and used for triangulation and to supplement the procurement data, after which the procurement documents were re-analysed. Last, the qualitative data analysis rendered quantitative data collection and the use of quantitative research methods. Further details are presented in sections 3.5 (data collection) and 3.6 (data analysis).

Paper V

In Sweden, 290 small to large municipalities are responsible for the elderly care. Based on the aim of exploring the novel use of BE models to foster QI in public contractual relationships with a focus on expected and actual usefulness, a medium-sized municipality was studied over 2.5 years. The buyer and other stakeholders involved were followed throughout the project from the idea phase, through to the education phase, inclusion phase of the BE model in the procurement document, evaluation phase of the tendering, and finally, to the start-up phase of the contractual relationship between the selected partners. The researchers have followed the project and collected data from all phases of the project.

Four major stakeholder groups were included in the use of the BE model; municipalities (buyer and two other municipalities), care providers (potential and award-winning), elderly committees (politicians), and BE experts (educators and facilitators from one organisation). The municipality using the BE model has long experience in the public procurement of social care, as had the other municipalities and most of the care providers, whom all contributed subject matter knowledge from their respective fields, enrichening the contextual understanding.

As it is important to understand how to work with BE models (Eriksson, 2003a), education sessions were held for both the municipalities and potential care providers. The BE experts possessed expert knowledge on the BE model and QI, contributing through education and project facilitation. The project was facilitated not only through education, but the BE model experts also provided support for project planning, and thus, to some extent drove the project alongside the municipality, and also led the tender evaluation process using the BE model.

At the outset, our role as researchers was planned to be passive unless we received direct inquiries. However, in the later parts of the project, various circumstances such as high personnel turnover at different stakeholder organisations resulted in the loss of acquired knowledge. As such, as researchers, we ended up being two of the few individuals that had experience of the project from the start, and consequently, we had to discontinue our passive frame to become project facilitators during two workshops. This change in researcher roles may be seen as following the pragmatic view, where knowledge is used to solve real-world problems (Feilzer, 2010).

Data collection proceeded throughout the project, and a wide array of data collection methods were used, including interviews, observations, respondent diaries, documents, and workshops. Data analysis has been pursued and recorded in detail parallel with the data collection during the entire project. As the project proceeded, data analysis insights led to adjustments in the purpose but eventually resulted in the conclusions of the paper, see Figure 3.4.

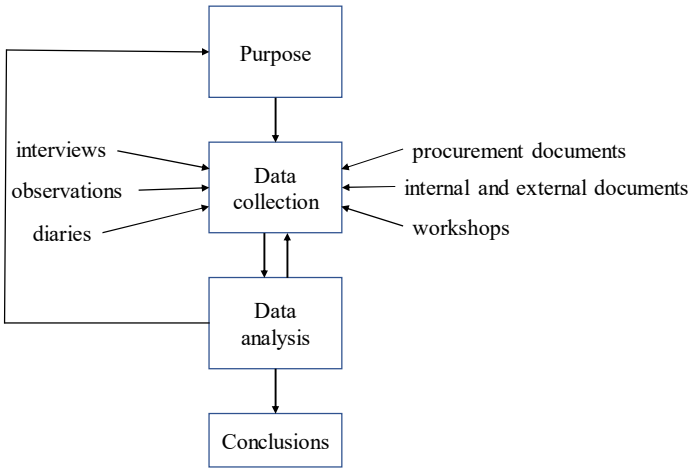

Figure 3.4 The research process in Study 3, Paper V. For more information, see data collection and analysis sections (3.5 and 3.6).

3.5 Data collection

To answer the research questions concerned with the usefulness of the methods studied in this thesis, the research strategy proposed testing these methods in collaboration with domain experts to further our understanding of the possibilities and limitations of using these methods for QI in care. To do so, a variety of qualitative and quantitative data were collected for triangulation, completeness, explaining the findings, illustrating the data, and instrument development (Doyle et al., 2009). Sampling has mainly been purposive, the research questions were answered based on rich information about the studied phenomenon (Teddlie and Yu, 2007) and on insights and experience from specifically selected stakeholders (Devers and Frankel, 2000) such as knowledgeable domain experts (Paper I and III) and from snowballing literature (Teddlie and Yu, 2007), as pursued in Paper II. Some level of convenience sampling (Etikan et al., 2016) can also be argued to have occurred, as other domain experts (and their data) possibly could have been chosen, but it was convenient to continue the already established collaboration between RCC West and CHI. Further details about data collection are elaborated upon below and summarised in Table 3.2.

Table 3.2 Methods used for data collection per paper. X denotes that the method has been used in the paper.

		Paper				
		I	**II**	**III**	**IV**	**V**
Data collection	Interviews/expert focus groups	X		X	X	X
	Observations/workshops					X
	Patient data	X		X		
	Documents				X	X
	Diaries					X
	Literature review		X			

3.5.1 Interviews/expert focus groups

In this thesis, semi-structured interviews enabled researchers to understand better the current real-world practices of stakeholders who shared their experiences, perceptions, and perspectives of the context (Wahyuni, 2012). Specifically, expert interviews were held that focused on the interviewees expert knowledge, rather than their personal narratives (Meuser and Nagel, 2009). Further, expert focus groups were additionally conducted to extract subject-matter knowledge and beliefs from a collective perspective (Gill et al., 2008), driven by discussions in the expert group (see, e.g., Kopperoinen et al., 2014).

Not only is subject-matter knowledge necessary for a contextual understanding in QI (Perla et al., 2013; Kaplan et al., 2012), it has also been shown to be central to successful method development (Street et al., 2007). Here, the interviews and focus groups fulfilled several purposes. First, to build contextual understanding, partly through triangulation of several stakeholder views (Paper I, III, IV and V), which has been shown to shed light on complex health issues on a multidimensional level (Farmer et al., 2006). Second, the interviews and focus groups ensured a clinically relevant data collection (Paper I and III) and analysis (Paper I and III). The interviews and focus groups are elaborated upon below and summarised in Table 3.3.

Table 3.3 Data collection per paper.

Paper	Number of stakeholders	Number of occasions	Time per occasion (min)	Type of data collection method
I	1–4	4	60–120	Expert focus group
II	n/a	n/a	n/a	n/a
III	1–2	6	60–180	Expert focus group
	3	3	40–90	Individual semi-structured interview (meeting or telephone)
	>1 (number unknown)	1	n/a	E-mail answer based on visualisations and open-ended questions discussed in a 'process group' during a local hospital meeting.
IV	7	11	45–100	Individual semi-structured interview (face-to-face or telephone)
V	12	12	30–90	Individual semi-structured interview (face-to-face or telephone)

*n/a = not applicable

Paper I

In Paper I, five expert focus groups (Gill et al., 2008) were conducted, which included 1–4 process owners, depending on their availability. To safeguard a contextual understanding, the statistician responsible for the data extraction at RCC West joined one meeting and clarified the details of the registry data used in the visualisations. Additionally, I was supported by a fellow researcher during three meetings, to support the data collection and

explain the potential of the different methods to the process owners. The focus groups lasted between 1–2 hours each and were always guided by the latest visualisations, updated based on discussions in the last focus group. During the early stages, the focus groups were mainly unstructured, similar to the approach of an informal interview (Gummesson, 2000), as questions were posed based on the ongoing discussions driven by the process owners and researchers. Clarification questions were asked during visualisation preparations via short e-mails to the relevant domain expert in-between the focus groups. At a later stage of the data collection, semi-structured questions related to the visualisation and methods' usefulness were asked; such as 'How do you work with visualising your data today?' and 'Do you find that Lexis diagrams are useful for you? If so, how?' This approach ensured a focus on both clinical relevance and method usefulness. All of the meetings were audio-recorded, and the central parts were transcribed. Field notes were also taken during the meetings.

Paper III

In Paper III, expert interviews (Meuser and Nagel, 2009) were held with the process owners and the data expert that created the event log on which the visualisations was based, including both the quality register and fiscal data. As in Paper I, the interviews were unstructured or semi-structured, leaving room for spontaneous discussions based on the interviewees' expertise. In total, the expert interviews involved six meetings lasting 60–180 min and several briefer conversations (approximately 5–15 min each).

In addition, to ensure the accurate interpretation of the mined care processes for each hospital, the results were presented to regional and local process owners, physicians, and nurses that were involved in breast cancer processes at each hospital between 2009 and 2012. Clinicians were asked to answer open-end questions regarding the mined processes and their structures, including whether the results align with real situations as misalignment has been identified as a potential problem in process mining (Suriadi et al., 2017). This data was primarily collected during one meeting and two telephone interviews, each lasting 40–90 min, and from detailed written feedback from a local process owner who had reflected on the results together with co-workers during a meeting. One meeting with the process owner was audio-recorded while notes were otherwise taken during each meeting/interview, followed by a longer memo written in connection to the meeting/interview.

Paper IV

In Paper IV, eleven semi-structured in-depth telephone or face-to-face interviews were held with seven managers from the procuring municipalities. The primary motivation underlying these interviews was to gain insight into their thoughts and goals when they had composed the procurement documents. These insights in turn deepened and expanded our understanding of the procurement documents, and lead to triangulation for confirmation

and completeness (Breitmayer et al., 1993). The interviews lasted 45–100 minutes and were all audio-recorded and transcribed verbatim.

Paper V

In Paper V, semi-structured interviews with different stakeholders were performed to collect as many stakeholder's perceptions of the BE model usefulness as possible, i.e. to achieve completeness (Breitmayer et al., 1993). A total of 12 stakeholders were interviewed, representing buyers, caregivers, educators/facilitators, and politicians. The interviews were conducted both over the telephone and face-to-face, lasted between 30 to over 90 minutes, and were also recorded and transcribed.

3.5.2 Observations

Participant observations were used for Paper V to passively observe the stakeholders in their social settings and context (Spradley, 1980; Yin, 2013) and to avoid disturbing the process so that more general conclusions could be drawn. Although a few questions were answered, and some clarifications were made, the focus remained on taking field notes regarding discussions, reactions, and group dynamics. As researchers, we participated in almost all of the key events (including meetings and educational sessions) but avoided the confidential procurement evaluation sessions. This produced insights into how the BE model was received by different stakeholders and included stakeholders' rationales for using the BE model and how their understanding of the model developed over time.

Towards the end of the project, two workshops were held with all three municipalities as well as the award-winning care provider. The aim was to understand the expectations of the participants regarding a planned partnership and to take the first steps towards outlining a framework for the partnership during the contractual period. At the workshop, as researchers, we took on a more prominent role than earlier, facilitating the activities alongside the educator/facilitator (Pierce et al., 2000). Still, we limited our activities as much as possible to facilitation and observation to reduce our impact on their discussions and conclusions. Specifically, one of us was more active while the other maintained a more observational role, predominantly taking notes and writing reflections. The workshops were audio-recorded, and observations collected throughout the research project facilitated a direct understanding of the group dynamics, individual reactions, and discussions.

3.5.3 Patient data: Quality registry and fiscal data

The national quality register is documentation that records individual patient data, covering patient problems, medical interventions, and outcomes after treatment (Nationella kvalitetsregister, 2019a). There are 96 quality registries in Sweden that have the aim of continuously improving care through research, knowledge support, and patient cooperation (Nationella kvalitetsregister, 2019b). All national quality registers are quality controlled annually by comparing them to medical records. The regional cancer centres are competence centres responsible for the cancer quality registers (Nationella

kvalitetsregister, 2019a) and relevant to this thesis, RCC West is responsible for both the breast cancer and gynaecological cancer registers.

