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Managing variation in hospital patient flows

Olle Olsson

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MANAGING VARIATION IN HOSPITAL PATIENT FLOWS

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ABSTRACT

Performing healthcare services is a complex practice. With the continuous developments in the medical field, healthcare organisations and professionals have become increasingly specialised, and healthcare services increasingly fragmented. When focusing on how to treat and cure diseases, the organisational and managerial aspects of care delivery can be overlooked. This increases the risk of sub-optimisation, when focusing on single activities, patient flows or healthcare units without considering the impact on the organisation as a whole. With every individual patient also having different combinations of diseases, severity levels and responses to medical interventions, much variation is introduced into patient flows. To address these challenges, the purpose of this thesis is:

To explore the impact and management of variation in patient flows within hospitals.

This thesis reports the results from three different studies, performed at three different hospitals. The first study analyses the impact of changes in patient inflow, available resources, treatment times and duration of activities on bed occupancy and length of stay. It does so by developing a simulation model of an emergency department (ED) and inpatient ward. The results show that the impact of variation in acute patient flows is smaller for the ED than the inpatient ward, which indicates that EDs might be more adaptable than inpatient wards in handling variation in acute patient flows. Bed occupancy on inpatient wards also seems to be strongly influenced by variation in patient flows.

The second study is based on a single case study of the management of variation in acute patient flows at a university hospital. In accordance with the results of the first study, this second study shows that many actions are used to handle high bed occupancy, while few are used to handle ED overcrowding. More actions are also used to improve the situation in clinical departments than in the hospital as a whole, increasing the risk of sub-optimisation. The study highlights the need for top management to support department chiefs in managing variation in patient flows, e.g. by establishing a hospital-wide strategy for handling variation in acute patient flows.

In the third study, the combined results from a case study and a quantitative before/after study are used to analyse whether the implementation of standardised cancer care pathways leads to crowding out effects, in terms of longer waiting times for other elective patient groups. The study shows that care pathway implementation is likely to lead to crowding out effects, if these effects are not addressed in the implementation process. Hence, a strategy to handle variation in one patient flow influences the options for handling variation in other patient flows and at the healthcare units as a whole. Crowding out effects were evaluated as most likely for patients from the patient group that is overtaken by the care pathway patients, and least likely for patients from the patient group with the lowest priority, due to a redistribution of waiting times between different patient groups.

All in all, the research reported in this thesis demonstrates the need to take a systems perspective when managing variation in patient flows in order to avoid sub-optimisation, which otherwise often follows when focusing on just one part of a system.

SAMMANFATTNING

Hälso- och sjukvårdstjänster är komplexa, vilket medför att de behöver utföras och kvalitetssäkras av medicinskt utbildad personal. På grund av den ständiga utvecklingen inom hälso- och sjukvården har personal och organisationer inom hälso- och sjukvården blivit alltmer specialiserade och sjukvårdstjänster alltmer fragmenterade. Genom att fokusera på hur man behandlar och botar sjukdomar och skador har frågor kring organisering, ledning och styrning av hälso- och sjukvård delvis kommit i skymundan. När man istället fokuserar på enskilda aktiviteter, patientflöden och sjukvårdsenheter, utan att beakta påverkan på andra delar inom en organisation ökar risken för suboptimeringar. När varje patient också har varierande kombinationer av sjukdomar med olika allvarlighetsgrader samt svarar olika på behandlingar och åtgärder skapas mycket variation i patientflödena. Utifrån dessa utmaningar är syftet med avhandlingen:

Att utforska påverkan, hantering och styrning av variabla patientflöden på sjukhus.

Avhandlingen redogör för resultaten från tre olika studier, vilka genomförts på tre olika sjukhus. Den första studien utvecklar en simuleringsmodell för att analysera vilken påverkan förändringar i patientinflöde, resurser samt tiden för behandling och aktiviteter i flödet på en akutmottagning och vårdavdelning har på belägningsgraden och vistelsetiden. Baserat på resultaten från simuleringsmodellen så tycks påverkan av variationen i akutpatientflödena vara mindre för akutmottagningar än vårdavdelningar. Detta pekar på att akutmottagningar generellt sätt är mer anpassningsbara än vårdavdelningar när det kommer till att hantera varierande patientflöden. Belägningsgraden på vårdavdelningar verkar också utifrån studiens resultat vara starkt påverkbar av variationen i patientflödena.

Den andra studien utgår från en fallstudie gällande hantering och styrning av varierande akutpatientflöden på ett universitetssjukhus. I samklang med resultaten från den första studien visar den andra studien på att många åtgärder används för att hantera hög belägningsgrad på vårdavdelningar, medan få åtgärder används för att hantera en överfull akutmottagning. Fler åtgärder används också för att förbättra situationen på kliniker, än åtgärder för att förbättra situationen på sjukhuset som helhet, vilket ökar risken för suboptimeringar. Studien visar också på klinikchefernas behov av stöd från sjukhusledningen för att hantera varierande akutpatientflöden.

I den tredje studien kombineras en fallstudie med en kvantitativ före-efter-studie för att analysera huruvida implementering av standardiserade vårdförlopp medför undanträngningseffekter genom längre väntetider för andra elektiva patientgrupper. Analyserna visar att implementering av standardiserade vårdförlopp troligtvis medför undanträngningseffekter, om dessa aspekter inte inkluderas i implementeringsprocessen. En åtgärd för att hantera variation inom ett patientflöde påverkar alltså möjligheterna att hantera variation inom ett annat patientflöde, samt för sjukvårdsenheten som helhet. Undanträngningseffekter framträder som mest troliga för den patientgrupp som blivit ”förbipasserad” av patienterna inom ett standardiserat vårdförlopp, och mindre troliga ju lägre prioriterad en patientgrupp är. Dessa effekter uppstår när införandet av standardiserade vårdförlopp införs genom en omprioritering mellan olika patientgrupper.

Sammantaget visar avhandlingen på betydelsen av att ha ett systemperspektiv när det kommer till hur man hanterar varierande patientflöden. Detta för att motverka suboptimeringar, vilka annars ofta uppkommer när man fokuserar på en del av ett system.

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Detta har varit en resa må jag säga! Om jag vetat hur mycket ansträngning, disciplin och envishet som behövts för att ta sig genom djupa dalar och vidare på smala stigar hade nog denna resa inte inletts överhuvudtaget. Som det så ofta verkar vara med de stora resorna i livet. När jag nu står på andra sidan och tittar tillbaka är det dock värt varenda ansträngning, motivationsdipp och misslyckat försök. Jag har växt som logistiker och människa och samtidigt tagit några trevande, men ack så viktiga steg på resan mot att förstå komplexiteten i den värld vi lever i.

Utan hjälp och stöd från många inblandade hade jag nog inte tagit mig i mål. Mina handledare har varit viktiga guider på olika strapatser under resans gång. Tack Erik för handfast stöd och engagemang. Tack Mattias för ditt utifrånperspektiv och kunskap om sjukvårdskontexten. Tack Mats för att du trodde på min förmåga och stöttade mig under resans början. Tack Håkan för din förståelse och klokskap kring flöden och strukturer inom organisationer i allmänhet, och sjukvårdsorganisationer i synnerhet.

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Färjestaden, Oktober 2021

Olle Olsson

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1 INTRODUCTION

This introductory chapter describes and motivates the purpose of this thesis and the research questions it aims to answer. The starting point is the increasing demands being imposed on healthcare organisations, and the challenges of managing variation in healthcare services. An overview of how the papers and reports appended to the thesis relate to the research questions is also provided. The final section of the chapter aims to clarify the terminology used in the thesis.

1.1 HEALTHCARE: A LARGE INDUSTRY FACING INCREASING DEMANDS

The Swedish healthcare system is managed by 20 regions and 290 municipalities. The regions and municipalities have independent powers of taxation and have their own self-governing local authorities with responsibility for different services. The regions provide primary and specialised medical care, while the municipalities provide geriatric and home care. Elected representatives in the regions or municipalities make decisions regarding the services that are closest to citizens (Swedish Association of Local Authorities and Regions, 2021). The principle of local self-government also enables the regions to adapt their activities to local conditions. Hence, in comparison to other countries, the Swedish healthcare system is highly decentralised. The regions employ roughly 280 000 individuals, and the municipalities approximately 880 000 individuals (Swedish Association of Local Authorities and Regions, 2020).

Providing healthcare is costly and health expenditure represents a large proportion of the gross domestic product (GDP) in most countries. For the OECD member countries, average health expenditure in 2019 was 8.8% of GDP, while Sweden's health expenditure was 10.9% of GDP (OECD Health Statistics, 2021). Health expenditure's share of GDP has also been continuously increasing over recent decades, from an average of 4.6% for the OECD member countries in 1970 (OECD Health Statistics, 2018).

A contributing factor to the past and present increases in health expenditure is the growing proportion of elderly in the Swedish population. By 2040, Statistics Sweden (2018) estimates that the number of elderly aged between 65 and 79 years will have increased from 1.5 million to 1.7 million, while the elderly aged 80 years and above will have increased from 0.5 million to 0.9 million. To meet the demands of this ageing population, approximately 90 000 additional employees are needed, due to increased demand for healthcare and geriatric care (Swedish Association of Local Authorities and Regions, 2014).

Moreover, the technological development in pharmaceuticals and advanced treatments also increases demand in the healthcare sector. The costs for Swedish healthcare are expected to increase with 80% by 2050, due to increased aspiration levels, new treatments and greater numbers of patients (Ministry of Health and Social Affairs, 2010).

In addition to the challenges due to future developments, there are also challenges in present healthcare provision. Accessibility and waiting times are recurring topics in Swedish healthcare provision. For example, the proportion of patients waiting longer than 90 days for a first appointment in specialised medical care or a surgical procedure increased between 2014 and 2019 (Swedish Association of Local Authorities and Regions, 2020). In the same report, the economic situation for most of the Swedish regions is described as strained, with net costs increasing, entailing weak economic results. The Covid-19 pandemic has also put pressure on the healthcare system, and much elective care has been postponed (Swedish Association of Local Authorities and Regions, 2020).

In addition to these present and future developments, the organisation and management of healthcare service provision pose further challenges that also need to be addressed in order to provide more and better healthcare for the money spent. The management and organisation of healthcare services are therefore described below.

1.2 HEALTHCARE ORGANISATION AND MANAGEMENT POSE CHALLENGES FOR PROCESS ORIENTATION

Healthcare organisations are often described as professional bureaucracies, a term introduced by Mintzberg (1979). As the term implies, the work performed is complex, requiring it to be carried out and controlled by professionals, such as doctors and nurses. The work is also mainly stable in terms of work practices; hence the skills of the professionals can be improved through standardised, step-wise training (Mintzberg et al., 2002). Professionals are also often given considerable control over their own work and perform it independently of their colleagues. Thus, the profession, not the manager, provides much of the structure and coordination in service provision (Mintzberg, 1998).

Due to the continuous developments in the medical field, the focus on how to treat and cure diseases has also outweighed the attention on managerial and organisational aspects in healthcare service provision (Bohmer, 2009; Timmermans and Berg, 2003). As a result of this development, healthcare organisations and their professionals have become increasingly specialised, and healthcare services increasingly fragmented (Coleman, 2003).

The fact that healthcare organisations are functionally specialised also poses challenges for inter-departmental cooperation and coordination. Patient processes can also be hindered or delayed, often inadvertently, by the attempts of departments to improve performance without taking into account the consequences for other parts of the organisation or patient processes (Scott and Hawkins, 2008). When the impact on the system as a whole is not considered, sub-optimisation often follows (Stock and Lambert, 2001).

The concepts of logistics and supply-chain management (SCM) are process oriented instead of functionally oriented (Towill and Christopher, 2005). Moving towards a more process-oriented system in healthcare is necessary (Mould et al., 2010) and has the potential to reduce sub-optimisation by focusing on patient flows (Parnaby and Towill, 2008). A holistic view of the whole patient process is therefore stressed by many authors (e.g. Aronsson et al., 2011; Glouberman and Mintzberg, 2001; Meijboom et al., 2011; Parnaby and Towill, 2008); not only as an overall strategy but also as a strategy for the sub-processes within each clinical department, and how they can contribute in the best way to the performance of the whole (Aronsson et al., 2011).

Towill and Christopher (2005) also show that logistics and SCM practices that were originally developed and successfully used for commercial services and products can perform just as well for the organisation of effective healthcare systems with a focus on patient flows. De Vries and Huijsman (2011) further conclude that existing concepts,

models and supply-chain practices can be extended to SCM in health services. This thesis is founded upon a logistics and SCM perspective, emphasising the need for an increased focus on patient flows and the system as a whole in functionally specialised healthcare organisations.

With healthcare organisations being functionally specialised, and healthcare services increasingly fragmented (Coleman, 2003), managing variations in patient flows is challenging. Patient flows are subject to many types of variation (Berry and Bendapudi, 2007), and therefore the next section addresses the different types of variation that occur in healthcare services. These need to be acknowledged in order to move towards a more process-oriented and patient-flow-focused system of healthcare.

1.3 HEALTHCARE SERVICES ARE SUBJECT TO MUCH VARIATION

The term variation describes the act of varying (Merriam-Webster, 2021); a partial change in the form, position, qualities or state of a thing. Variation in this thesis is regarded as a deviation from the mean value of a certain variable. For example, the deviations from the mean value in the time to conduct a doctor's appointment are henceforth described as variations.

Variation when providing services, such as healthcare services, is often compared to variation when producing goods, but there are some important differences. The provision of services is often more labour-intensive (Arlbjörn and Halldorsson, 2002), and services are provided and consumed at least partly at the same time (Grönroos, 2007; Arlbjörn and Halldorsson, 2002). Hence, it is not possible to store or transport services, due to their simultaneous provision and consumption (Arlbjörn and Halldorsson, 2002). In addition, customers also participate, at least to a certain extent, in the service provision process (Grönroos, 2007).

In healthcare, every individual patient also has different combinations of diseases and severity levels, and responds differently to medical interventions (Litvak and Long 2000; Noon et al., 2003). Patients are also in need of “whole-person” services customised to each individual patient's medical and mental condition, age, personal traits and preferences as well as family circumstances (Berry and Bendapudi, 2007). These factors introduce much variation into service provision.

There is also variation originating from the service providers. Some variation originates from different approaches, levels of ability and preferences among healthcare personnel, which introduce variation into service provision (Litvak and Long 2000; Noon et al., 2003). For instance, decisions on further treatment are always based on the judgement of a physician. James and Savitz (2011) describe this as practice variation, and they identify large variations in physicians' practices for a number of high-volume surgeries at Intermountain Healthcare in United States of America. They also showed that the variation in the total

quality of care between individual physicians was small, even though every physician “had something to learn, but also something to teach” (James and Savitz, 2011, p. 1186).

Some variation is also introduced through the planning and organisation of the different resources used in service provision. For example, prioritising between different patient groups leads to demand being subdivided into smaller groups, increasing variation in waiting times and average wait in the system (Silvester et al., 2004). Discontinuous scheduling of specific clinics or activities on only one or two days per week also introduces variation into the system (Allder et al., 2011).

As exemplified above, patient flows are subject to much variation, originating from the patients, the service providers and the interaction between these. In the next section, the negative implications of improper management of variation in patient flows will be further discussed.

1.4 HEALTHCARE PERFORMANCE DECLINES WITHOUT PROPER MANAGEMENT OF VARIATION

An implication of healthcare services being influenced by a lot of variation is that managing variation is important. One way to do so is to reduce, or eliminate, it. However, for many of the types of variation that have a strong influence upon healthcare services, such as different severity levels of a disease, different responses to therapy and varying levels of ability among healthcare personnel (Litvak and Long 2000; Noon et al., 2003), reducing variation can be difficult, time consuming or nearly impossible. Hence, it becomes important to manage it in other ways.

The influence of variation upon resource utilisation and throughput time was first specified by Kingman (1961). The Kingman equation provides an approximation of the waiting time for a single activity based on its resource utilisation and variation. Resource utilisation is defined here as the percentage of the time during which a resource is used. The relationship between these variables can be clarified by the illustration below.

FIGURE 1.1 – THE INFLUENCE OF VARIATION ON THROUGHPUT TIME AND RESOURCE UTILISATION (ADAPTED FROM MODIG AND ÅHLSTRÖM, 2013, P. 50).