Fiscal data for Region Västra Götaland is stored in a case-costing system, which enables the extraction of patient costs per health care visit (Eklind et al., 2015). Although the case-costing registries exist predominantly for budgeting purposes, there is ongoing research on the possibilities of using the data to improve the quality of care, as exemplified in this thesis. Fiscal data was continuously validated by comparing it with healthcare invoices and similar to the quality registers, it is considered to be high quality. Both the quality registries and case-costing data are available for research once ethical approval has been granted if deemed necessary by the ethical board.

Paper I

Data from the gynaecological quality register was used for Paper I, including all patient data from Region Västra Götaland from the start of the registers of the three sub diagnoses; ovarian cancer (from 2008), cervix cancer (from 2011), and corpus cancer (from 2010) until the last quality-controlled data had been collected; that is, patients diagnosed until 31 December 2016. Surviving patients were subsequently followed until death or data extraction on 17 November 2018. Patient data included the structure, process, and outcome data reflecting care process key events (surgery, treatment, relapse and death) and time stamps as well as patient attribute data (e.g., age).

Paper III

In paper III, the extracted data included breast cancer patient data and fiscal data for breast cancer patients in Region Västra Götaland from 2009–2012. The data were pre-processed by a responsible data expert in Region Västra Götaland, forming an event log data set in which each row in the data set represented one event for one patient at a specific point in time. As the event log for Paper III mainly included the structure, process, and fiscal data, such as hospital and patient information, time stamps, and costs, this data became the basis of the analysis. The lack of outcome measures was not considered a problem, as the one-year survival rate was high, and thus, not affected by differences in the care processes. Patient-reported outcome measures (PROMs; Marshall et al., 2006) would have been interesting to include but were not measured for breast cancer until recently and were therefore absent from the event logs.

3.5.4 Documents

Documents were used in Paper IV and V to draw conclusions regarding the activities, ideas, and intentions of the procuring organisation (Wolff, 2004). While procurement documents and documents related to using the BE model, constituted the main body of documents used, other internal and external documents were also used, as presented below. The different documents contributed with both unique insights and confirmation or support to draw conclusions on other data (Layder, 1998).

Paper IV

Based on the limited research on QI in public care procurement, Paper IV serves to examine the current state of QI in public care procurement. As procured care is based on a contract, which is in turn based on procurement documents, these documents may be assumed to form the basis of the QI activities, ideas, and intentions of the procuring organisation. Procurement documents were therefore collected from the database Visma opic (www.visma.com), which is said to be the most comprehensive database for Swedish procurement documents. This study used purposive sampling (Devers and Frankel, 2000) by limiting the research to a Swedish setting and further focusing on the relatively homogenous group of procurements for elderly residential care. Thereby, variables of no interest were held constant, allowing for reliable comparisons (Flick, 2014). The use of data on the procurement of elderly care allowed for a relatively large sample of 71 procurements to be collected from January 2013 to June 2015. This was large enough to reach saturation (Strauss, 1987) and therefore enabled comparisons across the sample population. All of the procurement documents followed a basic structure based on 2–3 qualification steps in the procurement process: i) Pre-qualification based on economic feasibility during the contractual period, ii) set basic requirements on the care provided, and, if applicable, iii) additional quality-based requirements to distinguish between tenderers. The latter two were the focus of Paper IV.

Paper V

After identifying how QI is manifested in public care procurement, the specific case researched in Paper V explored a new way of working to ensure QI in public procured care. Documents collected were procurement documents, including specifications, contracts, and protocols from the negotiations, as well as internal and external documents related to the specific case study of using the BE model for care procurement, such as meeting protocols and notes, education materials, and annual reports. The results of the assessment based on the BE model were summarised in a feedback report, that also forms a part of the documentation used in this research. To gain a broad view of the current challenges of procured elderly care within the municipality, newspaper articles were also collected.

3.5.5 Diaries

Solicited diaries (Verma et al., 2012) were used in Paper V to gain an understanding of how the participants of the project reflected on the process. The diaries also ensured that the participants had access to their reflections during the later stages of the process. The participants were asked to reflect on the key steps of the process, such as educational sessions, individual work assignments and meetings, and write in the diary in close proximity of each occasion. The diary included a space for dates and space for recording thoughts, ideas, pre-assumptions, questions, improvement suggestions, strengths, and other aspects that the participants found relevant to the project. Three diaries out of ten were used and returned.

3.5.6 Literature review

A literature review was, as is normal procedure in research, pursued in all studies. However, specific attention is here given to Paper II, which was written as a narrative literature review. Frank et al. (2014) concluded that 'narrative literature reviews are appropriate for describing the history or development of a problem and its solution' (p. 99). A systematic literature review based on a pre-defined set of journals and keywords was discarded due to the many weak and complex connections between process mining and QI rendering very few hits in systematic literature searches. Data was instead collected through i) an existing literature review on process mining in healthcare (Rojas et al., 2016), and ii) an extensive snowballing literature review, which together ensured a comprehensive understanding of the field.

All papers were read at least once and sometimes multiple times. Several questions guided the analysis: 'What has been done?', 'Is there any QI connection (if so, which)?', and 'Is healthcare collaboration included (if so, how)'? The analysis proved very useful for acquiring an overview of the field but also in the discussions among the researchers interested in grasping the complexity of the topic. Two process mining cases were identified as having clear connections to QI, exemplifying the synchronic and diachronic variation of healthcare processes (Bergman et al., 2015) and highlighting the potential for longitudinal studies and comparisons between the factors (e.g., hospitals) to ensure equity of care, which is an aim of QI (IoM, 2001).

3.6 Data analysis

As with the data collection, no specific preference was given to qualitative or quantitative methods. Rather, each analytic method was used based on a pragmatic perspective that aimed at obtaining a comprehensive answer to each research question. In line with Jick (1979) and Flyvbjerg (2006), the qualitative and quantitative data often complemented each other in the analysis; for example, the qualitative expert focus group data supplemented and supported a further understanding of the quantitative data presented in the Lexis diagram. A summary of the data analysis methods used in each paper can be found in Table 3.4.

Table 3.4 Summary of methods used for data analysis per paper. X denotes that the method has been used in the paper.

		Paper				
		I	II*	III	IV	V
Data analysis	Content analysis	X			X	X
	Exploratory data analysis	X		X		
	Statistical analysis			X	X	

* not applicable; for information about Paper II, see section 3.5.6 Literature review.

3.6.1 Content analysis

To analyse the qualitative data and identify themes, trends, criteria, or quotes, content analysis was used as an overarching analysis method in Papers I, IV, and V. To be open to new, unexpected insights, the analysis were not based on any existing framework, although prior theoretical knowledge was used to guide and limit the analysis to facets important to QI.

Paper I

For Paper I, the purpose of the research was to explore the potential of Lexis diagrams to support QI through survival data analysis, focusing on feedback, timeliness, and complexity. Based on the collaboration with process owners to ensure relevance, the collected data comprised of audio-recorded focus groups and additional field notes taken directly after each meeting. The data was analysed several times by listening to the recordings and writing summaries. As different interviewees were present in the focus groups, the data from the different focus groups were compared to discover key discussions and conclusions related to QI. The focus group data analysis produced illustrative quotes used to highlight key aspects of the process owners' perceptions of the method's usefulness for QI.

Paper IV

As procurement documents had been collected and interviews transcribed, they were inductively analysed inspired by and following the guidelines of, the constant comparison method (Glaser and Strauss, 2009). In this way, all of the data was constantly compared to all of the other data in the data set (O'Connor et al., 2008) as well as to the literature and the researchers' prior knowledge of QI. The data was also re-evaluated iteratively through the identified criterion (Flick, 2014). The procurement document content was initially categorised depending on the initial procurement document's wording, but later these criteria became more general, comparable to previously established QI criteria. To strengthen the document analysis, an interview data analysis was used to validate the results as well as identify additional criterion. The generalised identified QI criteria allowed for comparisons of established BE criteria, leading to a general assessment of QI in care procurement. NVivo 10 was used for the data analysis in this study.

Notably, as the procurement documents were composed, both in terms of design and diction somewhat differently compared to each other, it was necessary to read all of the procurement documents carefully and, with the expertise accumulated over time, interpret the content. If there had not been such heterogeneity in the language of care procurement, a quantitative study based on word counts could have been considered.

Paper V

In Paper V, the longitudinal approach included several data collection points distributed over time, which were continuously analysed throughout the project. The data were discussed throughout the project, and detailed records were kept. Transcripts, field notes,

and memos were frequently read and discussed; and new interpretations, thoughts, and questions were noted in the memos. Procurement documents, contracts, and feedback reports were analysed similarly. Usually, both researchers read the material separately, resulting in comments and questions. After that, the data was discussed and elaborated upon, and notes were compared. New notes were created on the new questions and thoughts that emerged. The focus of the data analysis was to search for patterns in the data to understand how BE models foster QI in public contractual relationships, with a specific focus on their usefulness.

3.6.2 Exploratory data analysis

Exploratory data analysis (De Mast and Trip, 2007) was chosen to analyse both case studies including patient data (Paper I and III) given the presence of a rich data set alongside the limited prior knowledge on the usefulness of the methods. Moreover, the versatility of both methods (De Weerdt et al., 2012; Francis and Pritchard, 2000), opened new avenues for exploring several different visualisations. These preconditions were suited to the strengths of exploratory data analysis; to rely on visualisations to acquire knowledge from the data and form an understanding of what appears to be occurring (Tukey, 1980). This method contrasts confirmatory data analysis, which searches for statistical significance based on previously posed or determined questions, and may follow an exploratory data analysis (Tukey and Tukey, 1988).

Paper I

The use of Lexis diagrams was not the immediate or direct method choice for Paper I, rather the primary aim was to use control charts for rare events (Santiago and Smith, 2013) as a new way to analyse survival data. However, when the time between individual deaths was visualised, the process owners lacked additional data to draw conclusions, such as the time between diagnosis and death or whether the patients had relapsed. Thus, several variables and events needed to be visualised in one graphical presentation, while QI preferences included the need to follow the process over time (Provost, 2011). The Lexis diagram seemed to be a promising means of fulfilling both needs and was therefore chosen instead of control charts. Different Lexis diagram visualisations were explored together with the process owners. Specifically, the usefulness of different colours and markings were analysed to determine whether it was possible to visualise the relevant data in an intelligible way. Notably, although further advancements of the Lexis diagram exist, (see, e.g., Rau et al., 2017), Paper I used the basic Lexis diagram to fulfil the QI requirement to keep the visualisation as simple as possible (Plsek, 1999) and to enable visualisation at both the individual and population level (Jiang et al., 2016). The data was analysed using the Epi package in the programming software R Studios (Carstensen et al., 2008) while supporting pre-processing was performed in MS (Microsoft) Excel.

Paper III

The explorative data analysis in Paper III included exploring visualisations based on the nature of the event data log and clinical relevance. This included exploring different types of process mining visualisations (Mans et al., 2009) to ensure the correct level of abstraction and granularity for clinical relevance and high data quality (Mans et al., 2013; Jagadeesh Chandra Bose et al., 2013). This resulted in focusing on some major patient pathway events and limiting the use of timestamps on dates. Several different software programs were used. The 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 converting the file formats.

3.6.3 Statistical analyses

Statistical analysis was used in Paper III and IV, and may partly be understood as confirmatory data analysis, following the exploratory data analysis (Tukey and Tukey, 1988), to assess the significance and present descriptive data.

Paper III

The event data log was stratified in two ways; by i) surgery hospital and ii) identified patient groups, both of which were based on the process owners' expertise. Then, within each patient group, the most frequent, less frequent, and unique pathways were identified through exploratory data analysis. Statistical significance calculations were then performed regarding the cost differences between the three identified pathway types for each patient subgroup. To ensure the correct method of significance testing was applied, the cost distribution of each group was analysed in SAS JMP 13 before significance testing. SAS JMP 13 was also used for the statistical analysis. Additionally, descriptive statistics were included to provide an overview of the data, and these were generated using SAS JMP 13 and MS Excel.

Paper IV

In Paper IV, non-parametric rank correlation analyses were performed to identify correlations between the identified maturity levels for each criterion and municipality size, year of procurement, and contract length. Descriptive statistics were produced to provide an overview of the quantitative data, and again, SAS JMP 13 was used for the statistical analysis.

3.7 Research quality and ethical considerations

As mixed methods were used in this thesis, it is not self-evident whether the research should seek to utilise validity and reliability (Bryman and Bell, 2011) or trustworthiness (Guba and Lincoln, 1989) when it comes to discussing the quality of the research. Trustworthiness consists of four criteria: credibility, transferability, dependability, and confirmability (Guba and Lincoln, 1989), and these will be explained and elaborated upon below. While validity and reliability imply measurable quantitative research (Bryman and Bell, 2011), Guba and Lincoln (1989) emphasise the use of the term trustworthiness when conducting qualitative

research. Going to the core of the research with its focus on usefulness, it could also be argued that even though there are quantitative aspects of the studies, regardless of efforts taken to be objective, the researchers' and domain experts' interpretations colour the results produced. This means that another researcher (possibly in collaboration with other domain experts) might come up with somewhat different conclusions. Additionally, my conclusions have mainly been based on qualitative data. Therefore, trustworthiness was used as a measure of quality in this thesis; however, it was linked to validity and reliability as presented by Bryman and Bell (2011). For a summary, see Table 3.5.

3.7.1 Credibility

Like internal validity, credibility depends on whether the researcher's results and conclusions align with the account of the respondent. This means that the researcher should have the same understanding as the respondent, and this can be achieved using methods such as confirmation from domain experts or triangulation (Bryman and Bell, 2011). In Paper I and III, close collaboration with domain experts throughout the research helped to ensure the credibility of the results. In Paper IV and V, the data were triangulated to ensure the study's credibility (Flick, 2014). Specifically, investigator triangulation (Denzin, 1970) was used to reduce researcher bias during the identification and grading of QI criteria in Paper IV and both researchers discussed and compared insights throughout the analysis in Paper V. Further, interviews with municipalities were used to confirm and extend the criteria identified during procurement document analysis in Paper IV. Increased credibility in Paper IV might have resulted from reading the tender documents from the tendering care providers, as some parts of the procurement documents do not provide much information regarding the QI level per se. One example was the statement 'describe your quality management system'. This problem was handled by focusing on the clarity and reasoning surrounding the requirements of the procurement documents, and good examples were identified where factors such as quality management system requirements were further elaborated upon. The credibility of the data posed fewer problems in Paper V, although procurement documents were also analysed here without their respective tender documents from the tendering care providers. Credibility in Paper V was instead ensured through other sources, including the BE model and feedback report, which enabled triangulation and thereby reduced the risk of misinterpretation.

3.7.2 Transferability

Like external validity, transferability concerns whether the results can be converted into generalizable claims, that is, whether they can be transferred and applied to another setting or context. Yin (2013) presents two kinds of generalisation (similar to transferability): statistical generalisation, where the results are generalised to a larger population, and analytic generalisation, where the focus is not on that specific population but rather on highlighting a certain theoretical concept or principle. All of the studies in this thesis are based on analytic generalisation, as the samples were either too small or represented a population too context-based and dynamic for statistical generalizability (Yin, 2013). By

being conceptual rather than empirical and by reviewing studies covering different care settings, Paper II could be transferable within the field of QI irrespective of context. What is necessary for transferability of process mining is the existence of event data concerning the process of interest. Although Paper I and Paper III focus on a specific setting, it can be arguably assumed that similar results in terms of the usefulness of the Lexis diagram and process mining as well as the identified variation in present care pathways and costs will likely be found in other care settings. Further research on each specific setting is necessary, but these results can be used as a starting point. Nevertheless, the dynamic nature of care settings should be noted, and time may change the transferability of these results (Lincoln and Guba, 1985). Regarding Paper IV and V, neither papers' results were assumed to be transferable outside of the public care procurement context and possibly not for countries outside of the EU. While the QI criteria identified in Paper IV are likely transferable to other care procurement contexts as the criteria were general, the good and bad examples, however, might be less amenable to transfer. Similarly, it can be expected that some of the usefulness factors and challenges identified in Paper V can be discovered in other contexts as well. 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.

3.7.3 Dependability

Dependability is sometimes called trackability, as another researcher should be able to track the research process and shifts within it and this parallels reliability. Dependability can be ensured by keeping a complete record of the research process so that auditing can be performed. Due to the use of an exploratory approach, not all twists and turns could be followed in these studies. Still, Paper I arguably had good dependability as all of the focus groups had been audio-recorded, and the steps of the analysis had been documented. Paper III was more explorative by, for example, using different process mining visualisations throughout the data analysis, which were not fully recorded. Dependability was addressed in Paper I and III through the production of a detailed step-by-step description of how to produce the final visualisations. However, the extraction of patient data requires approval from an ethical committee if the research process should be repeated. The trackability of Paper II was managed through questions that guided the analysis but could have been improved if a systematic literature review had been possible. For Paper IV, dependability has been addressed by saving all documents, and by performing the analysis on NVivo 10 together with field notes in MS Excel to record details such as the classification, quotes, and comments on the documents. All of the interviews were transcribed verbatim. Lastly, for Paper V, the meetings and interviews were documented either with the use of field notes or audio-recordings. Additionally, as no confidential data had been collected, all documentation was saved, together with the notes taken throughout the research meetings during the data analysis.

3.7.4 Confirmability

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. In Paper I and III, the domain experts have guided the patient data collection and analysis decisions and reduced the risk of researcher bias. Confirmability is on the other hand a potential problem in Papers IV and V, despite the researchers' attempts to act in good faith, as some level of subjectivity was involved in criteria identification and procurement grading in Paper IV and in interpreting the collected data in Paper V. To address confirmability and avoid bias, the research group discussed each step of the analysis and reached a consensus in both Paper IV and Paper V.

Table 3.5 Measures taken to ensure research quality of each paper.

Paper	Credibility	Transferability	Dependability	Confirmability
I	Close collaboration with domain experts.	Partially - in a similar context.	Audio-recordings of focus groups and notes recorded for the remaining qualitative data collection. Data analysis is documented step-by-step.	Major patient data collection and analysis decisions guided by domain experts.
II	n/a*	Yes, it is a conceptual paper.	Documented literature review.	All papers included questions guiding the analysis.
III	Close collaboration with domain experts.	Partially – in a similar context.	Notes recorded for entire qualitative data collection. Data analysis steps are documented.	Major patient data collection and analysis decisions guided by domain experts.
IV	Investigator and data triangulation.	Potentially for the QI criteria. Otherwise, partially, in a similar context.	Coding and other documentation saved. Interviews transcribed verbatim.	Consensus discussions in the research group.
V	Investigator and data triangulation.	Partially, in a similar context.	Observations and interviews documented either by field notes or audio-recordings.	Consensus discussions in the research group.

*n/a = not applicable

3.7.5 Ethical considerations

Ethical approval was granted for the use of patient data in the empirical study in Paper III. In addition, the ethical board concluded that the data extraction for Paper I was not covered by the Ethical Review Act and they had no concerns against the use of the data. RCC West subsequently approved the use of extracted patient data for Paper I. Ethical considerations have otherwise followed standard research ethics, such as voluntary participation in interviews, observations, and focus groups, with the option to withdraw at any time, however, without signing informed consent forms.

4. SUMMARY OF APPENDED PAPERS

This chapter provides a summary of the purpose, results, and conclusions of each of the five appended papers.

4.1 Paper I: 'Exploring the usefulness of Lexis diagrams for quality improvement'

The purpose of this paper is to explore the potential of Lexis diagrams to support QI through survival data analysis, focusing on feedback, timeliness, and complexity. Lexis diagrams are chosen as they can be used to visualise multiple process factors at the same time, which is interesting for survival data and results in the visualisation of both individual and population-level data supporting clinical understanding, which has shown to be important in earlier research. Lexis diagrams may further support graphical excellence being 'that which gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space and which tells the truth about the data' (Tufte, 2001, p. 51) and the combination of Lexis diagrams, survival data, and support for QI seems still unaddressed.

An iterative process of data visualisation and analysis together with process owners indicated the usefulness of Lexis diagrams for QI. Specifically, Lexis diagrams facilitated the continuous, close to real-time update of data, enabling timeliness and timely feedback. The visualisation of attribute data revealed the complexity of that data, and this was demonstrated as useful to support important discussions between practitioners, facilitate the evaluation of the care provided, and potentially aid the identification of future QI efforts. The indication of data trends was perceived useful in hypothesis building, which may later be statistically tested using traditional survival curves. Therefore, Lexis diagrams were considered complementary to survival curves. Additionally, the individual lifelines plotted in the Lexis diagrams increased patient focus and could potentially be used to motivate both healthcare practitioners and managers. However, the inclusion of too many data points in a single visualisation cluttered the plot, reduced understanding, and thus, the development of interactive Lexis diagram visualisation is encouraged, as is the use of other types of Lexis diagrams handling larger data sets. To ensure the correct interpretation of data, it is also important to educate new users and to establish high-input data quality.

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

The purpose of this study was to understand how process mining can be used to support QI. This study compared the understanding of variation, using process mapping and KPIs, with 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 were explained, and differences in the various factors, such as the goals, nature of the data, staff roles, and the frameworks of both methodologies, were presented, and their main advantages and limitations were discussed. For example, process mapping facilitates the discussion and understanding between collaborating domain experts during process identification, but this knowledge can also be achieved by validating automatically mined processes, for which domain expert knowledge is crucial. Two cases exemplifying the ways in which process mining can be used to identify synchronic and diachronic variation were presented, with a step-by-step model of the pursuance of process mining.

Subsequently, four propositions pertaining to the practice of ways to include process mining in QI were proposed: 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 necessary research on process mining in QI were also suggested: i) How process mining can be integrated into QI of patient pathways and healthcare processes; ii) how health information systems in general, and process mining in particular, can be used for developing measurement systems that can be used for quality improvement purposes; and iii) how process mining and clinical knowledge can be combined with patient experience to facilitate QI for patient pathways (and for reality-check purposes) in a resource-efficient way. The aim of these propositions was to support healthcare to ensure that it can adopt process mining in a systematic way, and encourage further research to develop the potential for the use of process mining in QI.

The authors posited that process mining should be incorporated into QI to complement process mapping following healthcare digitalisation, to support the work of researchers and practitioners by driving QI through process visualisation and understanding. In addition, the findings could support data scientists in the process mining research field in identifying more effective means of implementing process mining and improving care quality.