The shape of the curves demonstrates the first influence of variation, namely that when resource utilisation approaches 100%, the throughput time increases dramatically. Under the influence of variation, the relationship between throughput time and resource utilisation is not linear, but exponential. The second effect of variation can be seen by comparing the two curves: with increased variation in an activity, the throughput time will also increase, unless resources are added, thus reducing the resource utilisation. With high variation in patient flows, short throughput time and high resource utilisation cannot be achieved simultaneously. Hence, the strategic choice between these two becomes more important. Many organisations focus on resource utilisation in each part of the patient flow (Modig and Åhlström, 2013), in order not to waste any resources. However, this choice makes it difficult to manage variation in patient flows. Overcrowded emergency departments, bed shortages on inpatient wards and long waiting lists for elective diagnostics and treatments are all common and important areas for improvement in many hospitals that can be related to the management of variation. This thesis will address the management of variation within these areas of improvement. They are therefore briefly presented below.

Overcrowding is a well-known problem in emergency departments (EDs). In a focus group study by Estey et al. (2003), two major reasons for overcrowding were identified: staff shortages and inefficient access to ED beds due to slow throughput of patients. Trzeciak and Rivers (2003) stated similar conclusions based on a literature review concerning the causes of and solutions to overcrowded EDs. They argued that a major cause of ED overcrowding was inadequate hospital bed numbers for the current population.

For inpatient wards, similar patterns appear, with a common issue being high bed occupancy and bed shortages. Proudlove et al. (2003) claim that a mismatch between

admission and discharge activity patterns, during the day, and the week, generates fluctuating and higher bed occupancy than would be the case if there was a match between the two. Response to high bed occupancy and bed shortages often led to a focus on rearranging the placement of admissions, and finding short-term solutions. Many of the decisions related to finding these solutions involve resolving conflicting goals, for example between the need for emergency and elective beds (Proudlove and Boaden, 2005).

For elective diagnostics and treatments, long waiting lists have been an issue for many years, with little progress in many countries. Although long waiting times may imply a lack of capacity, studies have shown otherwise. For total hip replacement (Frankel et al., 1999) in the United Kingdom (UK), it seems that potential demand is within the capacity of the National Health Service (NHS). In Sweden, waiting times vary significantly, for example in cancer care, with large differences in waiting times between patients with different types of cancer and between different regions (Robertsson et al., 2017).

These brief introductions indicate overcrowding, bed shortages and long waiting lists as being related to high resource utilisation, making it difficult to manage variation in patient flows without excessive throughput time and other negative effects, such as strain on healthcare professionals. It is therefore important to engage in further study of the management of variation in these areas of improvement.

1.5 PURPOSE AND RESEARCH QUESTIONS

To recapitulate, by 2050, the costs for Swedish healthcare are expected to increase by 80% due to increased aspiration levels, new treatments and pharmaceuticals, as well as larger numbers of patients (Ministry of Health and Social Affairs, 2010). With healthcare service provision being subject to much variation (Berry and Bendapudi, 2007; Noon et al., 2003) and variation having a negative effect on resource utilisation and/or throughput time (Kingman, 1961), it is important to manage variation.

With high resource utilisation by healthcare services, managing variation becomes difficult. Examples of this are overcrowded EDs (Estey et al., 2003; Trzeciak and Rivers, 2003), high bed occupancy and bed shortages on inpatient wards (Proudlove et al., 2003) and long waiting lists for elective diagnostics and treatments (Frankel, 1993; Robertsson et al., 2017). These issues are also influenced by the organisation of healthcare as professional bureaucracies (Mintzberg, 1979) performing highly specialised healthcare services, with the risk of creating a fragmented healthcare system (Coleman, 2003).

There is also a lack of research applying a holistic perspective concerning how variations in patient flows are managed within hospitals (Aronsson et al., 2011; Parnaby and Towill, 2009). This thesis aims to fill some of that gap, and hence the purpose of this thesis is:

To explore the impact and management of variation in patient flows within hospitals.

The use of an exploratory approach in this thesis is related to the depth of previous research regarding the management and impact of variation in patient flows within hospitals. Previous research has also shown that healthcare managers often believe that, unlike manufacturing industry, they cannot control their service provision or predict their patient inflow (Jarret, 1998; Vissers et al., 2001). The examples described earlier, with overcrowded EDs, high bed occupancy and bed shortages on inpatient wards, and long waiting lists for elective diagnostics and treatments, also demonstrate a lack of knowledge about how to manage variation in patient flows. Previous research has also shown that healthcare resources are often being used inappropriately, and not in accordance with the variations that exist in patient flows (Walley et al., 2006). This demonstrates a lack of knowledge concerning the impact and management of variation in patient flows. It is therefore relevant to explore how variation in patient flows is managed and how this impacts upon hospitals.

Regardless of the cause of the variation, it affects either the arrival rate or the service time; thus, for each activity in a patient flow there is variation in the arrival of patients and how long an activity takes (service time) for each patient (Modig and Åhlström, 2013). In a patient flow with several activities, these types of variation also influence each other, e.g. variation in service time for the first activity influences the variation in arrival rate for the second activity. All of the types of variation discussed in section 1.3 thus influence the arrival rate and service time for each activity in a patient flow. The impact and management of variation in arrival rates and service times are therefore the types of variation that are addressed in this thesis.

Because variation has a negative effect on resource utilisation and/or throughput time (Kingman, 1961), it is important to manage it. In order to do so, it is important to understand, in more detail, how variation negatively influences, and impacts upon, a system beyond the effects on single activities described by Kingman (1961). Previous research has also highlighted ED overcrowding and high bed occupancy on inpatient wards as being common issues in hospitals related to variation in patient flows. ED overcrowding has also been argued to be dependent on available beds on inpatient wards (Trzeciak and Rivers, 2003; Schiff, 2011), which in turn is influenced by a mismatch between demand and supply for permanent care facility spaces (Travers et al., 2008). In other words, these are impacts that have been identified in previous studies. However, there is a need to further explore the impacts of variation in patient flows and provide more knowledge concerning the impact that variation in acute patient flows has on healthcare units.

Acute patient flows are inherently variable and require immediate attention. Hence, these are of specific interest when analysing the impact of variation in patient flows. When handling acute patient flows at hospitals, the ED and inpatient wards are the organisational units mainly involved in handling these patients. Some patients also need acute surgery, but thereafter often also require inpatient care. Based on this line of reasoning the first research question is:

RQ1: How does variation in acute patient flows impact upon healthcare units?

In accordance with the discussion in section 1.4, research regarding the handling of variation in acute patient flows has mainly addressed EDs and inpatient wards. It is therefore of interest to explore how the impact of variation in acute patient flows differs between EDs and inpatient wards. Length of stay and bed occupancy are two important measures for these units, since they are linked, for example, to the workload of various personnel. Lengths of stay for different patient groups cared for on inpatient wards are also followed nationally and compared between hospitals. In addition, lengths of stay are followed nationally for EDs, while bed occupancy, and in particular bed shortages on inpatient wards, are also followed nationally. It is therefore also relevant to study how the impact of variation in acute patient flows differs between these measures. Hence, RQ1 is subdivided into the following underlying questions:

- a) How does the impact upon length of stay differ between EDs and inpatient wards?*
- b) How does the magnitude of impact differ between bed occupancy and length of stay?*

In previous research, the ability of healthcare providers to handle variation in patient inflow has been questioned. For instance, Walley et al. (2006) argue that the scheduling of healthcare resources are often not adapted to the variation in patient flows. More knowledge is thus needed to specify why variations in patient flows are not handled appropriately. It is therefore important to describe the types of action used in handling variation in acute patient flows. An action here corresponds to any type of measure that is used, at least in part, reactively or proactively, to handle variation in patient flows. The second research question hence embraces:

RQ2: What actions are used to handle variation in acute patient flows within hospitals?

To buffer for variation in arrival rate and service time, the Kingman equation shows that resource utilisation and throughput time are the variables to work with, when reducing variation is not applicable. However, when addressing the handling of variation in a larger system, such as a hospital, other options come into play, such as sharing resources between different patient flows, i.e. demand pooling. There is, however, a lack of categorisation of actions used to handle variation in acute patient flows in current research. The first underlying question of RQ2 is therefore:

- a) What types of action are used?*

As previously discussed, it is important to coordinate actions for handling variation in acute patient flows between healthcare units, in order to handle problems with overcrowded EDs and bed shortages on inpatient wards. This is due to the sub-optimisation that often follows when organisational units are managed individually, without considering the impact on the organisation as a whole (Stock and Lambert, 2001). It is hence reasonable to assume that the organisational level where an action is chosen and used can have implications for the

effectiveness of that action in handling variation. Some actions, for example, are chosen by the top management level at a hospital to smooth out bed occupancy between inpatient wards, while other actions are used by department chiefs to counteract bed shortages on inpatient wards in their clinical department. These actions can have different implications for patients, personnel and the hospital as a whole. Increasing our understanding regarding the organisational levels at which actions to handle variation in acute patient flows are used is therefore relevant. Hence, the second underlying question of RQ2 asks:

b) At which organisational levels are these actions used?

Due to the continuous developments in the medical field, the focus on how to treat and cure diseases has outweighed the attention on managerial and organisational aspects of healthcare service provision (Bohmer, 2009; Timmermans and Berg, 2003). As a result of this development, healthcare organisations and their professionals have also become increasingly specialised and healthcare services increasingly fragmented (Coleman, 2003). Healthcare organisations, being professional bureaucracies (Mintzberg, 1979), also perform complex work that is carried out and controlled by healthcare professionals (Mintzberg et al., 2002). The lack of overall responsibility for individual patients, due to each clinical department focusing on its own part of care delivery (Plsek and Greenhalgh, 2001), leads to an increased risk of inappropriate and delayed care due to patients' needs not matching the services provided by the specialised clinics (Brennan et al., 1991; Coleman, 2003).

In the NHS, middle managers often act as diplomats (Harrison et al., 1992) in order to be perceived as serving the best interests of the professional operating core and thereby maintaining acceptance (Harrison et al., 1992). However, Waring and Currie (2009) argue that when professionals, such as doctors, become managers, they do so partly to secure professional legitimacy and autonomy. These hybrid managers (e.g. Kitchener 2000; Shi et al., 2009) are very common in healthcare, in particular at middle management levels, where department chiefs are a common example. Since the domains of management and medicine have previously been opaque to each other, the institution of hybrid managers has enabled mutual visibility between management and medicine. Hybrid managers have also been shown to be more adept and effective at brokering knowledge across organisational boundaries (Waring et al., 2013), while establishing better communication and mutual understanding between medicine and management (Llewellyn, 2001). It is thus reasonable to assume that the organisation and involvement of middle management in hospitals will influence the actions used for handling variation in acute patient flows. Therefore, the third research question asks:

RQ3: *How do the hospital organisation and middle management involvement influence the use of actions to handle variation in acute patient flows?*

The previous research questions have all addressed managing variation in acute patient flows. Managing elective patient flows is also important; in fact, research shows that elective

patient flows often display more variation than acute patient flows. One example of this is the number of surgical procedures performed on a daily basis, which is more variable for elective than acute procedures (Walley et al., 2006). These types of variation are self-introduced and could thus be reduced in order to smooth out service provision. Since elective patient flows, in contrast to acute patient flows, do not require immediate attention from healthcare professionals, it is possible to have a waiting list of patients. Long waiting lists have, however, been an issue in many healthcare systems, e.g. the UK (Frankel, 1993; Nikolova et al., 2015), Norway (Askildsen et al., 2011) and Sweden (Robertsson et al., 2017), to name just a few. In Sweden, waiting times have varied considerably, for example in cancer care, with large differences in waiting times between patients in different regions and with different types of cancer (Robertsson et al., 2017). Long and unequal waiting times have also prompted national initiatives to introduce care pathways in Denmark, Norway and Sweden. These care pathways include time-targets for the whole pathway, as well as the various different activities encompassed within the pathway, partly in order to handle variation in these patient flows. In Denmark, waiting times have been reduced for most cancer areas following the introduction of care pathways, called *Pakkeforløb* (Probst and Andersen, 2012; Larsen et al., 2013). However, the effects on other patient groups have not been addressed when introducing care pathways. Nor have these issues been explicitly addressed in the previous research questions. Since care pathways often include time-targets for the patient process, this allows for quantitative studies, which could provide extended knowledge concerning the implications of different strategies used to handle variations in patient flows. The fourth research question therefore asks:

RQ4: How does the implementation of care pathways influence the handling of variation in elective patient flows?

As pointed out above, the effects on other patient groups have not been addressed in research studying the introduction of care pathways. One issue is whether the implementation of care pathways influences the ability to handle variations in other patient flows and, hence, if the actions used to handle variation in one patient process influence the options for handling variation in other patient processes, or in the healthcare unit as a whole. With care pathways often including time-targets, it is likely that the introduction of care pathways will influence waiting times due to changes in work practices. Thus, studying changes in waiting times and the reason behind these changes is a way to increase our understanding of how care pathway implementation influences the handling of variation in elective patient flows. RQ4 has therefore been subdivided into the following underlying questions:

How does the implementation of care pathways influence waiting times...

- a) ...for care pathway patients?*
- b) ...for other patient groups?*
- c) ...as a whole?*

In the next section, the different papers and reports, and how each of these addresses the research questions, are presented.

1.6 THE PARTS OF THE THESIS AND HOW THEY RELATE TO THE RESEARCH QUESTIONS

This thesis is built around three studies. These studies have resulted in a number of academic papers, reports and a case study, as listed below.

- Study 1: Paper I
- Study 2: Paper II, Paper III, Case study I
- Study 3: Paper IV, Report I, Report II

The studies were performed in chronological order, beginning with Study 1 and followed by Study 2 and Study 3. In Study 1, the impact of variation on performance at healthcare units is addressed, simulating the acute patient flow at an emergency department and the patient flow on an inpatient ward. In order to expand the understanding of how variation in acute patient flows is managed, Study 2 analysed the actions used to handle variation in acute patient flows at a hospital, and the influence of middle management and the organisation upon these actions. The third study complements the first two by addressing how waiting times in elective patient flows are influenced by the implementation of care pathways. In Table 1.1, the links between the research questions and the appended papers, reports and case study are depicted.

TABLE 1.1 – THE LINKS BETWEEN THE APPENDED DOCUMENTS AND THE RESEARCH QUESTIONS

Study	Part	RQ	Patient flow
Study 1	Paper I	1	Acute
	Paper II	2	Acute
	Paper III	3	Acute
	Case study I	2, 3	Acute
Study 3	Paper IV	4	Elective
	Report I	4	Elective
	Report II	4	Elective

This introductory chapter concludes with some clarifications regarding common terms used in the thesis.

1.7 TERMINOLOGY

Some of the terms and labels used in this thesis have been defined and described previously in this chapter, and others have not. The meanings and uses of some terms and expressions are also slightly different in the appended papers and reports in comparison to the main

text of this thesis. Therefore, this section aims to provide an overview of the terminology used in this thesis.

The main text of this thesis presents the management of variation in patient *flows*, in the plural. However, Papers II and III, along with Case study I, refer to the acute patient *flow*, in the singular. These appended parts of the thesis mainly define the acute patient flow as the flow of patients visiting the ED and thereafter being sent home or being admitted to an inpatient ward at the hospital, and hence refer to it as a single flow. The main text of the thesis, however, describes this as a number of acute patient flows that together correspond to the previously used term acute patient flow.

A related difference in the use of terms between the appended documents and the main text of the thesis are the terms *variable patient flow* and *variation in patient flows*. The former term is used in Papers II and III and Case study I and sometimes includes the word *acute*, e.g. variable acute patient flow. This refers to a patient flow being variable in terms of arrival rate and service time, in accordance with the rest of this thesis. In the main text of this thesis, however, the term *variation in patient flows* is used, since the meaning of this term is more straightforward. Hence, these terms are considered synonymous in this thesis.

The main text of the thesis also aspires to distinguish between the terms *handling* and *managing*. These terms are mostly used when discussing the *handling* of variation in patient flows and the *management* of variation in patient flows. These terms have been used quite interchangeably in Papers II and III and Case study I, but in the main text of this thesis the term *handling* refers to measures that are of a more practical and operational nature, whereas the term *managing* is used for broader decision-making and steering of organisational units or patient flows.