4.3 Paper III: 'Relationship between patient costs and patient pathways'

This study explored the use of process mining in understanding the relationship between patient pathways and patient cost variations, with a two-fold purpose as follows: i) Identifying and comparing pathways within different patient groups; and ii) analysing the cost variations based on the individual patient groups and their pathways. To ensure that the results were relevant to healthcare, the analysis was performed in collaboration with domain experts.

In earlier studies, the standardisation of to-be care pathways was shown to reduce costs; however, these studies did not consider the high level of variation of as-is care pathways. Identification of as-is care pathway types (most frequent, less frequent, and unique pathways) through process mining, based on four patient groups receiving different medical treatment and their relation to patient costs revealed several insights. Unique pathways

were the most overall expensive pathway type if significant differences between the pathway types could be identified. Earlier studies were confirmed for mastectomy patients as most frequent pathways had lower cost, whereas contracting and inconclusive results emerged for partial mastectomy patient groups. These findings indicate that factors other than the standardisation of to-be pathways, such as treatment outcome priorities, affected cost patterns. Moreover, other benefits of standardisation could be prevalent; the hospital with the strongest focus on their to-be care pathway showed the highest proportion of patients who followed the most frequent pathway and few patients followed unique pathways. Although this hospital was not the cheapest overall, the median lead time between diagnosis and surgery was shorter relative to those for other hospitals, potentially because of the organisation of a one-stop-shop clinic.

4.4. Paper IV: 'Exploring criteria for quality improvement in care procurement'

The purpose of this study was to explore how QI is manifested in care procurement, through the development and analysis of QI criteria in this context. The study was based on 71 procurement documents and 11 in-depth interviews with managers from procuring municipalities.

The study identified 11 QI criteria and compared them to known BE themes. The research findings and analysis suggested that the external context of care procurement embraced certain important parts of QI, while other parts of QI, such as process and systems perspectives, were largely neglected. In addition, there were high levels of variability in the identified criteria, revealing differences in the extent to which the QI criteria were well developed in the procurement documents. While the well-developed criteria included external evaluation, cooperation, QI aim, use of quality registries, and workforce training, others require further attention. Importantly, QI leadership and the potential for harnessing employee ideas require increased attention in future care procurement. Overall, there was a strong focus on the patient perspective, which permeated the other identified QI criteria but might have occurred at the expense of organisation-focused processes and systems perspectives. The lack of criteria regarding agility and the future perspective demonstrated the static view of quality, as did the focus on monitoring, rather than improving, in evaluation. Nevertheless, several procurement documents aimed for QI, and long contract length was positively correlated with QI, which included encouragement of new thinking and workforce training. Moreover, there was some indication that there was an increase in the incorporation of QI into care procurement over the years.

Good examples identified via grading could serve as inspiration for care buyers in public organisations during the design of procurement documents, and the identified correlation could inspire learning between municipalities; therefore, these results could enhance future care procurement to become drivers for QI. The results could also be used as a point of departure for QI researchers, allowing them to elaborate on the integration of QI in care

procurement or commissioning and developing best practice or standards for evaluating QI in care procurement. A second possible development suggested was the use of a BE model in public care procurement, which may strengthen the focus of QI in care procurement. Research on BE in public procurement is limited, and hence, BE researchers were encouraged to do more studies in the public care procurement context.

4.5 Paper V: 'The use of business excellence models to foster quality improvement in public contractual relationships'

This study aimed to explore the novel use of BE models to foster QI in public contractual relationships with a focus on expected and actual usefulness. While previous research focused on the assessment and improvement of single organisations, this study sought to determine how BE models are used for cooperation between organisations to improve QI efforts between the two parties.

A case study was conducted, and data were collected via interviews, participation observations, workshops, procurement documents, reflective diaries, and internal (non-public) and external (public) documentation. The findings included the expected usefulness of the BE model for care procurement, based on the views of four different key stakeholders; buyer, care provider, politicians and BE model experts, and actual usefulness of the model, based on how the model was used. The stakeholders had disparate expectations on the BE model, including driving a dynamic view on quality, ensuring that the care provider rather than the buyer stipulates quality, identifying mature tendering organisations and subsequent QI efforts, and increasing objectivity in the awarding decision. Overall, the stakeholders were positive towards the model and had high hopes that it would contribute to QI. However, the findings indicated that it was mainly the expected usefulness directly related to the structured BE model that was realised, while challenges related to insecurity, lack of understanding, and limited education in combination with over-reliance on the BE model to foster QI may have hindered other expected usefulness from being realised.

The analysis resulted in two propositions for research: i) to understand if, how, and to what extent the challenges of insecurity, lack of understanding and over-reliance of the BE model reducing the drive for QI may be mitigated, and ii) to understand how to develop and ensure a culture that can manage multiple stakeholders in the contractual relationship and the development of a partnership. Two propositions for practice were also formulated: i) Ensuring that enough time, education, and expert support are available in the novel use of a BE model for public care procurement, thereby being prepared for the additional challenges arising from, for example, the forced collaboration between contracting parties; and ii) buyer organisations should make a strategic plan, which includes both expectations and processes, for how to incorporate the BE model into daily work.

The study extends previous QI research, in particular, by broadening the novel use and usefulness of BE models between stakeholders and within and between organisations, with

insights of how stakeholders use and incorporate the BE models into the context of public are procurement as well as identifying challenges that come with using these types of models.

5. RESULTS AND ANALYSIS

The purpose of this thesis is to explore the usefulness of methods describing care complexity for QI in care. This chapter focuses on presenting and analysing the results within and across the three studies presented in the thesis to answer the two research questions presented in the introduction.

5.1. Method properties to describe care complexity

This thesis focuses on methods describing care complexity. A method's ability to describe complexity is dependent on its properties and reflects its usefulness. This argument is illustrated in two examples from current research: i) Plsek (1999) encouraged the use of methods with certain properties, such as producing simple, graphical displays of information, to ensure that data are easily understandable by practitioners (the usefulness, in this case, is that the data become understandable by practitioners); and ii) Provost (2011) argued for methods that display data over time, to follow change and predict future trends. The property of the method is to display data over time, while its usefulness is prediction. Therefore, there is a direct link between methods' properties and usefulness regarding a certain focus, and in this case, method properties are related to describing care complexity, and method usefulness is related to QI. Therefore, in this thesis, relevant method properties were related to describing care complexity. Notably, two methods that describe care complexity in different ways require identification of two different sets of method properties.

As noted by several scholars (see, e.g., Batalden and Stoltz, 1995; Perla et al., 2013; Parry, 2014), the use of methods and interpretation of results are contingent on subject-matter knowledge; therefore, the research design ensured that exploration of method usefulness for QI in care was driven by subject-matter knowledge. However, because of the use of the explorative approach and lack of existing frameworks for categorising method usefulness, no specific theoretical frameworks guided the analysis and presentation of usefulness results.

5.2 RQ1: What usefulness can visual methods describing care process complexity have for QI?

The first research question (RQ1) is *'What usefulness can visual methods describing care process complexity have for QI?'* Two methods addressing care process complexity through different visualisations were explored in this thesis: Lexis diagrams and process mining. To clarify the potential gain that would be added to QI through the explored methods, each method was compared to a traditional method used to analyse the chosen type of care process data; the Lexis diagram was compared to survival curves, and process mining was compared to process mapping. As visualisation is central for all four methods, Figure 5.1 presents a typical visualisation from each method.

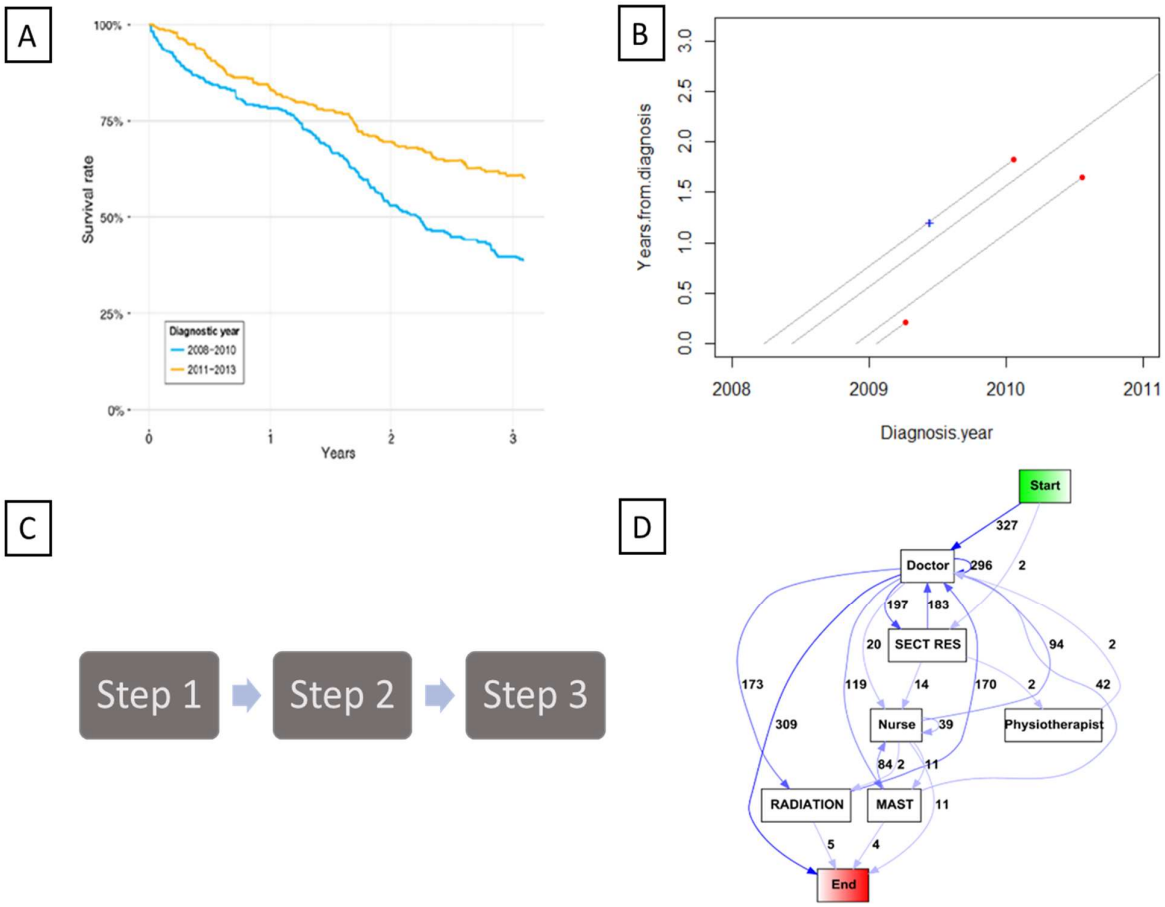

Figure 5.1. Examples of visualisations resulting from the four methods; A and C are current methods, while B and D are proposed new quality improvement methods. 5.1A: Kaplan-Meier survival curves (Reprinted from Dahm-Kähler et al., 2016, with permission from Elsevier). 5.1B: Example of a Lexis diagram of four individuals, with coloured markings denoting death (dots) or intermediate events (crosses). 5.1C: Simple example of a process map. 5.1D: Example of a mined process (from the conference poster of Paper III). Each square refers to an event, arrows refers to the transition between two events, and numbers refer to the number of patients following each transition.