2 FRAME OF REFERENCE

The frame of reference is divided into six sections. The first section describes specific characteristics of healthcare in terms of its being a service industry. In the second section, aspects of healthcare organisation and management that have a potential influence on the handling of variation in patient flows are elaborated. The following section introduces the different types and origins of variation that are present in a healthcare context. Thereafter, the fourth section describes common challenges in healthcare service provision that can be related to variation in patient flows. The fifth section examines strategies and concepts for managing variation. The last section provides a framework for managing variation at different levels of abstraction, using knowledge and concepts from the previous sections.

2.1 HEALTHCARE: A SERVICE INDUSTRY¹

Healthcare may be viewed as a service industry. Traditionally, in logistics and SCM research, the flow of physical products has been analysed. In a healthcare setting, the primary interest is instead patient flows, along with supporting material flows (Visser and Beech, 2005). A key difference is that the presence of customer inputs induces variation in services. Sampson (2001) states this as follow (p. 16):

With service processes, the customer provides significant inputs into the production process. With manufacturing processes, groups of customers may contribute ideas to the design of the product, but individual customers' only participation is to select and consume the output. All managerial themes unique to services are founded in this distinction.

Due to these customer inputs, services are, at least partly, provided and consumed at the same time. Grönroos and Ravald (2011) further divide the service production process into three phases, based on the participation of the service supplier and the customer. The first is a production phase where only the supplier is present, with the aim of facilitating value creation; for example, preparing an operating theatre before a surgical operation. In the second phase, the interaction between customer and supplier takes place, e.g. the surgery. The third phase includes the parts of the process that the customer carry out without involvement with the supplier; for example, the exercises performed during rehabilitation after surgery.

Other characteristics of services that are important to acknowledge is that they are often labour-intensive and cannot be stored or transported due to their simultaneous production and consumption (Arlbjörn and Halldorsson, 2002). Services are also more likely to consist of linked activities (intangible) than goods (tangible) (Grönroos, 2007). The intangible element of services also makes them more difficult to automate or to evaluate in terms of quality. Services are also perishable, with the implication that unused capacity is irreversibly lost.

In addition to services being different from goods, there are differences between healthcare services and other services. Berry and Bendapudi (2007) describe these differences in terms of six features, described below:

- *Customers are sick* – Customers have some elements of pain, illness, uncertainty, fear and perceived lack of control. The patients might also live in the service “factory” and the emotions that follow an illness influence their ability to evaluate, and make choices.
- *Customers are reluctant* – Customers may be reluctant co-producers because healthcare is a service they need but may not want. In addition, the customer’s role as a “co-producer” is often needed for a favourable outcome.

¹ A previous version of this section is included in the licentiate thesis (see section 1.4 in Appendix 1)

- *Customers relinquish privacy* – Since healthcare services are inherently personal, but not private, customers relish privacy, physically, emotionally and spiritually. Patients may have to undress and discuss very personal matters with clinicians whom they are meeting for the first time.
- *Customers need a “whole-person” service* – There is a need for healthcare personnel to understand each individual patient and to customise the service according to the patient’s medical and mental condition, age, personal traits and preferences as well as family situations. This puts pressure on the clinician’s capability and inclination to combine their knowledge of medicine with an understanding of the individual patient.
- *Customers are at risk* – A profession that is intended to restore health also causes harm. Hospital-acquired infections, inappropriate medication and communication errors harm millions of patients worldwide every year.
- *Clinicians are stressed* – Serving acutely ill people is stressful work and doctors, nurses and other healthcare professionals are often visibly tired and fatigued. The work shifts are long and, especially for nurses and assistant nurses, include “heavy” work such as lifting or turning patients. The emotional stress of delivering bad news to patients and families also adds to the stressful environment.

Besides these aspects, patients as customers have also become more conscious and critical consumers in general, a role that they will probably maintain when requesting and receiving healthcare services (Meijboom et al., 2004). All in all, healthcare services are complex, requiring a delicate interplay between patients and healthcare personnel. Also, the results and use of healthcare services are influenced by the organisation of healthcare professionals and the challenges this poses to managing patient flows. The next section addresses this issue.

2.2 ORGANISING HEALTHCARE

Healthcare organisations can be described as professional bureaucracies. The work performed is complex, yet stable, allowing the professionals’ skills to be improved through standardised, step-wise training (Mintzberg et al., 2002). Hence, doctors have the legitimacy to define the purpose and actual delivery of health services (Doolin, 2002), while also being able to resist or modify any proposed changes that threaten their interests within the organisation (Harrison et al., 1992; Mintzberg, 1979). To keep up with the continuous developments in the medical field, healthcare organisations and their professionals have become increasingly specialised and fragmented (Coleman, 2003). Hence, the focus on how to treat and cure diseases has been greater than the attention on organisational and managerial aspects of healthcare service provision (Bohmer, 2009; Timmermans and Berg, 2003).

This functional specialisation in healthcare organisations has been positive in terms of the quality of health services. However, it poses challenges for inter-departmental cooperation

and coordination. When each clinical department only focuses on its own aspect of care delivery (Plsek and Greenhalgh, 2001), this leads to an unclear division of responsibilities and a need to coordinate between clinical departments. A lack of overall responsibility for individual patients implies an increased risk of medical errors, as well as inappropriate and/or delayed care due to patients' needs not matching the services provided by the specialised clinics, or patients "falling between the cracks" due to failures in communication (Brennan et al., 1991; Coleman, 2003). With each clinical department having separate budgets and performance measurement systems, the focus is also directed towards performing as an internal unit, rather than as a collective "organisation" (Plsek and Greenhalgh, 2001).

Due to having a functionally specialised organisation, with healthcare service provision in general being controlled by healthcare professionals, and high levels of resource utilisation in each part of the patient flow (Modig and Åhlström, 2013), handling variation in the patient flow is challenging. The fact that doctors are common in managerial positions, and increasingly incorporated into them in healthcare organisations (Kitchener, 2000; Blomgren, 2015), is another important aspect of the management of variation in patient flows. The next section therefore discusses this further.

2.2.1 MIDDLE MANAGERS IN HEALTHCARE

There is a substantial difference in status and legitimacy between doctors, who enjoy significant clinical autonomy, and other actors, such as nurses, managers and other professions (Abbott, 1988; Oborn and Dawson, 2010). This clinical autonomy rests on the exclusive ability of clinicians to define illness, diagnose patients and decide between appropriate treatments (Dent, 1993). Middle managers have traditionally often acted as diplomats in order to be perceived as serving the best interests of the operating professionals, and thereby maintaining acceptance (Harrison et al., 1992).

Doctors who become managers become bureaucratised to some extent through their acceptance of managerial responsibility (Kitchener, 2000). However, they also often protect high levels of medical sovereignty and counter attempts to increase managerial control of clinical practice (Waring and Currie, 2009). In contrast, these "hybrid managers" can also add value by merging knowledge of the strategic intent of top management with knowledge of practice on the ground (Burgess and Currie, 2013). Although research on hybrid managers has mostly studied doctors (Doolin, 2002; Kitchener, 2000; Llewellyn, 2001), other professions, in particular nurses, also act as hybrid managers in healthcare settings (Fitzgerald et al., 2013).

Hybrid managers do not only implement strategies from top management (Floyd and Wooldridge, 1992), but they are also involved in the development of strategy (Dopson and Fitzgerald, 2006) and broker knowledge to top management within the organisation (Currie and Procter, 2005; Shi et al., 2009). In healthcare, hybrid managers' strategic understanding is also positively related to supporting changes and synthesising new information (Pappas

et al., 2004). The position of hybrid managers is also suitable for supporting knowledge sharing and learning due to their legitimacy, which enables them to participate in multiple communities and relationships (Waring et al., 2013).

Traditionally, clinicians and managers work with different sets of ideas and act according to different logics. They therefore have problems decoding and making sense of each other's messages (Ackroyd, 1996; Llewellyn, 2001). Since hybrid managers can incorporate managerial tasks into their clinical work, but managers are unable to carry out clinical duties, hybrid managers enjoy a unique position within healthcare organisations. Hybrid managers can simultaneously use sets of ideas from both clinical practice and management, and enact the analogy of a two-way window (Llewellyn, 2001). Since the domains of management and medicine have previously been opaque to each other (constituted as "one-way windows"), the institution of hybrid managers enables mutual visibility between these two domains. Hybrid managers have been shown to be more adept and effective at brokering knowledge across organisational boundaries (Waring et al., 2013). The creation of "two-way windows" thus implies a greater degree of communication and mutual understanding between medicine and management (Llewellyn, 2001). However, the willingness of middle managers to broker knowledge, and thus become hybrid managers, is linked to an identity transition, in which a professional perspective is complemented with a managerial one (Witman et al., 2011). To enable this transition, early career socialisation has been proven crucial (Burgess and Currie, 2013).

With the organisation of healthcare and the involvement of middle management having a potential influence upon the handling of variation in patient flows, the next section delves deeper into the different types and origins of variation present in a healthcare context.

2.3 VARIATION IN HEALTHCARE SERVICES²

As described in the first chapter of this thesis, the term *variation in patient flows* is used to refer to patient flows under the influence of variation. It was also decided that managing variation in arrival rates and service times would be the types of variation that are addressed in this thesis. The term variation, as previously discussed, is regarded as referring to a deviation from the mean value of a specific variable; for example, the deviations from the mean value in the number of patients who arrive at an emergency department.

The variation in a certain variable is dependent on the variations in the components making up that variable. The number of patients arriving at an emergency department at a specific time of day is influenced, for instance, by the weekday, the month, the weather and the demographic distribution in the catchment area, among other things. Variation can also be measured at different levels, whereby, for example, the number of patients arriving at an emergency department is highly variable when comparing different hours of the day, while the monthly, or yearly number of patients is quite constant. As a concept, variation is

² A previous version of this section is included in the licentiate thesis (see section 1.5 in Appendix 1)

complex, and there are different types and origins of variation described in the literature. This section presents two main groups of variation: internally and externally created variation. The latter is strongly related to the customers, in this context primarily patients. The former is created by the ways in which work within the organisation is executed. Allder et al. (2011) describe a number of behaviours in healthcare systems that create variation internally:

1. *The system artificially increases variation in arrival rate* – First appointment referral requests are often batched between general practitioners and secondary care, creating artificial ups and downs in demand.
2. *Capacity variation is introduced into the system* – Queues are made worse by the scheduling of specific appointments on only one or two days per week. The capacity to discharge patients from inpatient wards is also often decreased during holiday periods, due to an increased proportion of inexperienced physicians who are reluctant to discharge patients.
3. *Prioritisation increases variation* – One of the known effects of prioritisation systems, such as basic forms of triage, is that it splits demand into subgroups. These subgroups experience higher net variation in arrival rates, increasing the average waiting time in the system.
4. *Subspecialities generate increases in variation* – Any form of division of patients into smaller subgroups, such as the creation of a new specialist clinic, increases delay in a very similar way to that of prioritisation. In contrast, sharing resources between multiple providers smooths out demand and reduces queues.
5. *Waiting list initiatives increase variation* – Adding short-term capacity to try to reduce or eliminate queues increases the variation in arrival rates and generates temporary surges in demand that spread to downstream actors. This unbalances the system and moves delays and queues from one place to another. Often the initiative simply shifts the queues from one speciality to another, as previously shared resources are moved.

These are examples of some of the ways in which the planning of healthcare services and resources introduces variations into the healthcare system. There is also variation that originates from healthcare personnel. Due to different approaches, preferences and levels of ability, healthcare personnel introduce variation into service provision (Litvak and Long 2000; Noon et al., 2003). For instance, physicians must always make a judgement as the basis for decisions about further treatment. In comparison to the examples of how the planning of healthcare services introduces variation, the variations introduced due to different levels of ability and the decisions about therapies made by healthcare personnel are more difficult to manage. These types of variation are therefore usually denoted to the externally created category. In addition to healthcare personnel, the customers, or patients, introduce externally created variation, and some different types are described below.

Customers do not all want services at the same time, or at times that are necessarily convenient for the organisation that provides the service (Frei, 2006). In many situations, it is possible to address arrival variation through appointments or reservations, but in situations where the customers cannot foresee or delay their needs, this solution is not usable (Frei, 2006; Bicheno et al., 2009), an obvious example being acute patients arriving at an emergency department (ED).

Today, few patients in need of healthcare services follow the textbook example of a “model patient” with clear symptoms that are easily diagnosable and treatable. Instead, most patients have a unique combination of diseases, severity levels and responses to therapy; hence, much variation is introduced into healthcare service provision (Litvak and Long 2000; Noon et al., 2003). The interactions of multiple diseases and the effects of a given treatment also make it difficult to foresee the next step in the patient process. When each diagnostic test or test of treatment generates new information that influences decisions about future therapies, the patient process becomes iterative (Bohmer, 2005; Bohmer, 2009). These complexities introduce variation in both arrival rates and service times in the patient flows.

The fact that customers’ desires and requests do not emerge along standard lines poses challenges for practically every kind of service business (Frei, 2006). In healthcare, where patients need treatment but may not want it (Berry and Bendapudi, 2007), variation in patients’ desires are also ambiguous. Opinions about what it means to be treated well in a service environment also vary among customers. The unpredictability in personal preference hence makes it complicated to serve a broad customer base using standardised processes (Frei, 2006). These types of preferences and desires mainly influence variation in service time, but also have an effect on the choice of activities within the patient flows, and hence variation in arrival rates.

Another source of variation is the differences in capabilities that customers possess. This may originate from differences in knowledge, skill, physical abilities or resources, and some customers therefore perform tasks easily, whereas others require more support. When customers perform an activity during a service interaction, it is also up to them how much effort they apply to the task (Frei, 2006). In the third phase of the value-creating process (Grönroos and Ravald, 2011) described in section 2.1, where customers perform activities without interaction with the supplier, e.g. rehabilitation exercises after surgery, it becomes essential to handle variation in patient capability and effort. When customers are active in the production and delivery of a service, it becomes more important to handle variation in capability and effort, because it influences service time and arrival rates.

As described above, patient flows are subject to much variation, originating from the patients, the healthcare service providers, and the interaction between them. With services being different from goods due to the presence of customer inputs, accommodating variation is one of the biggest challenges for service operations (Sampson and Froehle,

2006). When possible, reducing variation in customer input may serve as a means to improve the service. One way to do this is to provide a limited number of offerings to customers. The applicability of this strategy is, however, of limited scope for many Swedish hospitals. With the Swedish healthcare system consisting of 20 self-governing regions, in quite a sparsely populated country, Swedish hospitals have to provide a broad spectrum of healthcare services. Thus, with many sources of variation in patient flows that are difficult to reduce, an important strategy for Swedish hospitals is to manage variation in patient flows in other ways.

The next section further discusses why managing variation is important, and exemplifies this by introducing some common issues in healthcare that are partly caused by a lack of focus regarding the management of variation in patient flows.

2.4 EFFECTS OF VARIATION

The influence of variation upon resource efficiency and throughput time approximated by Kingman (1961) was discussed in section 1.4. The Kingman equation provides an approximation of the waiting time for a single activity based on its resource utilisation and degree of variation. Because it is not possible to store finished services, including healthcare services, due to customer inputs (Arlbjörn and Halldorsson, 2002; Sampson, 2001), variations in service time and arrival rates need to be buffered using some combination of capacity or time. Having a broader scope than a single activity allows for other options to manage variation, by using different types of flexible capacities, e.g. sharing staff between healthcare units or educating personnel in critical tasks (Noon et al., 2003). Hence, flexibility between activities, patient flows and healthcare units becomes important in order to achieve both high resource utilisation and low throughput time. However, a central, and common, problem is the focus on resource utilisation in each part of the patient process, making it difficult to manage variation without excess waiting time. Overcrowded emergency departments, bed shortages on inpatient wards and long waiting lists for elective diagnostics and treatments are all common and important areas of improvement related to the management of variation. This thesis will address the management of variation within these areas of improvement. They are therefore described further below.