Table 5.1 summarises the results of each study based on the appended papers (i.e., Papers I, II, and III); the results are presented to i) contrast the traditional and explored new methods and ii) facilitate comparison between all four of the methods related to RQ1. Table 5.1 presents a set of method properties that have been identified as reflective of how the methods describe care process complexity, along with the identified types of usefulness for each method. The explorative analysis demonstrated that the methods could be useful for two types of benefit: *evaluative* and *organisational*. *Evaluative benefits* are closely related to how the method is useful in understanding the complexity of the care process itself, which could be used to improve the specific care process. *Organisational benefit* pertains to the usefulness of the method to drive or support organisational QI issues.

Table 5.1 Summary of the results of Studies 1 and 2 divided into the method's properties and benefits for QI. Bold text represents the findings of the studies, plain text with references is that taken from literature and mentioned in the papers, while plain text without references reflects basic method knowledge.

		Study 1 Paper I		**Study 2** Papers II & III	
	Case data	Survival care process data, gynaecological cancer		Care process and cost data, breast cancer	
	Existing/new method	Kaplan-Meier survival curves	Lexis diagrams	Process mapping	Process mining
Methods' properties	Aim for QI	Before-after survival analysis to identify statistically significant improvement (Kristoffersen et al., 2015)	**Continuous care process evaluation and improvement**	Care process understanding, and improvement (Trebble et al., 2010)	Continuous care process discovery, monitoring, and improvement (Van der Aalst et al., 2012)
	Visualisation	**Static, aggregated**	**Dynamic, potentially interactive**	Static, aggregated	Dynamic, interactive
	Data type	Digital, one variable	Digital, several variables	Expert-driven, several variables	Digital, several variables
	Data set size	Large	Small	Any	Any
	Unit of analysis	Group	Individual and group	Group	Individual to group
Methods' benefits for QI	Evaluative benefits	Evaluation of QI intervention; before- and after study rendering statistical significance measures (Dahm-Kähler et al., 2016)	**Timely feedback** **Hypothesis building** **Question data quality** **Complementary to survival curves**	Evaluate and design standardisation of care processes (Trebble et al., 2010) Best practice (Le Duff et al., 2005)	**Process variation and system overview** **Best practice and compliance** **Question data quality** **Complementary to process mapping**
	Organisational benefits	Motivate an improvement effort (Kristoffersen et al., 2015)	**Discussion across organisational borders and silos** **Motivating co-workers and managers** **Patient focus** **Challenge mental models**	Bridge organisational silos (Greaves et al., 2013) Facilitate shared understanding within the process mapping team (Antonacci et al., 2018) Engages staff (Trebble et al., 2010)	**Discussion across organisational borders and silos** **Resource use** **Questioning assumptions** **Challenge mental models**

Further, *evaluative benefits* are mainly, but not strictly, related to the understanding of variation and knowledge about the system from the system of profound knowledge (Deming, 1994). Similarly, *organisational benefits* are related to the system of profound knowledge mainly through knowledge about the system, psychology, and knowledge theory (Deming, 1994). Comparing the results of the two studies facilitates identification of the common or contradicting themes regarding the potential for using Lexis diagrams and process mining for QI.

5.2.1 Methods' properties

Study 1 (Paper I) focused on care process complexity, where not only variations in events over time but also variation regarding events' interrelatedness and attributes' variation within certain events, such as each deceased patient's cause of death, are interesting to describe and visualise. By analysing survival data, Lexis diagrams (Figure 5.1B) are compared to traditional Kaplan-Meier survival curves (Figure 5.1A). Figure 5.1A (survival curves), Figure 5.1B (Lexis diagram), and Table 5.1 illustrate that the properties of the two methods differed in several ways. Specifically, Kaplan-Meier survival curves use aggregated data to ensure a sufficiently large sample size. A single variable, survival, is for QI purposes analysed at the group-level, in before and after studies (Dahm-Kähler et al., 2016; Kristoffersen et al., 2015). Before and after studies limit the method's necessary usefulness for local QI understanding (Shojania and Grimshaw, 2005) but are useful at a later stage to achieve generalisable, global knowledge. In contrast, Lexis diagrams present raw data at an individual level and can be continuously updated, whereby local process changes can be followed in real-time. Although first developed to present joint age-period-cohort effects (Keiding, 2011) through individual lifelines, including for example, time of birth, time of death, and age, in a simple graph (Vandeschrick, 2001), Lexis diagrams can be used to describe the details of care processes through dynamic, potentially interactive visualisations. To facilitate these visualisations, preferably small sample sizes are used, as larger sample sizes have been shown to clutter the diagram and reduce interpretability. Based on the findings in this thesis, it is proposed that in QI, Lexis diagrams have the aim of continuous care process evaluation and improvement.

Study 2 (Papers II and III) focused on analysing data for which the order of care process events and their variation within groups or over time is central. Figure 5.1C (process mapping), Figure 5.1D (process mining) and Table 5.1 illustrate the difference between the traditional and potentially new methods. Process mapping is an expert-driven method for care process understanding and improvement (Trebble et al., 2010), which is often used to gain an overview of process events or steps resulting in static visualisation at an aggregated level (Rebuge and Ferreira, 2012). As it is expert-driven, process mapping is not dependent on sample size but is normally used at a group level. Similarly, process mining is not dependent on sample size, but contrary to process mapping, builds the visualisation from raw data at an individual level to create a dynamic, interactive visualisation including several variables, such as events and lead times, with the possibility of zooming from

individual to group-level processes, using current software such as Disco (www.fluxicon.com/disco). Thereby, process mining facilitates continuous care process discovery, monitoring, and improvement (Van der Aalst, 2016).

Lexis diagrams (Study 1) and process mining (Study 2) address care process complexity somewhat differently. Lexis diagrams focus on feedback and timeliness by following the detailed care process complexity of several variables over time, while process mining allows for a real-time overview of the variation in the care process and its lead times, including, for example, bottleneck analysis, with the possibility of zooming from a group to an individual level.

5.2.2 Methods' benefits for QI

Summarising the results regarding how the methods used in Studies 1 and 2 are useful to QI (Table 5.1), both similarities and differences between the methods are highlighted with respect to *evaluative* and *organisational benefits*, which are elaborated upon in the following sections.

5.2.2.1 Evaluative benefits

Evaluative benefits build closely on the method properties, whereby some benefits could be identified across studies. The static view is a central theme of the current methods' properties. Study 1 demonstrated that Kaplan-Meier survival curves are static by aggregating data for the statistical significance of before and after measures, being fit for their purpose of generating global, generalizable knowledge but not for producing local, actionable knowledge. Study 2 demonstrated that process mapping is static by focusing primarily on standardisation. Additionally, both studies (Papers I and III) demonstrated that even process owners, as experts responsible for a care process, did not fully understand the variation inherent in 'their' processes with current methods, as the processes are too complex. Similar results have been demonstrated in other studies (see, e.g., Rebuge and Ferreira, 2012; Yoo et al., 2016). Moreover, the limitation of human memory could prevent a mapped process from reflecting reality (Mans et al., 2008), and because of the dynamic nature of care (Rebuge and Ferreira, 2012), there is a need for continuous updates. Continuous, expert-driven process mapping is unrealistic from a resource perspective and could be the reason why process mapping was rarely if ever, performed by hospitals (Paper III). On the contrary, both Lexis diagrams and process mining fulfil the need for (close to) real-time data by harnessing data from health information systems. Therefore, Lexis diagrams and process mining facilitate timely understanding of local process variation and systems, using data that is continuously updated, in accordance with the Learning Health System (Friedman and Rigby, 2013). In Studies 1 and 2, both proposed new methods for QI were demonstrated to increase awareness of data quality issues through sometimes unrealistic or erroneous data visualisation, which was often identified by domain experts and sometimes discovered by the researcher and confirmed by the domain experts. Paper

II argues for the development of the health information system to ensure data accuracy, as this would allow further resource-saving and reduce the risk of false conclusions and action.

Each method was shown to possess unique evaluative benefits for QI. Study 1 demonstrated that Lexis diagrams are useful for presenting timely trends and establishing hypotheses. After that, with sufficiently large sample sizes, hypotheses could be tested for statistical significance and visualised using Kaplan-Meier survival curves. In addition, Study 2 demonstrated that process mining could be used to identify best practice and check compliance with planned 'to-be' processes, and the latter was often produced through process mapping. Notably, the traditional and new methods can be used to complement each other, reflected by their differences in purpose and method properties, as well as identified benefits.

5.2.2.2 Organisational benefits

Some organisational benefits for QI are shared across traditional and new methods for QI. Specifically, all methods were shown to have the potential to bridge organisational borders, except for survival curves where this perspective was not identified. Several researchers have identified organisational borders or silos as a key problem in care improvement (see, e.g., Leape et al., 2009; Glouberman and Mintzberg, 2001). Glouberman and Mintzberg (2001) identified four groups with different perspectives in healthcare, which are sometimes called the '4Cs of healthcare': Doctors (focusing on curing), nurses (focusing on caring), management (focusing on controlling), and trustees (focusing on the community). In both studies, the bridging of organisational borders was supported by different methods in different ways. This difference was particularly distinct between process mapping and the two new proposed methods, Lexis diagrams and process mining. In process mapping, the resulting maps are sometimes used to understand care processes but can also be used to standardise the care system across organisational silos (Strasser et al., 2013). Lexis diagrams and process mining visualisations that focus mainly on understanding care process complexity and variation proved useful as a basis for discussion; demonstrating the potential to provide insight and learning across organisational groups. This was exemplified in Study 1, as the individual lifelines included in the visualisation was perceived as useful in motivating both co-workers (cure) and managers (control), and this is an important aspect of the psychology pillar in the system of profound knowledge (Deming, 1994). The identified variation in patient pathways and costs resulting from process mining was the main focus of the discussion between the 'cure' and 'control' border in Paper III (through collaboration with both a clinician and a data expert).

A learning process was also identified, as the visualisations of care process complexity challenged the mental models of the process owners, even though they were already accustomed to working with QI in their care processes. This was particularly pronounced in Study 1, and evident in the way in which process owners applied the medical logic of

statistical significance and group-level survival probability during early discussions, but guided by the visualisations and further discussion, later turned to QI logic and used data to increase patient perspective and focused on timely identification of trends, consistent with Provost (2011). The trends identified in the Lexis diagrams were also proposed by the process owners as useful in establishing hypotheses to be tested in larger studies. Process mining allows the exploration of data in new ways, such as stratification based on care processes (Study 2, Paper III) or the identification of positive deviants showing better outcomes relative to those produced by the main process (Study 2, Paper II), which could reveal improvement possibilities.

Other organisational benefits important for QI, identified specifically for one of the proposed new methods in the studies, included increased patient focus (Study 1), more efficient resource use (Study 2) and questioning current assumptions from both theoretical (standardisation did not always lead to lower costs), and empirical (care process variation was larger than expected) perspectives (Study 2).

5.2.3 Methods' properties and benefits for QI

Both proposed new methods allowed for continuous updating of visualisations, facilitating real-time analysis, which is an important property of QI methods to aid relevant improvement action (Kilo, 1998). Interactive and flexible visualisations that allow for the comprehensible presentation of data could support collaboration (Shneiderman et al., 2013); this is important when combined with the usefulness of visualising different process attributes according to the local context (Study 1) or moving between individual and group data (Study 2). User-friendly software for interactive analysis already exists for process mining (Study 2), and its development for Lexis diagrams is encouraged (Study 1). The importance of interactive visualisation is not yet central to QI, which currently involves primarily simple, graphic displays (Plsek, 1999), but it is established in the field of visual analytics (see, e.g., Keim et al., 2008). The possibility of adjusting visualisation according to the needs of the stakeholders facilitates visualisation of different perspectives (Study 1) and identification of the root causes among the existing variables in the database (Study 2). This could pave the way for more resource-efficient and learning-focused care organisations (Studies 1 and 2), and visualisations could be adapted to a changing context wherein other variables are important (Study 1).