2.4.1 OVERCROWDED EMERGENCY DEPARTMENTS

Overcrowding is a well-known problem in EDs. Even though no specified definition of overcrowding has been agreed upon, factors relating to the ED itself, such as patient waiting times or number of visits, are often included. Factors related to the hospital, such as bed occupancy on inpatient wards or numbers of patients waiting for an inpatient bed, are also common (Hwang and Concato, 2004). A broad and general definition is given in Estey et al. (2003, p. 87): “anything that impedes the flow of patients through the ED, affects the quality of care delivered or results in patient frustration and stress to staff”.

Through a systematic literature review in the field of ED overcrowding, Hoot and Aronsky (2008) summarise the most commonly studied causes of ED overcrowding, namely non-urgent visits, frequent-flyer patients, influenza season, inadequate staffing, inpatient boarding and hospital bed shortage. In another literature review, Trzeciak and Rivers (2003) concluded that a major cause of ED overcrowding in general was an inadequate number of inpatient beds for the current population.

In a study by Estey et al. (2003), overcrowding was perceived as having many causes, including seasonal factors. Two major problems were emphasised, however, namely staff shortages and inefficient access to ED beds due to slow throughput of patients. When ED personnel estimated the impact of different causes of overcrowding, Schiff (2011) concluded that downstream issues, such as access to inpatient beds, were a major group with on average 63% impact, compared to intra-ED flow with 20% impact and upstream issues at 18%.

A lack of ED staff, as well as insufficient ED and hospital beds, point towards overcrowding being related to high resource utilisation, leading to difficulties in managing variation in the patient flow without excessive throughput time. Patients entering the ED during periods of high bed occupancy have also been found to have increased in-hospital mortality rates (Richardson, 2006). In a large cohort study including seven EDs in the Stockholm Region of Sweden, a significant association was identified between high levels of ED overcrowding and increased 30-day mortality (af Ugglas et al., 2020a).

2.4.2 HIGH BED OCCUPANCY ON INPATIENT WARDS³

For inpatient wards, similar patterns appear concerning the effects of variation in patient flows, with a frequent issue being high bed occupancy and bed shortages. A mismatch in the timing of admissions and discharges is argued by Proudlove et al. (2003) to create fluctuating and higher bed occupancy than would otherwise be the case. This is due to most admissions activity taking place before the corresponding discharge activity. Moreover, daily variations in elective intake and discharges are often greater than daily variations in emergency patient inflow in the NHS (Proudlove and Boaden, 2005). This results in unnecessarily long stays for patients, making the management of patient flows challenging.

Another cause of high bed occupancy is bed-blocking. This can be defined as: “A blocked bed is a bed occupied by a patient who in the consultant’s opinion no longer requires the services provided for that bed, but who cannot be discharged or transferred to more suitable accommodation” (Hall and Bytheway, 1982, p. 1987). Bed-blocking can be a problem if patients from a specialised inpatient ward cannot be transferred to a revalidation unit in time, hence blocking beds for patients in need of the specialised treatment (Andersson and Karlberg, 2000). Such “bed-blockers” would not only cost the system much less if placed in a less-specialised facility, but they would also receive more

³ A previous version of this section is included in the licentiate thesis (see section 1.2 in Appendix 1)

appropriate care and services (Meijboom et al., 2011). Bed-blocking also occurs when elderly patients with high care needs cannot be accepted by permanent care facilities, thus blocking a bed. The issue of high bed occupancy within hospitals therefore partly stems from a mismatch between demand and supply for permanent care facility spaces (Travers et al., 2008).

As stated above, responses to bed shortages and high bed occupancy often lead to a concentration on juggling the placement of admissions: bed-finding and firefighting. Many of the decisions related to finding short-term solutions involve resolving conflicts, for example the competition for beds between emergency and elective admissions, and the appropriateness of placement versus where beds are available (Proudlove and Boaden, 2005). Since every transfer of a patient between clinical departments is workload intensive and takes on average an hour of nursing time (Hendrich and Lee, 2005), the rearranging between beds takes much valuable nursing time when few beds are available.

In a meta-analysis of 28 studies, Kane et al. (2007) found associations between increased registered nurse staffing and lower odds of hospital-related mortality or adverse patient events. Aiken et al. (2002) used cross-sectional analyses of linked data from surveys distributed to nurses and patient outcomes in Pennsylvania, and found similar results. They concluded that surgical patients from hospitals with high patient-to-nurse ratios experience higher risk-adjusted 30-day mortality and failure-to-rescue rates, as well as nurses being more likely to experience job dissatisfaction and burnout.

A large observational cohort study also evaluated the influence of bed occupancy for 30-day mortality, in-hospital mortality, readmission for inpatient care within 30 days, and revisits to the ED within seven days (af Ugglas et al., 2020b). It did so by analysing data for all adult patients visiting one of six participating EDs in the Stockholm Region of Sweden. The study could not find an association between increasing hospital bed occupancy and mortality. There was, however, an association between increasing hospital bed occupancy and increased length of stay in the ED and a decline in admissions for inpatient care.

Hence, a mismatch between resources and peaks in demand lead to reduced quality of care in healthcare services, blocked beds and extra work having to be put into finding beds for admissions.

2.4.3 LONG WAITING LISTS FOR ELECTIVE DIAGNOSTICS AND TREATMENTS

For elective diagnostics and treatments, long waiting lists have been an issue for many countries, for a long time. In Sweden, waiting times vary significantly, for example in cancer care, with large differences in waiting times between patients in different regions, as well as between different types of cancer (Robertsson et al., 2017). Long and unequal waiting times have prompted national initiatives with standardised cancer care pathways in Denmark, Norway and Sweden. While waiting times for diagnosis and treatment have been shortened for the patients who have been included in the cancer care pathways (Probst and Andersen,

2012; Larsen et al., 2013), the issue of increased waiting times for other patient groups has been discussed (Dagens Medicin, 2017; Sjukhusläkaren, 2018).

Similar apprehension has been confirmed in the UK regarding the introduction of two-week-wait clinics for cancer diagnostics. Waiting times for patient groups with low-risk, or vague symptoms of cancer have been negatively influenced in favour of high-risk groups after the clinics' introduction (Hamilton, 2009). For breast cancer, there is also evidence of longer waiting times for routine referrals after implementing the two-week wait for urgent referrals in the UK (Potter et al., 2007; Cant and Yu, 2000). There have also been increases in referrals, potentially due to the poor prognostic value of the referral guidelines (Potter et al., 2007; Cant and Yu, 2000). Thus, throughput time is shortened for some patient groups at the expense of increased waiting times for other patient groups, when available resources and work practices remain constant.

The examples of overcrowding, high bed occupancy and long waiting lists reveal a need to improve the management of variation in patient flows in order to avoid the negative effects described. These examples also indicate that variation in patient flows should not be addressed in isolation from other patient flows managed in the healthcare unit, or in isolation from the upstream and downstream units involved in each patient flow. Applying a systems perspective regarding how variation in patient flows are managed at hospitals could therefore be appropriate (Aronsson et al., 2011; Parnaby and Towill, 2009). In the next section, strategies for managing variation in patient flows will be presented.

2.5 MANAGING VARIATION

The management of variation often comes down to a trade-off between resource utilisation and throughput times (Ellram et al., 2004). The two management concepts lean and agile manage variation in different ways and have mostly been discussed in the management literature regarding manufacturing companies. There is also research addressing the use of combinations of lean and agile, in both private and public organisations, including healthcare. Below, these concepts, and their combined use, are introduced. The choice to include these concepts in this thesis is further discussed in the methodology chapter (see 3.2.2).

Managing variation in a single patient flow requires the interdependencies between the different activities in the patient flow to be handled. One way to do this is to standardise the patient process. As a means to standardise patient processes, healthcare organisations often use different types of pathway. In simplified terms, a care pathway is a sequence of activities for the care and treatment of a well-defined group of patients during a well-defined period of time based on the best available evidence and practice (de Bleser et al., 2006). The use of pathways as an approach to managing variation is also introduced in this section.

2.5.1 LEAN⁴

Lean originates from the Toyota Production System, and this management concept gained widespread attention through the release of the bestselling book *The Machine that Changed the World* (Womack et al., 1990). The foundation of lean is the elimination of waste, meaning everything that does not add value to the product (Monden, 1983). Variation is considered to be waste and should therefore be eliminated or reduced (Bicheno, 2009). The objective of implementing lean is to increase customer value by streamlining the flow of production while persistently eliminating waste, thereby reducing the resources needed to produce a given set of goods (Womack et al., 1990).

Some key elements of lean are described by Jones et al. (1997):

- Levelling the flow of orders and work through the elimination of all causes of demand distortion and amplification.
- Products flow directly from operation to operation without interruption.
- Only make or deliver what is ordered – sell one, order one.
- Work at the same pace as customer demand.
- Standardise the best work cycle for every operation.
- Minimise the necessary safety stock between operations.
- Enable every operation to detect and stop when an error occurs, to prevent passing on errors.
- Use visual control devices to manage progress and irregularities.
- Document irregularities and use root cause elimination to prevent recurrences.

Lean as an organisational strategy is mainly associated with the success of Toyota, but the interest in lean healthcare can be traced back to the widespread successes of lean improvement projects at Virginia Mason, ThedaCare and Pittsburgh General Hospitals in the early 2000s. Lean, when implemented in healthcare, is a concept that focuses on eliminating non-value-adding activities (waste) in order to improve the flow of patients, goods or information through the organisation (Brandao de Souza, 2009). Within the healthcare sector, lean is being applied in both acute (Radnor et al., 2006; Joosten et al., 2009) and community settings (Grove et al., 2010a, 2010b) in order to efficiently manage and improve quality and patient safety (Mazzocato et al., 2010).

A growing body of literature indicates that lean has been successfully applied in hospitals, showing a positive impact on cost, quality and patient and staff satisfaction (Radnor and Osborne, 2013). However, literature is sparse on the study of lean within hospitals as a whole, whereas it is common to study single wards or clinical departments (D’Andreamatteo et al., 2015). Most published papers showing results supporting the use of lean methods come from case studies within a single clinic or process, rather than addressing a complete organisation, care pathway or patient group (Radnor et al., 2012).

⁴ Some parts of this section is modified from the frame of reference in Paper II

Graban (2008) also argues that most healthcare organisations that have attempted to implement lean have focused mainly on the elimination of waste, while leaving out other important factors of the lean concept, such as smoothing flow and improving workplace environments.

Hence, even though lean approaches have been used in several hospitals around the globe, in most cases it has been used in order to create a foundation enabling more efficient production planning. This could be called “lean basics”, with the overall purpose of reducing waste and preparing the organisation for a change towards process orientation (Aronsson et al., 2011).

2.5.2 AGILE⁵

The concept of agility originated in manufacturing and was first introduced with the publication in the USA of a report entitled *21st Century Manufacturing Enterprise Strategy* (Goldman and Preiss, 1991). The concept is partially based on a manufacturing method known as the flexible manufacturing system, which draws attention to one of the key components of agility: flexibility (Christopher and Towill, 2001). Through studies in manufacturing contexts, flexibility has been identified as a necessary capability for successful supply chains (Lau, 1996; de Toni and Tonchia, 2005). The characteristics of flexibility can be divided into three types (Sherehiy et al., 2007):

- Numerical flexibility, concerning the number of working hours or employees set up as a response to fluctuations in demand;
- Functional flexibility, relating to the development of employees’ skills to be able to accomplish other types of tasks;
- Financial flexibility, which concerns having a salary system adapted to each individual.

The concept of agility was developed as a response to the increasing rate of change and uncertainty in the business environment (Ismail and Sharifi, 2006). Many definitions of agility have been provided, with considerable differences, but all have included the core of agility – being adaptable to changes in the environment – whether these changes originate from the customer, competitors, legislation or other stakeholders. Christopher (2000, p. 38), for example, defines agility as “the ability of an organisation to respond rapidly to changes in demand, both in terms of volume and variety”. Therefore, agility can be seen as a set of approaches that solves the problem of demand uncertainty and variation through increasing flexibility (Lee, 2004). It includes the redesigning of organisational structures, logistics processes, information systems and management decisions, in order to achieve a timely and effective response to rapidly changing environments (Christopher and Towill, 2002).

⁵ Some parts of this section is modified from the frame of reference in Paper II

Further characteristics of agility include a rapid speed of response (Qrunfleh and Tarafdar, 2013), for example, to new market opportunities (Kidd, 1995), enabled by a close connection to end-user trends or shared information among supply-chain partners (Christopher, 2000; Aitken et al., 2002). In healthcare, this can entail seeing healthcare agents, such as nurses, physicians, patients and relatives, as interdependent subjects who exchange information with each other and their environment and themselves react and change based on that information (McDaniel and Driebe, 2001).

The capability to change direction with ease, thus of being adaptable, is another characteristic of agile organisations; for example, by entering completely new markets or product areas (Kidd, 1995), or by using individualised combinations of products and services in small lot sizes (Aitken et al., 2002). Creating flexibility through the use of specialist players and having a high degree of process integration between organisations in the supply chain are other examples (Christopher, 2000).

In healthcare, one way to adapt to variations in the patient mix could be to have a central pool of personnel, with the competence to work in different departments. The results from a literature review regarding the use of agility in healthcare organisations also indicate that hospital management benefits from being supportive of employees, but not controlling them in detail (Tolf et al., 2015). If employees are trusted, Tolf et al. (2015) argue that they will be able to distinguish between, and separate, standardised processes from organic and flexible ones. This, however, requires fully motivated and empowered employees who cooperate both internally and externally.

2.5.3 LEAN, AGILE OR LEAGILE?⁶

In the last two sections, the concepts of lean and agile have been introduced. This section compares these concepts, focusing on how they handle variation. As previously discussed, it is not possible to store finished services, including healthcare services, due to customer inputs (Arlbjörn and Halldorsson, 2002; Sampson, 2001); therefore, variations in service time and arrival rates need to be buffered using some combination of capacity or time. The choices about how to buffer against variation are described by Aronsson et al. (2011) in terms of using flexible or fixed lead-time and capacity. Lead-time is here regarded as the time elapsed between the initiation and completion of a process. Hence, if the process consists of a single activity, it is equal to the throughput time. A lean strategy here would be equivalent to having a fixed capacity and high utilisation of resources, e.g. personnel and equipment. Protection from variation is therefore required; hence, queues are used to buffer against variation. The downside of this approach is that the lead-time for patients will vary, depending on the number of patients who need the service (see Figure 2.1). An agile equivalent would be to work with flexible capacity and a fixed lead-time, requiring high

⁶ Some parts of this section is modified from the frame of reference in Paper II

availability of the extra resources needed to perform the services on time. Reliability in terms of lead-time is the advantage of this approach.

FIGURE 2.1 – FIXED OR FLEXIBLE, LEAD-TIME OR CAPACITY (ADAPTED FROM ARONSSON ET AL., 2011, P. 181)

This division between lean and agile as process strategies with different approaches to managing variation is a generalisation of these concepts. For lean, the approximation of having a fixed capacity and flexible lead-time builds on the objective of lean to increase customer value by streamlining the flow of production while persistently eliminating waste, thereby reducing the resources needed to produce a given set of goods (Womack et al., 1990). The foundation of lean is hence regarded as doing more with less, i.e. being efficient (Christopher, 2000). The lean philosophy was also developed in a marketplace where demand is predictable, the requirement for variety is low and volumes are high. Flexibility is hence of less importance in the automotive industry than in the healthcare sector, which encompasses much variation in patient flows. Bohmer (2009, p. 16) also highlights the fact that “many of the approaches and tools drawn from industrial settings fail to adequately account for the residual uncertainty in medical care or explicitly address the experimental nature of much care”.

Christopher (2000) extends the discussion on lean and agile by proposing a framework to assist in selecting between a lean or agile approach, based on the volume and variety of the goods or services being produced. A lean approach is preferred when variety is low and volume high, and an agile approach is applicable when the opposite applies (see Figure 2.2).

Variety	High	Agile	
	Low		Lean
		Low	High
		Volume	

FIGURE 2.2 – AGILE OR LEAN (ADAPTED FROM CHRISTOPHER, 2000, P. 39)

Naylor et al. (1999) instead argue for the use of both lean and agile strategies based on the positioning of the decoupling point, with a lean strategy used upstream and an agile strategy used downstream from the decoupling point. This “leagile strategy” separates the part of the organisation that is oriented towards customer orders from the part based on planning. Inventory is thus held at the decoupling point as a buffer between fluctuating demand and smooth production output (Naylor et al., 1999; Mason-Jones et al., 2000). By making a distinction between using lean and agile combinations based on a time/space matrix (see Figure 2.3), Towill and Christopher (2002) further extend the discussion on leagility.