As described in Paper I, Lexis diagrams could be used to motivate both fellow co-workers ('cure') and decision-makers ('control'), while Study 2 exemplified the way in which organisational borders could be bridged by collaboration between the process owner/physician ('cure') and data expert responsible for cost-casing data ('control').

5.2.4 Methods' limitations

Despite the usefulness of the methods identified with both Lexis diagrams and process mining, they are both subject to limitations. One of the strengths of the Lexis diagram is the visualisation of small sample sizes, below those handled by statistical significance

analysis, while large samples clutter the diagram (Study 1). However, statistical significance is usually required in medical research to ensure generalizable, global knowledge, and subsequently, Lexis diagrams could be used to present local trends as a preliminary step towards statistical significance hypothesis testing using traditional survival curves. In this way, the two methods complement each other (Study 1). Similarly, the results of process mining are based on existing local data, but process mapping based on well-researched generalizable best practice could be more useful for planning new care processes (Study 2). By presenting data in different ways, the proposed new methods for QI could complement both current methods and each other. Additionally, both methods require an explanation for new users through education, but once understood, they are expected to be easy to use.

5.3 RQ2: What usefulness can methods describing care organisation complexity have for QI in public procurement?

RQ2 is answered in Study 3. Unlike RQ1, in which the methods addressed complexity in a limited care process, public procurement encompasses the entire care organisation and therefore required a method that describes care organisation complexity. One possible method is the use of a BE model (Bröchner et al., 2016). While Paper IV (Study 3) focused on identifying how QI manifests in traditional public care procurement, Paper V (Study 3) explored the use of a BE model in public care procurement for the first time, with the aim of awarding caregivers the highest levels of QI maturity and supporting QI during the contractual period. The study of the BE model use stands out compared to the other studies as it was implemented in practice, and it was, therefore, possible to explore both its expected and actual usefulness, resulting in certain challenges being identified raised in the method limitation section 5.3.4.

Similar to the presentation of methods in Table 5.1 for RQ1, Table 5.2 presents the method properties of the BE model and illustrates its *evaluative* and *organisational benefits*. To allow a comparison of the new method and the use of traditional public care procurement, the *properties* and *benefits* of traditional public care procurement are also presented in Table 5.2. Note that because of large differences between the visual methods describing care process complexity and the methods addressed in RQ2 describing care organisation complexity, another set of method properties is identified as relevant in Table 5.2.

Table 5.2 Summary of the results of Study 3 divided into methods' properties and benefits for QI. Bold text represents the study findings, the plain text with references is taken from literature and mentioned in the papers, while plain text without references reflects basic method knowledge.

		Study 3	
		Paper IV	**Paper V**
	Case data	Elderly care procurement documents	BE model included in procurement for elderly care
	Existing vs new method	Traditional public care procurement and follow up	Use of a BE model as part of public care procurement
Methods' properties	Aim	Chose care provider based on cost or a cost-quality balance (Bröchner et al., 2016)	Chose care provider based on quality maturity (SIQ, 2015)
	Quality view	**Static view on quality, adapt to regulations and requirements**	Organisation-wide dynamic view on quality (SIQ, 2015; Eriksson et al., 2016)
	Logic	Procurement	QI
	Restrictions	Many pre-defined detailed requirements are given (Health Navigator, 2013)	**Work procedures, development, and evaluation of QI focus areas should be described, apart from fulfilling some detailed requirements.**
	Driver	**Quality presented by buyer**	**Quality presented by the care provider**
	Awarding process	**Partly subjective**	**Objective, rigorous**
	Comprehensive-ness	**Limited QI focus**	Holistic QI focus (Eriksson et al., 2016; Tan et al., 2003)
Methods' benefits for QI	Evaluative	**The tender evaluation facilitates awarding according to quality and QI.** **Evaluation in several different ways**	Enable assessment of QI maturity in an organisation (Dahlgaard et al., 2013) **Feedback report helps to identify areas of strengths and weaknesses; identify focus areas for QI**
	Organisational	**Ensure (separate) focus on several important QI criteria in care procurement; collaboration, evaluation, and workforce training.** **Learning opportunities arise from good examples, variations, and correlations between criteria and other factors (e.g., municipality size).** **The most mature procurement documents may drive QI, others will have limited or no effect on QI.** **High patient focus, maybe at the expense of organisation-focused criteria**	**Facilitate collaboration across organisational borders** Feedback report used as a follow-up tool is expected to facilitate the partnership (SIQ, 2015) **Motivate QI efforts** **Share responsibility for addressing QI efforts between buyer and care provider** **Relocation of resource use**

5.3.1 Methods' properties

As quality has gained importance in procured care (Bröchner et al., 2016), the procurement documents have developed towards including QI to varying extents, as demonstrated in Study 3 (Papers IV and V) and summarised in Table 5.2. The archival study described in Paper IV showed that traditional procurement was influenced by procurement logic, partially at the expense of QI logic. Procurement logic is reflected through the numerous static and detailed requirements stipulated by the buyer (Health Navigator, 2013), which the tenderer is often merely confirming to fulfil. This procedure does not develop knowledge regarding the provision of care to support the 'doing of improvement' (Dixon-Woods, 2019); rather, as it stipulates what the care provider should do, it is more similar to a work procedure, such as a check sheet, than it is to a method. Traditional care procurement also appears to value low cost above quality and QI, as the identified properties of several procurements involved awarding only on cost, and quality generally exerted a low impact on awarding results, even for tenders fulfilling the maximum quality level (Study 3, Paper IV). Nevertheless, some public procurement had developed further towards QI and generally, several known BE key themes (Eriksson et al., 2016) were partly or fully covered by the identified QI criteria. Still, Paper IV described a generally fragmented and limited QI focus in traditional care procurement, through the existence of highly variable QI criteria coverage within and between procurements and a limited connection between criteria, as well as a lack of BE key themes, as detailed further below.

Study 3 (Paper V) explored one potential solution for driving QI flexibly during the contractual period, by using a BE model to assess the QI maturity in tenders and drive QI during the contractual period. The BE model increases QI focus in public care procurement, as tendering care providers are required to answer questions regarding how they address QI by briefly describing *how* they work with, develop, and evaluate several key areas such as leadership, processes, and customer focus (SIQ, 2015). The BE model thereby drives a process- and systems-focused view in which connections can be identified between different criteria, to establish a holistic view of the QI approach in the care organisation (Eriksson et al., 2016; Tan et al., 2003). As the BE model constitutes only one part of the procurement document, it is possible to include additional static, detailed requirements (e.g., where best practice evidence exists). One important property of using the BE model, which was also emphasised as a strength by the stakeholders in Study 3 (Paper V), is that caregivers present their organisations' work concerning quality and QI, and it is not stipulated by the buyer.

5.3.2 Methods' benefits for QI

The two types of benefit (*evaluative* and *organisational*) to QI, presented in section 5.2, also emerged when analysing the data in Study 3. This was particularly pronounced in the use of the BE model but also identifiable when analysing traditional public care procurement.

5.3.2.1 Evaluative benefits

Although public care procurement is a largely unexplored context in QI research, Study 3 (Paper IV) demonstrated that efforts had been made to include QI in traditional public care procurement, leading to evaluative benefits for QI. Several evaluation criteria, including the use of a tender evaluation model, internal and external follow-up during the contractual period, and the use of quality registries, are present in traditional care procurement (Study 3, Paper IV). The tender evaluation model criterion could be a unique driver for QI related to public care procurement. It represents part of the procurement document, whereby it is possible to include quality-focused criteria, which could exert the final impact on the awarding decision and have the potential to drive QI during the contractual period (Study 3, Paper IV). Follow up during contractual time is divided into two criteria: i) Internal follow up, whereby care providers evaluate themselves, and ii) external follow up, whereby the municipality follows up adherence to the contract. The case municipality described in Paper V had developed a process for external follow-up during the contractual period. However, based on traditional care procurement, the follow-up process reflected static requirements and was limited mainly to checking adherence to the contract rather than driving improvement (Study 3, Paper V). For follow up to be useful in driving QI results in public organisations, they should use the information and documentation to achieve results rather than focus on detailed requirements (Raharjo and Eriksson, 2017). From a positive perspective, many procurements focused on the use of quality registries, which could be a step towards the necessary development of information systems in social care (Neubeck et al., 2014). However, only approximately 25% of all procurements explicitly linked the use of quality registries to harnessing that data to support QI, the other procurements included only a requirement to document data in the quality registries (Study 3, Paper IV). All of the stakeholders interviewed in Study 3 (Paper V) emphasised the need to develop procurement to foster QI further, reflecting the limited focus on QI in traditional procurement and limited usefulness of traditional public procurement to QI. This was also reflected in the lack of several BE criteria shown to be important for QI: A process and systems approach, focus on agility, and the need to harness employees' ideas (Eriksson et al., 2016) as well as QI skills, as a QI criteria identified in Kaplan et al. (2012).

The BE model in Study 3 (Paper V) was used to assess the quality maturity of the tendering care organisation, similar to how assessment is pursued with general BE models (Dahlgaard et al., 2013). This is particularly useful in the award-winning process, to ensure that the tenderer with the highest quality maturity is awarded the contract, as quality maturity is linked to successful QI results (Eriksson et al., 2016). As is usual in the external assessment of an organisation before awards, the assessment was performed via a structured consensus process (Shergold, 1996; Study 3, Paper V). This assessment resulted in a score reflecting the maturity of each tendering organisation, and the evaluation results were summarised in a feedback report describing the strengths and weaknesses of the planned care from a QI perspective (Tan et al., 2003). The feedback report was used by the care provider (Study 3,

Paper V) to identify focus areas for future QI efforts and could support partnerships during the contractual period (SIQ, 2015).

5.3.2.2 Organisational benefits

As procurement documents are the basis of the contract (Study 3, Paper IV), well-developed QI criteria in care procurement could be expected to drive QI within the organisation, because of the requirement for the care provider to do so, whether they are motivated or not. When requirements drive QI, the focus of QI efforts is expected to be targeted at well-developed criteria within each procurement, in which it is therefore important to include all QI criteria. As patient focus generally permeated the requirements of the analysed procurement documents, care procurement could be expected to drive the important criterion of patient-centredness (IoM, 2001) within the care provider's organisation. However, it was in Study 3 (Paper IV) concluded that patient focus could occur at the expense of process- and systems-focused criteria. In addition, consistent with Raharjo and Eriksson (2017), the interviewed municipality stakeholders emphasised leadership for successful QI, but few procurement documents included this criterion. In Paper IV, we argued for a broader focus to ensure flexibility and agility and address individual needs and changes during the contractual period, to facilitate a successful QI approach in procured care.

Although the variation of the development levels of criteria was high both within and between procurements, it was possible to find well-developed examples for all identified QI criteria that were highlighted as good examples for use in improving future procurement (Study 3, Paper IV). As noted in the Introduction section, to ensure efficiency, QI is often developed through inspiration from others, rather than by inventing it anew (IoM, 2001). This mindset could also apply to public procurement; it was in Study 3 (Paper IV) argued that learning opportunities regarding criteria design in municipalities could arise from the existing good examples of the different criteria in Study 3 (Paper IV), in which guidance was also identified through the criteria's correlations with other factors (e.g., municipality size). This between-organisation evaluation, with a focus on best practice, could further drive QI in traditional care procurement.