Space	Different	Separate processes	Decoupling strategy
	Same	Not viable	Differentiate “base” from “surge”
		Same	Different
		Time	

FIGURE 2.3 – THE TIME/SPACE MATRIX (ADAPTED FROM TOWILL AND CHRISTOPHER, 2002, P. 303)

The bottom right-hand corner in Figure 2.3 opens up the opportunity to make and source a proportion of total expected demand ahead of forecast need. This base level can hence be predicted with high certainty, allowing a lean strategy. Closer to the actual demand, additional capacity should be accessible in order to handle any “surges” (Towill and Christopher, 2002). However, healthcare services involving patients cannot be performed ahead of demand. For healthcare services, this strategy could therefore correspond to

having a base-level of staff and beds, complemented with a preparedness to quickly increase staff numbers and available beds if needed.

The top right-hand box in Figure 2.3 uses the decoupling strategy discussed earlier (Towill and Christopher, 2002). Rahimnia and Moghadasian (2010) discuss this strategy in a healthcare context. They argue for the use of a lean process strategy before, and an agile process strategy after, the decoupling point. The decoupling point corresponds to having set a diagnosis for the patient, and the authors argue that it is after this point that the service becomes specialised and customised for each patient. This requires flexible management of the different resources, such as personnel and equipment, to be able to swiftly commit these to the patient. Aronsson et al. (2011), point out, however, that being lean before the decoupling point and agile after this point is not always applicable in a healthcare setting, since the patient, the customer, is involved in the whole process. Mishra et al. (2019) have also addressed the possibility of using a decoupling strategy, but to support material flows such as pharmaceuticals and medical equipment, by proposing a methodology for assessing the choice between where the inventory of these supplies should be placed.

The final corner, the top left-hand box, represents using separate processes. In manufacturing, an example would be using a lean factory for predictable high-volume products and an agile factory for low-volume, less predictable products (Towill and Christopher, 2002). In healthcare, separating patient flows for routine patients from patients with more complicated healthcare needs, or acute and elective patients, could be an enactment of this strategy. Using a fast track in emergency departments is an example of this approach, where patients with non-acute simple needs are managed separately (Considine et al., 2008; Vega and McGuire, 2007). Towill and Christopher (2005) discuss the use of standardised and customised care for groups of patients by elaborating upon the use of healthcare pipelines, where a pipeline represents the flow of patients from referral to full recovery. Within a healthcare delivery pipeline, it thus becomes important to distinguish between lean and agile parts of the pipeline, based on the complexity of treatment; for example, by separating quick routine surgery from more complex treatments, or scheduling routine treatments for periods with lower levels of acute patients. Using a hybrid strategy by combining lean and agile process strategies, to enable quick responses and flexibility, is also emphasised by Aronsson et al. (2011), instead of the predominant focus on lean in today's healthcare. They argue in favour of choosing a strategy for each sub-process, based on characteristics such as volume and variety, an approach that resembles Christopher's framework (2000) (see Figure 2.2). For example, a lean strategy becomes appropriate for standard blood testing, where the volume is large and the variety is small.

Combinations of customised care and standard care are also elaborated by Bohmer (2005). He argues that variations between individual patients concerning the optimal testing strategy, the effects of a given treatment, the potential interactions of multiple diseases and

treatments, as well as the patient's preferences, increase the need for customisation and decrease the possible level of standardisation in healthcare services. Customised care is also iterative, as opposed to standard care, which tends to be linear and comprised of an orderly sequence of steps. In customised care, each diagnostic test or test of therapy generates new information that influences future decisions. Therefore, it can only be assessed by its medical outcome and the extent to which it delivers "value" to the patient (Bohmer, 2005). Situations where a standardised sequence of care is initially prescribed can also be re-evaluated due to new developments in a patient's condition, unexpected diagnostic findings or surprising reactions to medication, which may call for swift changes to the healthcare process in order to avoid undesirable effects on workflow, service quality and/or cost (Lillrank et al., 2011).

2.5.4 CARE PATHWAYS

Care pathways, also known as clinical pathways, critical pathways or integrated care pathways (Vanhaecht et al., 2010), were inspired by the development of pathway thinking in industrial processes (Moder and Phillips, 1964). They were first introduced into healthcare in the 1980s in the United States (Vanhaecht et al., 2011). In simplified terms, a care pathway is a sequence of activities for the care and treatment of a well-defined group of patients during a well-defined period of time, based on the best available evidence and practice. Care pathways are typically quite comprehensive and include activities incorporating multidisciplinary teamwork and how to involve patients (Sermeus et al., 2005). An important aim when implementing care pathways is to create predictable care processes that are agreed upon by the healthcare providers involved (Zander, 2002). De Bleser et al. (2006, pp. 553) provide a definition of a clinical pathway:

A method for the patient-care management of a well-defined group of patients during a well-defined period of time. A clinical pathway explicitly states the goals and key elements of care based on Evidence Based Medicine (EBM) guidelines, best practice and patient expectations by facilitating the communication, coordinating roles and sequencing the activities of the multidisciplinary care team, patients and their relatives; by documenting, monitoring and evaluating variances; and by providing the necessary resources and outcomes. The aim of a clinical pathway is to improve the quality of care, reduce risks, increase patient satisfaction and increase the efficiency in the use of resources.

The term "clinical pathway" was first used by Zander et al. (1987) at the New England Medical Center. Today, the term is accepted in almost all settings and models of healthcare management (Hindle and Yazbeck, 2005; Sermeus et al., 2005). Many alternative names exist, however, and de Luc (2001), for example, found 17 different terms covering the concept of pathways. The most common terms were care pathway, integrated care pathway, critical pathway and care map.

Vanhaecht et al. (2010) describe different types of care pathways related to different levels of the healthcare system. At the most aggregated level is the model pathway; often an

organisationally independent policy document or guideline based on international or national evidence-based medicine. The model pathway is often developed nationally or regionally. At the next level, the operational pathway, an adapted version of the model pathway, is developed locally in the hospital and/or clinical department. The third level, the assigned pathway, is the pathway for each individual patient, adapted from the operational pathway to fit the needs of that specific patient. At the fourth level, the completed pathway is the pathway that can be reviewed after the discharge of the patient. Any differences between the operational pathway and the completed pathway provide information regarding the variances and the level of compliance to the key elements in the pathway (Panella et al., 2003).

In most countries, the use of pathways is still rather limited, especially when considering that 60–80% of patient groups in general hospitals are appropriate for pathway use (Vanhaecht et al., 2006). This could be related to care pathway implementation often being a complex intervention. When developing care pathways, one needs to take into account the evidence-based key interventions, patient involvement and interdisciplinary teamwork, along with the available resources (Vanhaecht et al., 2007a). Hence, introducing pathways into an organisation and developing, implementing and evaluating individual pathways is often a complex intervention (Campbell et al., 2007). It is important to identify bottlenecks and improve the process by using systematic, continuous improvements during implementation (Vanhaecht et al., 2007b).

When introducing standardised cancer care pathways in Denmark, Sweden and Norway, a primary objective was to decrease the waiting times until treatment was initiated. For each cancer diagnosis, a target time for the total number of days from well-founded suspicion to start of first treatment was therefore set and followed nationally. Having target times as an element of care pathways allows for comparison with the concepts of lean and agile in terms of managing capacity and lead-time. As previously discussed, a lean strategy would be equivalent to having a fixed capacity and flexible lead-time, while an agile strategy involves having flexible capacity and a fixed lead-time (Aronsson et al., 2011). The agile approach can hence be used to accommodate the target time in care pathways. Another option is to normally accommodate the target time with margins, using a flexible lead-time (lean approach), and thereby occasionally allowing longer lead-times, which are still within the target time, when demand exceeds the average. These alternatives are depicted in Figure 2.4. A combination of these approaches is likely to be common. However, the shorter the target time, the less useful is the approach of having a flexible lead-time.

FIGURE 2.4 – USING FLEXIBLE CAPACITY OR LEAD-TIME WITH MARGINS TO ACCOMMODATE TARGET TIME

After describing the concepts of lean, agile and care pathways, and how these concepts address the management of variation, the next section uses these concepts to develop a framework for managing variation in patient flows at different organisational levels.

2.6 MANAGING VARIATION IN PATIENT FLOWS AT DIFFERENT LEVELS OF ABSTRACTION

As previously discussed, there are different bodies of literature in both healthcare and management that address the management of variation in different ways. This thesis describes the concepts of lean, agile and combinations thereof, as well as the concept of care pathways. There are other concepts in the healthcare and management literature that include strategies for managing variation in the flow of goods, services, patients or information, e.g. Supply Chain Management, Total Quality Management and Healthcare Operations Management. The choice to only include care pathways, lean, agile and leagile in the thesis is largely based on the fact that it is these concepts that are used in the studies reported in this thesis. The choice will be motivated in more detail in the methodology chapter (see section 3.2).

In this frame of reference, the management of variation has been addressed at different levels of abstraction, from managing variation in a single activity, to the management of variation within an organisation as a whole. Based on the literature discussed in this chapter, a framework has been developed that includes four levels of abstraction regarding how variation in patient flows is managed. These four levels are:

- Level 1 – Managing variation in a single activity
- Level 2 – Managing variation in a single patient process
- Level 3 – Managing variation in a single healthcare unit
- Level 4 – Managing variation in a hospital

The first level of abstraction comprises managing variation in a single activity. Because healthcare is a service industry, variation in a single activity needs to be buffered using capacity or time. The choices of how to buffer against variation are described by Aronsson et al. (2011) as using flexible or fixed lead-time and capacity, and are depicted in Figure 2.1.

The second level of abstraction concerns managing variation in a single patient process. It requires the interdependencies between the different activities in the patient process to be handled, in addition to handling variation in each activity. As a means to standardise patient processes, healthcare often uses different types of pathway, as discussed in section 2.5.4. Another concept relevant to managing variation in a single patient process is the concept of bottlenecks. A bottleneck is often due to the lack of availability of a specific skill or piece of equipment. Waiting lists thus tend to occur before the bottleneck in the patient process, since this is the activity that can process fewest patients per time unit. With resources commonly being shared between different activities in the patient process, however, the bottleneck can move between these different activities in the patient process.

The third level of abstraction is managing variation in a single healthcare unit. A healthcare unit handles several different patient processes and thus needs to balance the resources managed by the unit between these processes. The term healthcare unit is used in this thesis to describe inpatient wards, EDs, outpatient units, intensive care units, surgical units, post-operative units, et cetera. Clinical departments are found at the organisational level above these units, but since the patient flows often go through several units, and also different clinical departments, the focus of this thesis is on healthcare units. Hence, the clinical departments are not depicted in

Figure 2.5. The concept of bottlenecks is also important at this level because reducing the number of queues at bottlenecks limits variation and decreases average waiting time (Silvester et al., 2004).

The fourth level of abstraction, managing variation in a hospital, is further divided into two types. The first, Level 4.1, is the management of variation in the dependency between units that act in the same part of the patient flow, denoted as parallel units, for example inpatient wards. Level 4.2 corresponds to managing variation at the intersection between two units that normally transfer patients between them, and are thus sequential units. For many patients, the ED and an inpatient ward are sequential units.

The two management concepts, lean and agile, manage variation in different ways and have been discussed mostly at the second, third and fourth levels of abstraction, even though they also address the management of variation at the first level (e.g. see Figure 2.1). With the objective of enhancing customer value by streamlining the flow of production and thereby reducing the resources used (Womack et al., 1990), the lean concept focuses on the second and third levels of abstraction. Agile, on the other hand, focuses more on the ability of an organisation to respond to changes in demand, in terms of both volume and variety

(Christopher, 2000); for example, by using flexibility in staffing levels and the division of tasks (Sherehiy et al., 2007). Hence, it emphasises the management of variation at the fourth level of abstraction.

The examples of overcrowding, high bed occupancy and long waiting lists previously described stem partly from insufficient management of variation at the third level of abstraction (see section 2.4). However, these examples also highlight the need to consider variation in patient flows from a more holistic perspective, addressing the different levels of abstraction when managing variation. This includes not managing a patient process in isolation from other patient processes within the healthcare unit, or in isolation from the upstream and downstream units involved in each patient process. Applying a systems perspective regarding how variations in patient flows are managed in hospitals is therefore appropriate (Aronsson et al., 2011; Parnaby and Towill, 2009).

By taking a systems perspective, a theoretical foundation in supply-chain management research (Mentzer et al., 2001; Sanders, 2007) and logistics research (Bowersox, 1978; Novack et al., 1992), some of these issues can be addressed. When using a systems perspective, the organisation is observed as a system of components that interact to accomplish a number of goals. A basis of systems theory is that none of these components can act independently of another in that system, that they are interrelated. A system hence has to be managed as a whole in order to achieve efficiency and effectiveness (Langley et al., 2008). In contrast, when the components are managed individually, without considering the impact on the organisation as a whole, sub-optimisation often follows (Stock and Lambert, 2001). The framework incorporating the four levels of abstraction provides a structure to describe and evaluate how variation in patient flows is managed from a systems perspective.

3 METHODOLOGY

The methodology chapter has been divided into four sections. The first section provides a general description of the research design of the thesis. The second section includes an overview of the methods used and the methodological choices made in each of the three studies performed. In the third section, a discussion of the research process is presented. Thereafter, the fourth and last section delineates the unit of analysis of the thesis, and explains how the research questions were analysed and answered.

3.1 RESEARCH DESIGN

A research design can generally be described as the coherent relationship between a study's research question and the data that needs to be collected. Since the existing knowledge within a research field affects the appropriateness of different types of research, and thus research designs, the type of research that will be conducted should first be decided (Yin, 2009). Ellram (1996) describes three objectives of research, depending on the maturity of the research field: exploratory, descriptive and explanatory. Exploratory research is used when there is limited knowledge within a research field and a basic understanding of a phenomenon is still needed. The issue of managing variation in patient flows is not new, but it is not a separate or distinct research field. Instead, the issue of managing variation in patient flows has been indirectly included in research in the fields of healthcare management, healthcare logistics and supply-chain management, as well as medical research, for example studying queues, ED overcrowding or hospital bed management.

In the research reported in this thesis, variation in patient flows is the main issue investigated. In addition to the lack of depth in previous research regarding the management and impact of variation in patient flows in hospitals, there seems to be a lack of knowledge in practice regarding these matters. Walley et al. (2006), for example, claim that healthcare resources are often used inappropriately and not adapted to the variations that exist, while healthcare managers often believe that, unlike in manufacturing industry, they cannot control their service production or predict their patient inflow (Jarret, 1998; Vissers et al., 2001). The examples described previously, involving overcrowded EDs (Estey et al., 2003; Trzeciak and Rivers, 2003), high bed occupancy and bed shortages on inpatient wards (Proudlove et al., 2003) and long waiting lists for elective diagnostics and treatments (Frankel, 1993; Robertsson et al., 2017), also demonstrate a lack of knowledge about managing variation in patient flows. It is therefore relevant to *explore* how variation in patient flows is managed and how such variation impacts upon hospitals.

The exploratory aim of the research reported in this thesis has directed the author to adopt a research approach similar to abductive reasoning. Described as a combination of inductive and deductive reasoning, abductive reasoning uses an iterative research process by moving back and forth between the empirical and theoretical worlds (Dubois and Gadde, 2002; Kovács and Spens, 2005). Within an abductive research process, the starting point is often empirical observations that do not match existing theories, starting an iterative process where the objective is to develop new theoretical frameworks or extend existing ones (Kovács and Spens, 2005).

An abductive approach is also recommended when the researcher's intent is to understand an observed phenomenon and its context using the lens of an existing theory (Shah et al., 2008). This thesis uses theories from different fields of research, which until now have seldom been used in a healthcare context or in the context of managing variation in patient flows. The use of abductive reasoning, with the aim of increasing understanding by adding

a new perspective, is therefore relevant. For the thesis as a whole, an iterative process was used, combining literature reviews with empirical evidence from simulation modelling, case studies and a quantitative before/after study. Moving “back and forth” between the theoretical and empirical worlds has been a crucial part of the research process, allowing a deeper understanding of the management of variation in patient flows. This way of creating knowledge is also rather common in logistics research (Arlbjörn and Halldorsson, 2002).