Contrary to the traditional care procurement described in Paper IV, the BE model with a feedback report presented several potential drivers for QI in Study 3 (Paper V), which were used to identify QI efforts in the caregiver organisation and could facilitate partnerships between buyers and care providers during the contractual period (SIQ, 2015). In addition, education in the BE model and workshops with different stakeholders demonstrated the potential for the use of the BE model for collaboration including bridging the control (buyer) and care (care provider) organisational borders (Glouberman and Mintzberg, 2001). Importantly, the BE model ensured that the responsibility for addressing QI efforts was shared between buyers and care providers in the procurement process. Further, the motivation and initiation of QI efforts based on the feedback report indicated that the effects

of this shared responsibility continued during the contractual period, consistent with SIQ (2015). Another interesting organisational benefit was the use of resources. As the use of the BE model forces the care provider to plan and present care from the beginning, the additional time allocated to this effort was expected to be recouped via the reduced time needed to plan for and handle organisational issues during the contractual period. This could increase patient-centredness, as a structured approach increases efficiency, leading to additional time for patient care.

5.3.3 Methods' properties and benefits for QI

Paper IV described the attempts to include QI in care procurement (Bröchner et al., 2016; Socialstyrelsen, 2009), albeit with variable results and little system perspective. In addition, an analysis of the traditional care procurement properties illustrated that care procurement was more similar to a work procedure than it was to a QI method, limiting local knowledge building and its use in 'doing improvement' (Dixon-Woods, 2019). However, the well-developed requirements, presented as good examples in Study 3 (Paper IV), indicated that some procurements involved a strong focus on actions such as using data in learning and improvement. When criteria were well developed, they demonstrated the potential for evaluative and organisational benefits for QI evaluation, learning, and development in public care procurement. However, the criteria were not connected to each other, i.e., the inter-relatedness between criteria was lacking, and this was reflected in the lack of focus on processes and system perspective. The lack of focus on leadership, and agility, on the other hand, lead to a static, rather than dynamic, view of quality, which may restrict QI during the contractual period.

However, the use of the BE model connects sections such as leadership to processes and results (SIQ, 2015), and therefore, the different parts of the system of profound knowledge (Deming, 1994), to each other. Identification of QI efforts requires a local understanding of the problem (Shojania and Grimshaw, 2005), and care providers themselves can be assumed to be best at describing their own care organisation complexity to establish understanding. As noted above, this could increase the resource efficiency of the provision of care, as explicit planning of core processes achieved through producing the tender according to the BE model is expected to simplify the start-up process of providing care (Study 3, Paper V). In addition, both buyer and care provider organisations could be expected to develop maturity in their QI thinking as they learn and establish experience with the BE model (e.g., they could gain a deeper understanding of the meaning and potential of a system's approach). The BE model properties were also expected to bridge the quality management system required for the care organisations in Study 3, in Sweden regulated by SOSFS (2011:9), and planning of care through public procurement, e.g., through the need to describe their core processes (Paper V).

5.3.4 Methods' limitations

As with the visual methods, one limitation of using a BE model in care procurement was its complexity, which necessitated education, sufficient time, and hands-on experience. The importance of investing strongly in such activities became clear through the stakeholders' insecurity in how to use the BE model, despite some education and training, which may have contributed to inhibiting QI instead of supporting it (Paper V). Apart from education, many time-consuming activities are expected to depend on limited knowledge and experience. Once the tendering care providers have produced a few tenders based on a BE model, thereby identifying their main processes, much can probably be reused. Similarly, it is likely to be easier for buyers to use a BE model when they have gained experience. Nevertheless, the consensus process will always be time-consuming, and the availability of sufficient time should be ensured to allow the individuals concerned to cope with this process.

6. DISCUSSION

Building on the introduction, frame of reference, and result and analysis chapters, the discussion leads the reader towards the main contributions of the thesis.

The purpose of this thesis is to explore the usefulness of methods describing care complexity for QI in care. The purpose extends the need for care organisations to understand their complex reality, to drive QI (see, e.g., Mohammad et al., 2010; Shojania and Grimshaw, 2005). Nevertheless, methods for QI supporting the acquisition of local knowledge and the 'doing of improvement' (Dixon-Woods, 2019) have focused mainly on simplicity to support understanding of visualisations by practitioners (see, e.g., Plsek, 1999). Considering the large and increasing complexity in care, the use of current methods for QI may result in a too simplified view of reality, with limited support for QI. Therefore, methods with the potential to describe more of the care complexity have been explored in this thesis, such as variations within and between groups and over time in care processes, or the dynamic nature of care in public care procurement, to satisfy the needs of those receiving the care.

6.1 Framework for exploration of method usefulness for QI

As exemplified in the studies described in this thesis, increasing care complexity can be analysed from the perspectives of both process and organisation complexity, depending on the method used. Interestingly, although there is a clear difference between visual methods describing care process complexity and methods describing care organisation complexity for care procurement, all methods fulfilled two types of benefit (evaluative and organisational), which could support the further drive for QI. It was, thus, possible to classify the results of all of the included studies into these three groups, indicating that they could be common to these methods, which allows for a general framework to analyse method usefulness in describing care complexity (see Figure 6.1).

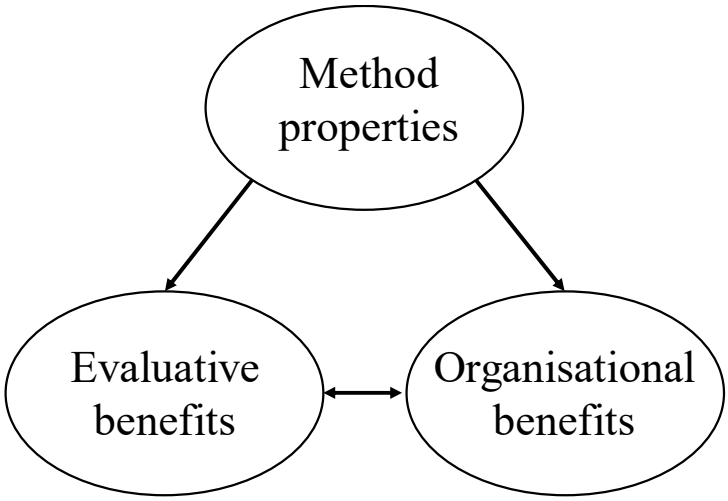

Figure 6.1 The connection between method properties and benefits

Evaluative benefits are emphasised in current research on methods (Provost, 2011; Stoto et al., 2017). However, with some exceptions (see, e.g., Helmering et al., 2012), less attention has been paid to how methods' description of complexity is directly or indirectly useful as an organisational benefit. Based on the exploration of Lexis diagrams and process mining and the use of BE models for public care procurement, the thesis demonstrates the potential to broaden the current problematization surrounding complexity in QI (posited by, for example, Plsek and Greenhalgh (2001) and Braithwaite et al. (2017), to emphasise the role of methods describing care complexity. Based on the Learning Health System, further development of methods for QI is expected to follow. Considering that the framework presented in Figure 6.1 was useful in comparing six methods in this thesis, it could support exploration of the usefulness of future methods for QI. Compared to earlier QI research describing the properties of methods, and identifying the benefits of their use (see e.g., Thor et al., 2007; Carnevalli and Miguel, 2008), this framework contributes more explicitly by relating method properties and benefits to each other, to guide exploration. For example, the direct effects of properties on organisational benefits are described in Papers II and V, as the use of process mining and the BE model, respectively, may affect resource allocation in the organisation. The indirect effect of properties is exemplified in Paper I, which describes how the Lexis diagram visualisation of individual patients' life lines (method property) allows physicians to reflect on the fact that many patients who are severely ill at diagnosis will live for several years (evaluative benefit), and that this understanding could motivate them in their work (organisational benefit). These relationships could be particularly important when methods have certain properties, such as presenting both individual and population data, which are beneficial in other research fields (Francis and Pritchard, 2000).

The relationship between method properties and benefits could also be useful for matching methods and complex problems and thereby support QI. For example, Dixon-Woods et al. (2012) posited that QI often requires contradictory approaches such as those involving the combination of rigorous planning with flexibility. This is not least the case for QI in care procurement, in which several legal aspects need to be combined with QI logic (Bröchner et al., 2016). The BE model fulfils the need for rigorous planning while continuing to facilitate flexibility, which may ensure a focus on QI outside of the stipulated quality demands, emphasised in the report by Health Navigator (2013). Similarly, QI could gain an even stronger focus on learning through data, using visual analytics, while the Learning Health System (Nwaru et al., 2017) could use the framework, and the results of RQ1, to take the necessary step from discussion to action (Budrionis and Bellika, 2016) when identifying methods and their benefits to support learning and improvement.

6.2 The interaction between method and subject-matter knowledge

Perla et al. (2013) and Parry (2014) posited that the interaction between improvement methods and subject-matter knowledge supports improvement (see the red box, Figure 6.2). This thesis not only confirmed the importance of this interaction but also contributed by

identifying two additional perspectives in the context of care complexity, as described below.

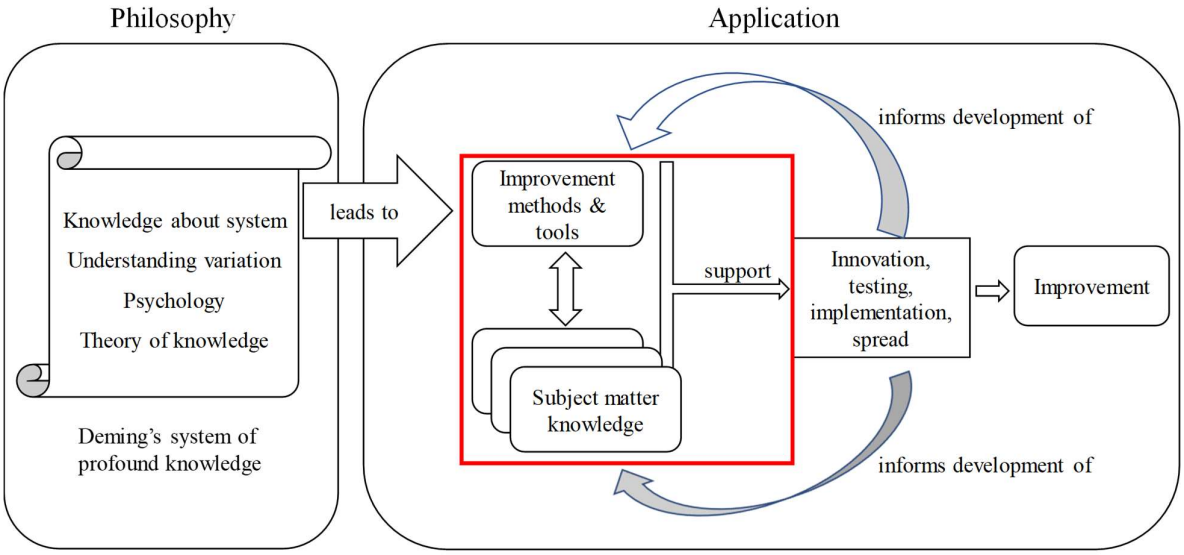

Figure 6.2 QI framework adapted from Parry (2014), with the focus of this thesis framed in red. Note that additional subject matter knowledge boxes have been added compared to Parry (2014) to represent different collaborating stakeholders with different subject-matter knowledge.