An abductive approach has also been used in the individual studies reported in this thesis. In Study 2, initial empirical data collection was performed in parallel with literature reviews. This moving “back and forth” between the theoretical and empirical worlds (Dubois and Gadde, 2002) guided the development of the interview guide for the semi-structured interviews performed during the second phase of the study. For the frame of reference concerning the concepts of lean, agile and leagile in Study 2, the empirical data from the semi-structured interviews was used to develop contextualised categories concerning lean and agile ways of handling variation in acute patient flows. Developing categories that fit the empirical data from the case, and not forcing data into pre-existing categories, is one of the foundations of the abductive approach to case research (Dubois and Gadde, 2002).

The starting point for Study 3 was an expectation that the implementation of standardised cancer care pathways in Sweden could cause crowding out effects. Both induction and abduction start out with empirical observations before any theoretical framework is introduced into the research process. While the primary aim of induction is to generalise findings from empirical data, the aim of abduction is to develop the understanding of a “new” phenomenon (Alvesson and Sköldberg, 1994). Based on research focusing on other policy programmes, crowding out effects are plausible when introducing standardised cancer care pathways. However, there is a lack of understanding about how these effects arise. Employing an abductive approach that combines a case study and a quantitative before/after study enabled the use of different types of data to increase the understanding of the phenomenon of crowding out effects when implementing care pathways.

As displayed by the examples above, moving back and forth between the theoretical and empirical worlds has been a crucial part of the research process, allowing a deeper understanding of the management of variation in patient flows.

3.2 RESEARCH METHODS

In this section, the research methods used in this doctoral thesis will be introduced. More detailed descriptions of these methods are provided in the appended papers, reports and case study, along with some of the other appendices. Table 3.1 outlines where these descriptions can be found. An overview of each study is also provided below, focusing on the main methodological choices made in the studies, the quality assurance of data, limitations of the research and a general description of the methods used.

TABLE 3.1 – RESEARCH METHODS USED IN THE DIFFERENT PARTS OF THE THESIS, AND WHERE THE DETAILED DESCRIPTIONS OF THESE CAN BE FOUND

Study	Part	Case study	Literature review	Simulation model	Quantitative before/after study
Study 1	Paper I	Appendix 1, sec. 2.7			
Study 2	Paper II	Appendix 1, sec. 2.5	Appendix 1, sec. 2.6		
	Paper III	Appendix 1, sec. 2.5	Paper III		
	Case study I	Appendix 1, sec. 2.5			
Study 3	Paper IV	Appendix 2			Paper IV, Appendix 3
	Report I	Appendix 4			
	Report II	Appendix 4			Report II, Appendix 3
Main text		Appendix 1, sec. 2.6, Appendix 2			

3.2.1 OVERVIEW OF STUDY 1

Study 1 includes Paper I, using a simulation model to investigate the consequences for bed occupancy and length of stay of altering patient inflow, available resources, treatment times and duration of activities in an emergency department and on an inpatient ward. In addition to the method section in Paper I, a more detailed description of the method can be found in section 2.7 in Appendix 1.

The choice of using a simulation model in Study 1 stems from simulation modelling being one of the few tools available when studying interactions between different types of variables, in particular when studying many modern systems, such as service organisations and factories (Banks et al., 2005). In addition, simulation has also been successfully used in healthcare systems (Ferreira et al., 2008; Pidd, 2004) and is appropriate for studying the effects of changes within a system (Banks et al., 2005). Hvitfeldt Forsberg et al. (2010) have also shown that research using simulation to increase the understanding of complex healthcare systems is scarce. To enable an understanding at a detailed level of the consequences of alterations in the patient flow for bed occupancy and length of stay, an operational level simulation was selected. In line with other simulation studies with a low level of abstraction, a discrete event simulation was considered most appropriate (Hvitfeldt Forsberg et al., 2010; Tako and Robinson, 2009).

The simulation model is based on two healthcare units at Hässleholm Hospital, the ED and an inpatient ward treating elderly people with co-existing diseases. This system was chosen because the patient flow is representative of many healthcare systems. The decision to study Hässleholm Hospital was not made by the author. Instead, the research group behind the

cooperation with the hospital chose this partner. However, Hässleholm Hospital has worked consistently with improvement efforts, which have been evaluated by members of the research group, with high-quality results (e.g. Carlsson, 2003; Carlsson and Sarv, 2001).

Data was mainly collected from interviews with healthcare personnel, observations in the studied departments and data for every patient who visited the ED (11,000 patients) and the inpatient ward (1,400 patients) in 2010. To ensure high face validity (Banks et al., 2005), the model was built in collaboration with both management and healthcare personnel, something that is widely recommended (see for example Banks et al., 2005; Law, 2007). Extensive documentation of the simulation model was also put together, including built-in assumptions and simplifications, in order to achieve transparency and trust with users of the model (Pidd, 1996). Representatives from different personnel categories also read the documentation and evaluated the model's validity (Banks et al., 2005; Law, 2007). Their feedback was gathered and incorporated into the model to further assure validity of the similarity between the modelled and actual length of stay for both the ED and inpatient ward. Mean values, confidence intervals and standard deviations displayed a solid unity between modelled and actual values. The validation processes used concluded that the model of the existing system is valid.

There are limitations to Study 1. The simulation model mimics a specific ED and inpatient ward, limiting the generalisability of the results. In relation to managing variation in patient flows, the influence of alterations in the studied variables can only implicitly evaluate the impact of variation. Hence, there is a need for additional research addressing how changes in variation in patient flows impact upon healthcare units.

3.2.2 OVERVIEW OF STUDY 2

Study 2 is based on a single case study of the management of variation in acute patient flows at the university hospital in Linköping. Case study I provides a thick description of the actors involved, and the strategies used, in managing variation in acute patient flows originating from the ED. Section 2.5 in Appendix 1 provides the main description of the case study method used. Papers II and III are also based on this case study, but use different frames of reference to analyse the management of variation in the acute patient flows.

Paper II categorises the actions used in handling the variation in acute patient flows using the concepts of lean and agile. These concepts offer contrasting approaches to the handling of variation, and are therefore used as two different perspectives on the task. The university hospital does not, however, have an expressed strategy of using either of the two concepts in its operations.

The foundation of lean is the pursuit of waste (Monden, 1983). Variation is considered to be waste and should therefore be reduced or eliminated (Bicheno, 2009). The objective of implementing lean is to increase customer value by streamlining the flow of production while persistently eliminating waste, thereby reducing the resources needed to produce a

given set of goods (Womack et al., 1990). The concept of agility was instead developed as a response to the increasing rate of change and uncertainty in the business environment (Ismail and Sharifi, 2006). Therefore agility includes strategies that solve the problem of demand uncertainty and variation through increasing flexibility (Lee, 2004). Hence, this concept focuses on the ability of an organisation to respond rapidly to changes in demand, in terms of both volume and variety (Christopher, 2000). Based on these characteristics, Paper II categorises actions used in handling variation using three categories from each concept (for a more detailed account of the development of the categories, see Paper II):

Agile

- extending the use of a resource;
- altering the amount of a resource, ahead of demand; and
- altering the amount of a resource, as a response to demand.

Lean

- an action that increases patient flow standardisation;
- an action that reduces the need for a resource; and
- an action that directly manages external variation.

While lean has been successfully applied in hospitals around the globe (Radnor and Osborne, 2013), agile has rarely been implemented in the healthcare industry. Given the extensive variation in patient flows, however, the focus on flexibility in the agile concept could be appropriate (Lee, 2004). Categorising the actions used in handling variation in acute patient flows using the concepts of lean and agile was consequently considered to be both practically and theoretically relevant. Section 2.6 in Appendix 1 provides a description of the literature review method used for the lean and agile frame of reference.

Paper III analyses the involvement of middle management in managing variation in acute patient flows. As previously discussed, the functional specialisation of healthcare organisations – with healthcare service provision in general being controlled by healthcare professionals – and the high resource utilisation in each part of the patient flow (Modig and Åhlström, 2013) pose challenges to managing the variation in patient flow. Villa et al. (2014) also highlight the fact that the lack of coordination between different patient flows and healthcare units is critical for understanding problems with the management of variation in patient flows. Hence, middle management becomes vital when developing strategies for managing this variation.

With doctors being common as department chiefs (regarded as middle management in Paper III), there are both challenges and opportunities for the management of variation in patient flows. For example, doctors often protect high levels of medical autonomy and resist attempts to increase the managerial control of clinical practice (Kitchener, 2000). Due to their professional background, they can also add value by merging knowledge of the strategic intent of top management with knowledge of practice on the ground (Burgess and

Currie, 2013). The strategic knowledge of these hybrid managers is also positively related to advocating changes and synthesising new information (Pappas et al., 2004). Despite these implications, research on the role of middle management in a healthcare context has been sparse (Currie and Procter, 2005). Hence, the involvement of middle management in managing variation in acute patient flows was the focus of Paper III. For a description of the literature review method regarding middle management involvement, see Paper III.

Case study research is appropriate when there is a lack of theory, or when the environmental context differs from the previous development and usage of theory (Stuart et al., 2002). Meredith (1998) also concludes that case studies can be used to increase knowledge in fields where the system being studied is complex. Healthcare organisations have been argued to be one of the most complex systems known to contemporary society (Glouberman and Mintzberg, 2001). In hospitals, acute patients arrive continuously at the ED and, in comparison to elective patients, whose care episode can be planned ahead, the acute patient flow is more challenging to manage efficiently, due to its unpredictability regarding timing, health issue and response to treatment. On inpatient wards admitting acute patients from the ED, the patient inflow is therefore difficult to predict. To describe how the acute patient flow is managed in a hospital, a case study approach thus seems appropriate. The use of lean and agile, along with middle management involvement, as frames of reference when studying the management of variation in acute patient flows is also a novel context for these theories. This allows for analytical generalisation (Yin, 2009) by broadening the scope of these theories to this specific context. Because the phenomenon being studied is complex and a hospital includes multiple clinical departments, which in many ways have the characteristics of independent organisations, a single case study approach was chosen (Yin, 2009).

The choice of organisation for the case study fell on the university hospital in Linköping. Several of the clinical departments operating within the hospital achieve clinical results of top international standard (Landstinget i Östergötland, 2014). Access to information and geographical proximity also contributed to this choice of organisation. In an evaluation between the university hospitals in Sweden that primarily considered medical quality, customer satisfaction, financial performance and waiting time, the university hospital in Linköping also came out in clear first place (*Dagens Medicin*, 2013). Hence, the ability of this hospital to manage variation in acute patient flows was anticipated to be of similar relative quality to that of other university hospitals in Sweden.

In order to gain an understanding of the context and the actors within the hospital, the data collection was initiated using unstructured interviews and observations, along with observations at meetings. In parallel, literature reviews were conducted concerning lean, agile and leagile as well as middle management and strategy formation. Based on the constructs from the literature reviews and contextual information gathered in the initial data collection, an interview guide for semi-structured interviews with middle and top

managers was outlined. This interview guide was sent to each respondent in advance and included clarifications of key terms used in the questions. Each semi-structured interview was recorded, transcribed and sent to the respondent for confirmation. These measures were employed to increase reliability and construct validity, as recommended by Yin (2009). The use of multiple data sources gave a fuller picture of the organisation (Bonoma, 1985) and allowed for data triangulation (Patton, 2002). In particular, the initial data collection facilitated the sorting of information during the subsequent semi-structured interviews, as well as asking additional questions, thus strengthening validity (Stuart et al., 2002). It was also important to both confirm and disconfirm some opinions, beliefs and statements expressed by respondents in the semi-structured interviews (Woodside, 2010).

By reporting partial results to a group consisting of clinical department chiefs, empirical evidence could be verified, and construct validity strengthened. All the collected empirical data was also included in a draft of the case report, with references to each source for traceability, in order to secure a reliable and reproducible method (Yin, 2009). To ensure construct validity, the final case description was also sent to three key informants with in-depth knowledge of the hospital's operations. Feedback from these key informants was obtained and incorporated into the case description. The analyses for Papers II and III were both based on the draft of the case report referred to above, and are described in these papers.

The research performed in Study 2 is based on an explorative, single case study methodology, which does have some limitations. Apart from allowing for analytical generalisation (Yin, 2009) by broadening the scope of theories regarding lean and agile and middle management involvement to the context of managing variation in acute patient flows, generalisation to other hospitals will require more studies. The case organisation being a university hospital also adds a layer of complexity to managing patient flows, due to the conflicting interests between teaching and research commitments. The results from Study 2 are therefore most relevant to other university hospitals, although not necessarily delimited to these.

Another limitation of Study 2 is that the appropriateness of the actions used to handle variation in the acute patient flows was not evaluated. Intuitively, some actions are more appropriate than others based on different variables such as costs, time and strain on personnel. The empirical data does not, however, allow for any comparisons, such as between the appropriateness of actions belonging to the different lean and agile categories.

3.2.3 OVERVIEW OF STUDY 3

Study 3 is based on a case study and a quantitative before/after study and addresses the question of whether the implementation of standardised cancer care pathways (CCPs) causes crowding out effects. Study 3 follows the implementation of CCPs, which was initiated nationally across Sweden in the autumn of 2015. With target times from diagnosis to first treatment followed nationally, the issue of crowding out effects has been discussed

both in the media (*Dagens Medicin*, 2017; *Sjukhusläkaren*, 2018) and in scientific publications (Schmidt et al., 2018). The National Board of Health and Welfare (2016) also distinguishes between three types of crowding out effects that might follow the implementation of CCPs:

1. Crowding out of other parts of the patient pathway;
2. Crowding out of the same patient group, as well as those who do not fit/cannot manage/do not want to follow the CCP;
3. Crowding out of other investigations, treatments and care, both within the same and other disease areas.

The case study is described in Report I, while the methodology is mainly described in Appendix 4. Paper IV describes and reports upon the results from the quantitative before/after study. Some additional methodological descriptions and choices not included in the paper are discussed in Appendix 3. Report II combines the results from the case study and the quantitative before/after study and was included in the final report examining the four-year programme to implement CCPs in Sweden issued by the National Board of Health and Welfare (2019).

Initially, in Study 3, a systematic literature review was performed around the concept of crowding out. This literature review was performed in order to identify previous research addressing crowding out effects and to formulate the purpose and research questions for Paper IV. It is described in Appendix 2. The issue of crowding out effects was also acknowledged in a progress report concerning the implementation of CCPs in Sweden, with the specialities of pathology, radiology and surgery considered most at risk from these effects (National Board of Health and Welfare, 2016). Since these specialities are involved in diagnostics and treatment within many CCPs, volumes can also become large. These specialities were therefore included in Study 3.

Both the case study and the before/after study analyse data from internal computer systems used by the specialities in question to plan and follow their production at Kalmar County Hospital. Since this data is used by the specialities to plan their production, it could be argued that they have an interest in assuring both the validity and reliability of the data, something that is emphasised by Elg and Fundin (2012) as one of three main quality assurance measures for performance measurement systems. The choice to study crowding out effects using data from Kalmar County Hospital is due to the author being an industrial doctoral student there.

In analysing crowding out effects, it is the waiting time between registration and completion of the surgery/radiology scan/pathology analysis that is studied. Within all of the studied specialities, the level of priority for the surgery/scan/analysis is decided upon during registration. This priority is decided by a doctor and is the basis for deciding how quickly the surgery/scan/analysis should be completed. Hence, changes in waiting times for the surgery/scans/analyses included in each priority category, and their association with CCP

implementation, were analysed. In terms of the types of crowding out effects described above, the data mainly enables analyses of the third type, but also to a minor extent the second type. Crowding out has previously been described as “situations where patients with lower priority are provided with treatment or care before patients with higher priority (thus greater medical need)” (Ministry of Health and Social Affairs, 2009, p. 40, author’s translation). However, the analyses are not limited to analysing waiting times for patients with higher priority than the patients in the CCPs; instead, patients with lower, equal and higher priority in comparison to those in the CCPs are included. When analysing the management of variation in patient flows from a systems perspective, all of these groups are of interest.

The data from these specialities has been validated by plotting inflow, production and waiting times for the studied data and thereafter presenting and discussing it with representatives working within the specialities. Elg and Fundin (2012) describe this as a “communicative action strategy”, which is another of the three main quality assurance measures for performance measurement systems.

In the before/after study (Paper IV), waiting times before and after CCP implementation were analysed, focusing on identifying patterns between the specialities, subspecialities and priority categories associated with CCP implementation. Since the inflow and provision of surgery/scans/analyses also influence waiting times, changes in these parameters between the before and after periods are also included in the analysis.

Case studies can be used to increase understanding in fields where the subject matter is complex (Meredith, 1998), or where theory in the specific context is lacking (Stuart et al., 2002). Care pathway implementation, such as the introduction of CCPs in Sweden, comprises a dual complexity, whereby the care pathway itself represents a complex intervention, while the organisational context upon which it is being implemented is also a complex system (Seys et al., 2019). Since the phenomenon under study, CCP implementation, is complex, a case study approach was chosen (Yin, 2009), in addition to the before/after study. The case study included two subspecialities. Among the surgical subspecialities, urology surgeries were chosen for the case study since two of the five CCPs first implemented are urological cancers, and the surgical procedures performed in these CCPs were easily distinguishable from the other surgeries in the extracted data for this subspeciality. Computer tomography (CT) scans were also chosen since the proportion of CCP scans was expected to be highest for this subspeciality within radiology.

To understand the influence of CCP implementation on waiting times for urology surgery and CT scans, it is important to understand the different steps in the planning and booking process for surgery and radiology scans. For this purpose, interviews, shadowing and participation in meetings were used, hence using data triangulation (Patton, 2002). Flowcharts of the planning and booking processes were also compiled and discussed or sent to key informants for confirmation, ensuring construct validity. Feedback was

retrieved and incorporated. Workshops with representatives from the subspeciality were also held, addressing the operational changes introduced during CCP implementation that might have influenced waiting times. By constructing time charts for the waiting times during the studied time period, including the changes introduced in the subspecialities, the implications of these changes on waiting times could be examined.

Conducting a quantitative before/after study in combination with a case study enabled knowledge regarding the patterns in changes in waiting times between the before and after period to be linked to changes in planning and booking. This created a deeper understanding of potential crowding out effects and the reasons behind them.

As with the other studies, there are limitations to Study 3. The results from the quantitative before/after study and the case study complement each other because the case study can provide understanding regarding the operational changes that may be responsible for the patterns identified in the quantitative before/after study. However, the study only addresses these issues within one organisation, requiring more quantitative research to analyse the patterns identified in Study 3. More qualitative research is also needed to provide knowledge about how crowding out effects are formed, and how they can be reduced in practice. In analysing waiting times for surgery/radiology scans/pathology analyses, Study 3 does not analyse crowding out effects in other parts of the patient pathway, the first type of crowding out effect described by the National Board of Health and Welfare (2016), which is another limitation.

3.3 UNIT OF ANALYSIS AND HOW THE RESEARCH QUESTIONS WERE ANALYSED

The unit of analysis is a vital component of research design (Yin, 2009), comprising the main entity analysed in a research study. It is essential to state a clear unit of analysis in research, in order to distinguish what should be studied as well as to address the purpose of a study. As stated in Chapter 1, the purpose of this thesis is:

To explore the impact and management of variation in patient flows within hospitals.

It is important to distinguish whether the unit of analysis exists at an individual, divisional, company or corporate level, depending on the research question (Flynn et al., 1990). In this thesis, the main unit of analysis is the management of variation in patient flows within hospitals. The choice of a hospital level is thus in line with the purpose of the thesis. However, other, embedded units of analysis (Yin, 2009) are also included. These correspond to the levels of abstraction introduced in section 2.6. In the next section, the levels of abstraction studied in each research question, and how the analysis is structured in general, are described.

3.3.1 RESEARCH QUESTIONS AND LEVELS OF ABSTRACTION

In Chapter 1 (see Table 1.1), the links between each paper, report and case study and the research questions are introduced. This section further addresses how each appended document contributes to answering the research questions and their underlying questions. The relationships between the different research questions and the four levels of abstraction concerning how variation in patient flows is managed are also discussed, and these are depicted in Figure 3.1. For further details concerning the analysis of the research questions, see Chapter 5.

FIGURE 3.1 – RELATIONSHIPS BETWEEN THE RESEARCH QUESTIONS AND THE FOUR LEVELS OF ABSTRACTION

Paper I is a simulation study that contributes to answering RQ1: *How does variation in acute patient flows impact upon healthcare units?* It does so by measuring how an ED and an inpatient ward with variation in patient flows each behaves when resources, number of patients and service times are being altered. The resulting changes in bed occupancy and length of stay provide an understanding of how healthcare units can tolerate variation. Paper I hence contributes to answering the two underlying questions of RQ1, namely:

- a) *How does the impact upon length of stay differ between EDs and inpatient wards?*
- b) *How does the magnitude of impact differ between bed occupancy and length of stay?*

By analysing the impact of variation for two healthcare units, Paper I also primarily contributes to the understanding of the third level of abstraction (see Figure 3.1).

Paper II and Case study I both include categorisations of the actions used to handle variation in acute patient flows at a university hospital, thus directly contributing to RQ2: *What actions are used to handle variation in acute patient flows within hospitals?* These categorisations also contribute to answering the first underlying question of RQ2: *What types of action are used?* A new analysis of the actions used to handle variation in acute patient flows using the different levels of abstraction is also included in the analysis of RQ2, enabling a contribution to all four levels of abstraction (see Figure 3.1). It especially contributes to answering the second underlying question of RQ2: *At which organisational levels are these actions used?*

Paper III explores the involvement of middle management in forming actions to handle variation in acute patient flows at a university hospital, and hence makes a key contribution to RQ3: *How do the hospital organisation and middle management involvement influence the use of actions to handle variation in acute patient flows?* The analysis performed to answer RQ3 is mainly new, and is based on the empirical material in Case study I and the results from Paper III. Case study I is thus important in answering RQ3 since it includes in-depth descriptions of the organisation and decision-making structure around the acute patient flows, as well as the actions used to handle the variation in acute patient flows. The analysis proposes that three main factors have an influence upon the actions used to handle variation in acute patient flows. Each of these factors is identified through the lens of propositions derived from the literature on healthcare organisation (see section 2.2) and middle management involvement (see section 2.2.1). Furthermore, RQ3 provides understanding regarding the management of variation in patient flows at all four levels of abstraction (see Figure 3.1).

To investigate whether the implementation of care pathways is associated with changes in waiting times for other patient groups, Paper IV analyses waiting times for surgery, radiology scans and pathology analyses before and after the implementation of CCPs. The paper thus delivers direct input to RQ4: *How does the implementation of care pathways influence the handling of variation in elective patient flows?* It does so by analysing how waiting times for different patient groups change after implementation. Hence, it also contributes to

answering the first two underlying questions of RQ4: *How does the implementation of care pathways influence waiting times...*

- a) *...for care pathway patients?*
- b) *...for other patient groups?*

Report I describes the changes that have been introduced when implementing CCPs in urology surgeries and computer tomography scans, and relates this to the changes in waiting times during the studied time period. It therefore contributes to answering RQ4 by providing an in-depth understanding of how waiting times have changed over time for these two healthcare units and by describing the activities performed in the implementation of CCPs. Report I also helps to answer the first and second underlying questions, as well as the third one: *How does the implementation of care pathways influence waiting times...*

- c) *...as a whole?*

Report II has been included as an appendix in the final report by the National Board of Health and Welfare (2019), evaluating the implementation of CCPs nationally in Sweden. It combines parts of Paper IV with Report I, and discusses crowding out effects following the implementation of CCPs. It also analyses possible explanations for the identified changes in waiting times, contributing to RQ4 and its underlying questions. Overall, RQ4 contributes to the understanding of how managing variation in a single patient process (Level 2) influences the ability to manage variation within a healthcare unit (Level 3) (see Figure 3.1). By combining the results from Paper IV and Reports I and II, the analysis in relation to RQ4 provides a more holistic perspective on the influence of care pathway implementation on the handling of variation in elective patient flows.

3.4 RESEARCH PROCESS

In this section, the research process will be described. An overview of the studies, appended documents and thesis work is also depicted in chronological order in Figure 3.2. The research process began in 2011, as a doctoral student project at Logistics Management (currently Logistics and Quality Management), a division of the Department of Economic and Industrial Development at Linköping University. The first research project I was involved in was developing a simulation model in collaboration with Hässleholm Hospital (Study 1), a relatively small hospital in the south-east of Sweden. The project was initiated as a continuation of the research project entitled “Vinnvårdprojektet”, a collaborative research project between the Logistics Management Division, the Division for Medical Management Centre at the Karolinska Institute and Hässleholm Hospital. The second research project was initiated in 2012 by my main supervisor at the time, Håkan Aronsson, and myself, in collaboration with Stefan Franzén, Division Chief at the Cardiology and Speciality Medicine Centre, Linköping University Hospital. This project involved studying the management of variation in the acute patient flows originating from the ED (Study 2). These two studies are the main part of my licentiate thesis, presented in the autumn of

2014. Since I had begun my doctoral student employment directly after receiving my Master of Engineering degree from the Faculty of Science and Engineering at Linköping University, I wanted to learn and understand more about the healthcare context, and conduct research with significant practical relevance. In the autumn of 2014, I therefore took employment as an industrial doctoral student at Kalmar County Hospital, incorporating 50% of my working hours as a business developer and 50% continuing with my PhD studies, with supervision from the Logistics and Quality Management Division. The division of working hours has not always been maintained; however, in general, the arrangement has been fruitful and well-functioning.

The research approach used under employment as an industrial doctoral student can be described as interactive research, a collaborative research approach described by Svensson (2002) as an offspring of action research. Integrative research makes use of a collaboration, and integration between the researcher system and the practitioner system (Svensson et al., 2015). In comparison to traditional forms of action research, interactive research does not focus on the researcher's role in, or responsibility for, organising and leading practical problem-solving or improvement work within organisations. Instead, interactive research aims to create opportunities for researchers and practitioners to create knowledge and learn together, based on commonly agreed efforts to study change and innovation within organisations (Ellström et al., 2020).

After initiating my employment as an industrial doctoral student, it took some time to identify a research project that was both feasible and of practical and theoretical relevance, in accordance with an interactive research approach. The choice narrowed down to studying whether the implementation of CCPs is causing crowding out effects (Study 3). To ensure that the aim of producing an analysis of the CCP implementation that contributes to both theory development and the practical needs of the hospital was achieved, I did not participate as a business developer in the implementation process. Joint learning and knowledge creation was instead accomplished by reporting my results to the hospital chief and department chiefs involved, while also engaging in workshops with practitioners at the healthcare units studied, discussing the operational changes introduced during CCP implementation and comparing these to changes in waiting times (see Appendix 4 for details).

The involvement of different stakeholders in the interactive research process has previously been shown to improve the validity of research results, while also shortening the time from research to practical application, and to increase the probability of a sustainable impact for the participating organisations (Svensson et al., 2007; Van de Ven, 2007). Methodological analyses also seem to indicate that collaborative and practice-oriented research approaches, used wisely and under favourable conditions, are not inferior to more traditional research methods in terms of the validity of the research results (Argyris, 1980; Eikeland, 2006). The

use of an interactive research approach thus seems appropriate for ensuring both practical and theoretical relevance.

FIGURE 3.2 – THE RESEARCH PROCESS ILLUSTRATED IN CHRONOLOGICAL ORDER

3.5 COMPARING THE LICENTIATE AND DOCTORAL THESIS

The content and approach of this doctoral thesis is a development of the licentiate thesis *Managing Variable Patient Flows at Hospitals* (which can be found in its complete version in Appendix 1). Hence, there are both similarities and differences between the two. The main focus is similar, exploring the management of variation in hospital patient flows. As depicted in Figure 3.2, Study 3 was performed after the licentiate thesis, addressing elective patient flows, in contrast to Study 1 and 2 that mainly address acute patient flows.

The focus of RQ1–3 are fairly similar in the licentiate and doctoral thesis. RQ1 of the licentiate thesis addresses how variation in acute patient flows *affect* hospitals, focusing on EDs and inpatient ward. In the doctoral thesis, RQ1 analyses how variation in acute patient flows *impact* healthcare units, EDs and inpatient wards. Although the terms used are slightly different, the focus of the research questions are similar. However, in answering RQ1, the doctoral thesis discusses and focuses more on the results from Paper I than the licentiate thesis.

RQ2 in the licentiate thesis addresses how variation in acute patient flows are *handled*, while RQ2 in the doctoral thesis addresses the *actions* used in handling variation in acute patient flows. As with RQ1, the focuses are alike. In answering RQ2 in the doctoral thesis, the analysis from the licentiate thesis is built further upon. In the doctoral thesis, a categorisation of actions using the different levels of abstraction in the handling of variation in patient flows developed in Chapter 2 (see

Figure 2.5) is also included.

Regarding RQ3, the licentiate thesis addresses how the *organisational configuration* influences the actions used to handle variation in acute patient flows. The doctoral thesis addresses how the *hospital organisation* and *middle management involvement* influence the use of actions to handle variation in acute patient flows. The analysis from the licentiate thesis is built further upon in the doctoral thesis, however, a larger emphasis is put towards the role of middle management in the doctoral thesis. The emphasis upon middle management was also strengthened between an earlier version of Paper III, appended in the licentiate thesis, and the final version, included in the doctoral thesis.

4 SUMMARY OF APPENDED PAPERS, REPORTS AND CASE STUDY

Four papers, two reports and one case study are appended to this thesis. They are all important for analysing the impact and management of variation in patient flows. This chapter therefore summarises the background, purpose, research approach and findings from each of these appended documents. In terms of the findings, the emphasis is on describing findings that are of relevance for the analysis in Chapter 5. The summaries also include a short description of the contributions made by each author.

4.1 PAPER I

Olsson, O. and Aronsson, H. (2012) “Understanding the impact of variation on healthcare systems”. This paper was presented at the *World Conference on Production & Operations Management* in Amsterdam, the Netherlands, in 2012.

Contributions to Paper I: The outline of the paper was discussed together with my co-author Håkan Aronsson, who at the time was my main supervisor. I was responsible for the design, development and validation of the simulation model as well as writing the paper. Håkan Aronsson provided feedback when needed.

4.1.1 SUMMARY OF PAPER I

The variation associated with demand and supply of healthcare services contributes to operating difficulties in healthcare. Understanding variation thus helps healthcare providers to more accurately address these issues. Paper I uses discrete event simulation to investigate the consequences of alterations (-20%, -10%, +10%, +20%) in patient inflow, available resources, treatment times and duration of activities at an emergency department and an inpatient ward on bed occupancy and length of stay.

The contribution of Paper I is to provide an increased understanding of how a healthcare system with high variation behaves when resources, patient inflow, treatment times and duration of activities are being altered. Overall, the relations between these variables are displayed in Figure 4.1, where the thickness of the arrows symbolises how strong the relations between the variables are. For example, the simulation runs suggest, for both the ED and inpatient ward, that increases in duration of activities (Δ Times) lead to substantial increases in length of stay (LOS), thus the thick arrow in Figure 4.1.

FIGURE 4.1 – RELATIONS BETWEEN THE SIMULATED VARIABLES (FIGURE 5 IN PAPER I)

The paper concludes that the variables are intimately related and that the modelled healthcare units are sensitive to changes due to a considerable variation in patient inflow and treatment times. Changes in terms of a 20% increase in patient inflow and duration of activities, as well as a reduction in bed numbers of 20%, for example, causes continuously increasing queues on the inpatient ward.

4.2 PAPER II

Olsson, O., Aronsson, H. (2015) “Managing a variable acute patient flow – categorising the strategies”, *Supply Chain Management: An International Journal*, Vol. 20, No. 2, pp. 113–127.

Contributions to Paper II: The design of the paper was agreed upon with my co-author Håkan Aronsson. The data collection was my responsibility, and Håkan Aronsson assisted during the semi-structured interviews. I was responsible for conducting the literature reviews and analyses, and for writing the paper. Håkan Aronsson gave feedback on several drafts of the paper and made small additions to the text.