6.2.1 Creating a common, objective view as a basis for discussion

As usefulness demonstrated both evaluative and organisational benefits, identified mainly through collaboration with domain experts, one contribution of this thesis is the understanding resulting from the interaction between methods describing care complexity and subject-matter knowledge. Specifically, the thesis enforces the connection between QI and visual analytics, thereby presenting data traditionally hidden in analysis (Stewart et al., 2002), and facilitating a deeper understanding (Shojania and Grimshaw, 2005) of patient care processes and outcomes, relative to that achieved via current methods for QI. Perla et al. (2013) stated that 'The real challenge is in the space and interplay between each context—between the knowledge, hunch, or intuition of the subject matter expert and the tests and methods that will guide their learning of a system' (p. 179). One reason for the limited emphasis on understanding complexity in QI research could be the tendency to strive for simplicity in data presentation (Plsek, 1999). However, the presentation of the complexity of care process data reduces the need for hunches and intuition from subject matter experts. Similarly, allowing care providers to explain their care organisation complexity removed the need for buyers' intuition or hunches about QI requirements in care. Still, further simplification could be necessary to support the domain experts in their understanding, as asked for regarding the BE model in Study 2 (Paper V), but also by using or developing interactive data visualisation for Lexis diagrams and process mining (Study 1).

The presentation of data not only minimised the need for guessing and hunches but also presented an objective view of the care processes and organisations. For quantitative data, the results of this thesis confirm earlier research that visualisation is useful as a basis for discussion (Few, 2014) and similarly, the description of the strengths and weaknesses of planned care in a feedback report was perceived as useful in discussions between different care stakeholders. Glouberman and Mintzberg (2001) posited that different organisational groups held their own perspectives of care. The collaboration of several stakeholders is visualised in Figure 6.2 as multiple boxes for subject-matter knowledge, which represent different types of professional knowledge and logic. The methods demonstrated the potential to bridge organisational borders through the creation of common ground, upon which to discuss and drive QI. Shneiderman et al. (2013) argued that dynamic visualisation facilitates team decision making on the hospital floor; however, this thesis suggests that Lexis diagrams and process mining visualisations, with objective and detailed views of the care process complexity, also facilitate knowledge acquisition across organisational borders. Similarly, as the BE model resulted in the presentation of planned care, including a feedback report upon which to act to achieve QI (Study 3, Paper V), these presentations could ensure a common view via which to bridge organisational borders.

It should be noted that the methods explored in this thesis described complexity differently, as their properties differed, and they bridged organisational borders in varying ways. Specifically, the use of a BE model demonstrated the potential to bridge organisational borders despite the fact that the contractual relationships are forced, as the tenders are anonymous until the awarding process is complete.

6.2.2 Fostering the QI mindset by describing care complexity

The results of this thesis confirmed the proposed triple interplay between methods describing care complexity, improvement knowledge, and subject-matter knowledge and combined the frameworks of Batalden and Splaine (2002) and Parry (2014). Not only is the system of profound knowledge important in the choice of methods (Parry, 2014), but the findings of this thesis implied that the methods and their results could foster QI logic in stakeholders, and possibly, organisations. This was achieved because the methods described care complexity in new ways, supporting further understanding of variation and the care system (Deming, 1994; Bergman et al., 2015) and highlighting new ways to learn and talk about the care system. Therefore, the system of profound knowledge could be fostered in care organisations, shifting the balance away from contradictory types of logic (Provost, 2011; Bröchner et al., 2016). The results obtained using the proposed framework (Figure 6.1) to compare traditional and new methods have the potential to identify the method that would be most useful for fostering QI logic in stakeholders.

6.3 Limitations of methods describing care complexity

Although the domain experts using methods describing care complexity were less dependent than usual on their memories and hunches, their role in using methods and

driving QI should not be underestimated, as the proposed methods were subject to limitations in describing care complexity.

Although both Lexis diagrams and process mining were useful in identifying data quality problems, as posited by Shneiderman et al. (2013), it would have been preferable to avoid the data quality issue entirely. The effects of low data quality might have been less clear before data were used to the extent they are today, particularly in complex and sometimes automated analyses. However, the correct analysis is contingent on high data quality (Suriadi et al., 2017), which can be addressed by documenting data in a comprehensive and accurate manner (Van der Aalst et al., 2012). Until the highest quality of data documentation can be ensured, if that is possible, domain experts should be critical of all data presented. It should also be remembered that visualisations only include historical data, the future may bring new data and resulting processes not covered in the visualisation.

Another potential limitation of using methods that describe care complexity is that although all of the explored methods were perceived useful, they represented a different way of working to that with which the stakeholders were familiar. As demonstrated in earlier research, investments in time, education, and practice are required to understand the analysis of complex data (Höög et al., 2016), and this need could be particularly pronounced with the use of new methods. In the early stages, such as method exploration, this could be partially addressed by dividing responsibilities between stakeholders, as illustrated in Studies 1 and 2. During the novel use of a method, as in Study 3 (Paper V), limited knowledge and experience reduced understanding, resulting in insecurity among the stakeholders that was severe enough to possibly inhibit QI by abandoning current practices without replacing them with new ones based on the use of the BE model during the contractual period. This indicates that rather than supporting improvement, which was the suggested result of combining improvement methods and professional knowledge in Parry (2014), failed interaction between methods and subject-matter knowledge could inhibit improvement, despite the best of intentions.

7. CONCLUSIONS AND FUTURE RESEARCH

Based on the analysis results and discussion, this chapter presents the conclusions of the thesis, consisting of theoretical contributions and managerial implications. The conclusions are followed by the limitations of the thesis and areas for future research.

7.1 Theoretical contributions

The purpose of this thesis is to explore the usefulness of methods describing care complexity for QI in care. This thesis has made three main contributions to QI, elaborated upon below.

First, the exploration of the usefulness of the methods employed in this thesis highlights the need to match methods with different contexts. The QI community often encourages the use of a few traditional methods; for example, a control chart is a typical example of a method for understanding variation (Bergman et al., 2015; Lemire et al., 2017). Although these main current methods have demonstrated well-studied benefits for QI, one size does not fit all; as this thesis demonstrates, current methods have shortcomings compared to the proposed new methods in this thesis when it comes to describing care complexity, and thus, QI can gain from leaving its well-beaten tracks and, with current and future care challenges in mind, further expand its repertoire of methods. The framework presented in Figure 6.1 may be an effective way to support this 'matching quest', identify methods useful to achieve certain benefits for QI, and strengthen improvement efforts. The framework was found useful for different contexts and organisational levels, and thus, the framework may also support the exploration of incorporating further methods in the QI method collection.

Second, methods should be chosen wisely, as implied above. The focus of this thesis has been on methods for QI describing care complexity, and the results demonstrate that the selected method properties allowed the data to be presented in a way that addresses the four pillars of the system of profound knowledge (Deming, 1994) and QI principles (Dean and Bowen, 1994; Bergman et al., 2015) differently than traditional methods used for QI. For example, process mining presents the full extent of care process variation by including data from every patient; thus, extending local knowledge of variation compared to process mapping, which often focuses on the (perceived) most common processes. These insights may, in turn, lead to the identification of promising new QI efforts. Despite the potentials of the proposed new methods, they also have their limitations. It should be remembered that one size does not fit all, and traditional methods are still preferable in certain situations and contexts.

Third, by using methods describing complexity, stakeholders learn not only about the specific data with which they are concerned; as the new perspectives potentially challenge and change their mental models, they also seem to develop their understanding of QI. This may drive understanding of QI within individual stakeholders and spread into their

organisations to help drive future QI efforts. This can be exemplified, for example, in realising the potential for systems thinking using BE models in public care procurement or in strengthening the patient perspective when seeing data for each patient, in a Lexis diagram. Methods describing care complexity may, therefore, be a way to develop the understanding of QI within an organisation, further emphasising the importance of matching the method with the context to address specific challenges.

7.2 Managerial implications

This thesis has the following three main managerial implications.

First, organisations need to match their local challenges and needs to select appropriate methods, meaning they need both contextual knowledge and some knowledge about existing methods. Although this thesis highlights the benefits of the Lexis diagram, process mining, and the use of BE models in certain contexts, these and other methods for QI may also be possible to match to different local needs, which could hopefully lead to acquisition of the necessary knowledge needed for QI to reduce waste and harm in care.

Second, matching method with context may require an openness towards new methods within the organisation, to dare to go beyond the traditional collection of methods for QI and try new methods shown to support QI, such as the novel use of BE models for public care procurement in Paper V. The resulting reward may be substantial if, as this thesis implies, correctly chosen methods can support understanding of care complexity and drive users to a deepened understanding of QI. However, introducing and using new methods also requires a certain effort, as stakeholders need education, time, and practice to learn. There is also a need to ensure high data quality, so that the interpretations and decisions made, drive rather than inhibit QI.

Third, collaboration across stakeholder groups and organisational borders, such as through multidisciplinary teams, is common in care settings today. Stakeholder collaboration helps fulfils several relevant aims, including the identification and interpretation of the relevant data. The methods' descriptions of care complexity were, on the other hand, shown to support discussion and a unified understanding of the local context between stakeholders and can thereby be used to support collaboration across organisational borders.

7.3 Limitations

This thesis has a number of limitations. First, driven by the purpose to explore the usefulness of methods describing care complexity for QI in care, the main focus of this thesis has been on identifying benefits of each method, possibly at the expense of identifying limitations. Additionally, the methods used in this thesis have been tested in only a single setting in a single country; other benefits (and limitations) may be discovered if the methods are applied in other settings. Third, this thesis has focused on an early stage in the exploration and application of QI methods, mainly based on expected and perceived usefulness and no real improvement of care has been studied.

7.4 Future research

The exploration that was pursued in this thesis may be considered a primary step towards establishing those methods in QI practice and theory. This implies a need to continue research on the proposed methods, in at least two ways. First, this thesis does not cover data on the improvement of care outcomes, which is the ultimate goal of using methods for QI (Parry, 2014). Future research, therefore, needs to extend the exploration started in this thesis towards identifying whether and how changes based on the knowledge built by the methods affect the outcome of care. Second, the use of the BE model in Paper V did not proceed smoothly, and further research is necessary on how to implement the methods in daily practice. The implementation of work procedures is the focus of implementation science (Bauer et al., 2015), being another research field. However, the two research fields approach each other; and recent QI research has encouraged the use of implementation science tools to drive QI efforts, specifically by supporting complex QI projects incorporating contextual understanding during implementation (Øvretveit et al., 2017). Future research could expand this connection to address the implementation of methods for QI, a possibility that has, to my knowledge, not yet been investigated, and thereby, contributes to both QI and implementation science.

To support both practice and research and to save time and resources in future research on method usefulness and implementation of new methods, inspiration regarding collaboration between practitioners and academics may be taken from this thesis and Rowley et al. (2012) and Marshall et al. (2013). In the long run, it would be interesting to know if collaboration might not only ensure clinical relevance but also counteract challenges around user acceptability (Keim et al., 2008), as domain experts at RCC West are now already knowledgeable about the methods and could thereby support and encourage method uptake in the organisation and their daily work.

Finally, future research is also necessary for continuing the identification and acquisition of method knowledge from different research fields to enrich and support QI. One specific example highlighted in this thesis is how to ensure high data quality; the field of computer science has identified that data quality issues include a range of different perspectives on data and has developed techniques to handle some issues for improved data analysis outcomes (Jagadeesh Chandra Bose et al., 2013).

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