4.2.1 SUMMARY OF PAPER II

Research on how management philosophies, such as lean and agile, are applied and how they can benefit healthcare providers is lacking (Aronsson et al., 2011; de Vries and Huijsman, 2011). To increase our understanding of the use of lean and agile in a healthcare context, the purpose of Paper II was:

To explore if actions used at a hospital to manage a variable acute patient flow can be categorised using the concepts of lean, agile and leagile.

Empirical evidence from a university hospital was gathered by means of interviews, shadowing and participation in meetings. Identified actions, used at different organisational levels, were categorised as lean or agile, while combinations of actions were compared with different leagile approaches.

The paper categorises 50 actions used to handle variation in acute patient flows originating from the ED into one of six lean or agile categories. Actions from every lean and agile category derived from the literature are used at the hospital, although to varying extents. The categories, along with the number of actions assigned to each category, are listed below:

- Agile 1: Extending the use of a resource (7)
- Agile 2: Altering the amount of a resource, ahead of demand (9)
- Agile 3: Altering the amount of a resource, as a response to demand (12)
- Lean 1: An action that increases patient flow standardisation (7)
- Lean 2: An action that reduces the need for a resource (11)
- Lean 3: An action that directly manages external variation (4)

Many of the agile actions are reactive, indicating a lack of proactive measures. Actions that directly manage external variation (Lean 3) are also few in number. Leagile approaches incorporating all three combinations derived from the literature are also used at the hospital. The use of actions within both lean and agile categories illustrates the opportunity to combine these strategies within hospitals, rather than only focusing on implementing lean. By cleverly combining lean and agile actions, different leagile approaches can be formed.

4.3 PAPER III

Olsson, O., Aronsson, H. and Sandberg, E. (2017) “Middle management involvement in handling variable patient flows”, *Management Research Review*, Vol. 40, No. 9, pp. 1007–1024.

Contributions to Paper III: All three authors collaborated on the design of the paper. The data collection was my responsibility, and Håkan Aronsson assisted during the semi-structured interviews. The literature review, along with the analysis and conclusions, were my responsibility, with assistance from Erik Sandberg. I wrote the main part of the paper, while feedback and additions to the text were provided by Håkan Aronsson and Erik Sandberg.

4.3.1 SUMMARY OF PAPER III

Research on the role of middle management in a healthcare context is sparse (Currie and Procter, 2005), while a lack of coordination between different pipelines and healthcare units is critical for addressing problems with the management of variation in patient flows (Villa et al., 2014). Middle management therefore becomes vital in managing variation in patient flows. The purpose of Paper III was hence to explore the involvement of middle management in forming strategies to handle variation in acute patient flows at a hospital, with a focus on acute patient flows originating from patients visiting the ED.

Empirical evidence from a university hospital was gathered by means of interviews, observations and participation in meetings. The role of middle management in the development of strategies was analysed using the literature on middle management involvement. In the paper, department chiefs were evaluated as being middle management. In handling variation in acute patient flows, middle management adopts a number of roles and behaviours, which have been previously described in research. In Paper III, a framework developed by Floyd and Wooldridge (1992) was used to identify examples of these roles, in relation to the involvement of middle managers in handling variation in acute patient flows.

By applying the framework by Floyd and Wooldridge (1992), the paper concludes that the facilitator role best describes middle management’s involvement in managing the variation in acute patient flows. Overall, middle managers at the hospital tend to focus on the facilitation and support of their own departmental practices, which results in unique strategies at the departmental level. Apart from the facilitator role, the findings of the paper indicate that only fragments of the other roles in the framework are demonstrated. Unclear mandates and a division of tasks between top and middle management, together with a lack of hospital-wide strategies concerning how acute patient flows should be managed, are contributing factors to this behaviour. The paper further highlights the need for top management to establish long-term goals to enhance middle management roles in developing strategies for handling variation in patient flows.

4.4 PAPER IV

Olsson, O. (2020) “Are cancer care pathways associated with longer waiting times. Analysing crowding out effects in radiology, pathology, and surgery”, *International Journal of Care Coordination*, Vol. 23, No. 4, pp. 147–155.

Contributions to Paper IV: The outline of the paper was discussed with my supervisors. I performed the research and wrote the paper.

4.4.1 SUMMARY OF PAPER IV

In the autumn of 2015, Sweden initiated the implementation of CCPs. With target times from diagnosis to first treatment followed nationally, the issue of crowding out effects has been discussed, especially for the pathology, radiology and surgical specialities. There is, however, a lack of research studying crowding out effects as a result of care pathway implementation. The purpose of Paper IV was hence:

To investigate whether the implementation of CCPs is associated with longer waiting times for surgery, radiology scans and pathology analyses for other patient groups.

Data from the internal production planning systems used in radiology, pathology and surgery at Kalmar County Hospital for the years 2014–2017 were analysed in the paper. By using the different priority categories used in these specialities, changes in waiting times before and after the implementation of CCPs could be analysed. Since crowding out effects are more relevant to study if the quantity of CCP-related pathology analyses/radiology scans/surgical procedures is large in relation to the total number of analyses/scans/surgical procedures, only some specific subspecialities with a high percentage of CCP-related analyses/scans/surgical procedures were included. These were urology, breast and lower gastrointestinal (LGI) subspecialities in the surgical speciality; cytopathology and histopathology in the pathology speciality; and magnetic resonance imaging (MRI) and CT scans in the radiology speciality.

The results of Paper IV are consistent with an association between the implementation of CCPs and longer waiting times for the priority category ranked immediately below the CCP category in all three specialities. Among the subspecialities that do display this pattern, there are plausible explanations, for example reduced inflow of cytopathology analyses and a very small proportion of CCP patients for MRI scans. In addition, none of the lowest priority categories within each subspeciality has experienced increased waiting times after CCP implementation, indicating that crowding out of low-priority patients is unlikely. The results are consistent with a change in prioritisation whereby CCP patients are experiencing shorter waiting times after CCP implementation at the expense of other patient groups. Further research is needed, however, to determine if these patterns are crowding out effects due to the introduction of CCPs.

4.5 REPORT I

Olsson, O. (2019) “Hur införandet av standardiserade vårdförlopp påverkat väntetider inom urologi och radiologi”, LIU-IEI-RR--19/00331—SE

Contributions to Report I: The outline of the report was discussed with my supervisors. I performed the research and wrote the report.

4.5.1 SUMMARY OF REPORT I

The report follows waiting times for urology surgery and CT scans before and after the implementation of CCPs. It also describes the planning processes for urology surgery and CT scans and includes the operational changes that these subspecialties have introduced into these processes during the studied time period. The report further analyses the effects of CCP implementation by comparing the operational changes with changes in waiting times for the different priority categories used in these subspecialties. It does so using a method called the run chart (Perla et al., 2011), where time charts for each priority category, including the operational changes introduced in the subspecialties, are analysed for signals that correspond to non-random patterns.

For urology surgery, the studied time period was between September 2014 and June 2017. The median waiting times for CCP surgery decreased after CCP implementation, even for the surgeries that should have been, but were not, included in the CCP. The signals from the run chart method indicate that the changes in waiting times were associated with actions to decrease the queue for CCP surgery beforehand, as well as dedicating a number of weekly time slots for these surgical procedures. For other urology surgery, the median waiting time increased after CCP implementation from 50 to 60 days, while the number of patients waiting also increased. In addition, the run chart signals show that these changes coincide with the operational changes described earlier. When dividing these into the three priority categories used, the effects differ, with the two least prioritised categories experiencing shorter waiting times after CCP implementation. However, these changes did not coincide with the operational changes. For the priority category ranked directly below the CCP surgery, median waiting times increased, from 14 to 19 days, as did the number of patients waiting, coinciding with the operational changes.

The median waiting time for CCP scans is noticeably shorter than the other elective CT scans, implying that these have experienced shorter waiting times than they would have before the CCP implementation. As for urology surgery, the changes in waiting times for the different priority categories vary. For those that have shorter waiting times after CCP implementation, the changes do not coincide with the operational changes introduced due to CCP implementation. In accordance with urology surgeries, the priority category ranked directly below CCP scans display an increased median waiting time, from 10 to 11 days. The run chart signals also show that this pattern coincides with the CCP implementation. Since this priority category and the CCP category are booked in the same way, and CCP scans have higher priority, this could be a crowding out effect.

4.6 REPORT II

Olsson, O. (2019), “Undanträngning till följd av SVF, exempel från Länssjukhuset i Kalmar”, Appendix 3 in the report *Om lärande, prioriteringar och ekonomiska aspekter - Effekter av satsningen på standardiserade vårdförlopp i cancervården, Slutrapport del 2, 2019*. National Board of Health and Welfare.

Contributions to Report II: I performed the research and wrote the report.

4.6.1 SUMMARY OF REPORT II

Report II combines the results from the case study (Report I) and the quantitative before/after study (Paper IV), and was included in the final report examining the four-year programme to implement CCPs in Sweden, issued by the National Board of Health and Welfare (2019).

Based on the results of the case study and quantitative before/after study, Report II argues that it is likely that the implementation of CCPs has caused crowding out effects in terms of longer waiting times for the priority category ranked immediately below the CCP patients. This corresponds to analyses/scans/surgery for patients who were previously among the most prioritised elective patients, with short waiting times. Since the introduction of these pathways, patients undergoing investigation and initial treatment within a CCP have been prioritised more highly than these other patients, which is likely to have increased their waiting times. Report II concludes that these patterns are consistent in the three studied specialities. Among the subspecialities that do display this pattern, there are also plausible explanations, according to the results from the quantitative before/after study. Report II also includes a schematic example (see Figure 4.2) explaining why it is plausible that it is the priority category ranked immediately below the CCP category that has the most prolonged waiting times. The example demonstrates the situation where a new priority category is included into an existing planning process, without other changes being made.

FIGURE 4.2 – SCHEMATIC FIGURE DEMONSTRATING CROWDING OUT EFFECTS FOLLOWING CCP IMPLEMENTATION (FIGURE 3 IN REPORT II)

The example shows that the mean waiting time changes the most for the overtaken priority category, in the example Prio1. For the other priority categories, Prio2 and Prio3, the extension of mean waiting time is marginal or zero.

4.7 CASE STUDY I

Olsson, O., Aronsson, H. (2014) “Managing a variable acute patient flow at a university hospital”, LIU-IEI-RR--14/00212—SE

Contributions to Case study I: I was responsible for data collection, and Håkan Aronsson assisted with the semi-structured interviews. I transcribed the interviews and wrote the report.

4.7.1 SUMMARY OF CASE STUDY I

The purpose of Case study I was to provide a description of how variation in acute patient flows is managed at the university hospital studied. Case study I is divided into two parts. The first addresses the decision-making and actors involved in managing acute patient flows at the hospital. In addition to the hierarchical levels of the hospital, it also describes the specific roles and working teams with responsibilities and mandates directly or indirectly related to acute patient flows (see Figure 4.3 below).

FIGURE 4.3 – THE AUTHORITIES (THICK LINES) DELEGATED AND THE INFORMATION FLOWS (DASHED LINES) BETWEEN ACTORS REGARDING ACUTE PATIENT FLOWS WITHIN THE HOSPITAL (FIGURE 5 IN CASE STUDY I)

The second section describes the actions used at the hospital to handle variation in acute patient flows, and is structured based on four categories of action. The first category is related to handling the inflow of acute patients, e.g. the different actions taken to avoid unnecessary admissions. Measures that enable efficient acute patient flows within the hospital comprise the second category, such as distributing admissions evenly across inpatient wards. The third category relates to working with the outflow of patients, for example by preparing discharge in parallel with treatment. Lastly, the fourth category includes actions that directly handle variation in acute patient flows by adjusting daily operations to the present situation within the hospital, clinical departments and inpatient wards.

5 ANSWERING THE RESEARCH QUESTIONS

This chapter answers the research questions developed in Chapter 1. The questions are addressed sequentially and the findings for each are summarised in relation to the four levels of abstraction derived in Chapter 2. The analysis for each research question includes the results from one or more of the appended papers, reports and case study. In addition, some new analyses are also incorporated into this chapter.

5.1 RELATIONS BETWEEN RESEARCH QUESTIONS 1–3

To recapitulate, the purpose of this thesis is *to explore the impact and management of variation in patient flows within hospitals*. The first three research questions concern acute patient flows while the fourth examines elective patient flows. RQ1 focuses on the impact of variation in acute patient flows, while RQ2 investigates the actions used in handling variation. RQ3 embraces how the hospital organisation and the involvement from middle management influences the use of actions to handle variation. Hence, RQ1–3 are interdependent. Figure 5.1 aims to visualise these interdependencies by exemplifying the focus of RQ1–3 in relation to a healthcare unit. As concluded in Chapter 1, variation in arrival rates and service times are the types of variation that are addressed in this thesis. Therefore, RQ1 addresses the aggregated impact of variation in arrival rates and service times for the activities performed within a healthcare unit. The impact of variation is, however, also influenced by the actions used in handling variation.

FIGURE 5.1 – THE RELATIONS BETWEEN RQ1–3 EXEMPLIFIED

5.2 RESEARCH QUESTION 1

Previous research has identified ED overcrowding and high bed occupancy as common negative influences, impacting upon variation in acute patient flows (Proudlove et al., 2003; Trzeciak and Rivers, 2003; Schiff, 2011). There is, however, a need to further explore the impacts of variation in patient flows, and to provide more detailed knowledge concerning the impact of variation in acute patient flows. In accordance with this reasoning, RQ1 and its two underlying questions were formulated in Chapter 1:

RQ1: *How does variation in acute patient flows impact upon healthcare units?*

- a) *How does the impact upon length of stay differ between EDs and inpatient wards?*
- b) *How does the magnitude of impact differ between bed occupancy and length of stay?*

To answer RQ1, the results from Paper I are analysed. This paper is a simulation study measuring how an ED and an inpatient ward, with variations in patient flows, behave when patient inflow, treatment times and the duration of activities are altered. The resulting changes in bed occupancy and length of stay provide an understanding of how healthcare units can tolerate variation. Paper I hence contributes to answering the two underlying questions of RQ1, and these are addressed below.

5.2.1 THE IMPACT OF VARIATION IS SMALLER FOR EDs THAN FOR INPATIENT WARDS

In Paper I, the influence of alterations in patient inflow, or treatment times and duration of activities, for an ED and an inpatient ward, was tested. The alterations were tested by simply increasing or decreasing the mean value of one of these variables by 10 or 20%. For patient inflow, this corresponds to changing the average number of patients arriving at the ED, and thereafter on the inpatient ward, thus changing the mean value of arrival rates. Alterations in treatment times and duration of activities change the average time it takes for a patient to progress through each step of the patient process, hence altering the mean value of service times. The variation in arrival rates and service times, which for example can be measured using the standard deviation, are not changed, however; only the mean value of the arrival rate and service times.

For every one of these alterations, five simulation runs with durations of two years were completed. The results are presented in Tables 3 and 4 in Paper I. Although the variations in arrival rates and service times are not changed, the simulation runs performed in Paper I demonstrate the robustness of healthcare units in handling increased numbers of patients, or prolonged treatment times and duration of activities. With increased variation in patient flows, which increases the standard deviation of the arrival rate and service times, these effects will also appear at times. Paper I can thus provide insights into the potential impact of variation in acute patient flows.

When comparing the effects of an altered patient inflow, the ED was more robust, with a smaller increase in LOS due to increased patient inflow. When treatment times and duration of activities were altered, similar, although less clear-cut, patterns were demonstrated. The results thus point towards EDs being more adaptable to changes in patient flows than inpatient wards. A finding regarding the impact of variation in acute patient flows can therefore be formulated:

The impact of variation in acute patient flows is smaller for EDs than for inpatient wards.

5.2.2 BED OCCUPANCY IS HIGHLY INFLUENCED BY VARIATION

In addition to analysing the influence of alterations in patient inflow, treatment times and duration of activities, Paper I also analyses the influence of alterations in the number of available beds on the inpatient ward. Changes in all of the three variables analysed had a strong influence on bed occupancy, while only changes in treatment times and duration of activities were concluded to have a strong influence on LOS. The relations between the variables are visualised in Figure 5.2, where the thickness of the arrows symbolises how strong the relations between the variables are.

FIGURE 5.2 – RELATIONS BETWEEN THE SIMULATED VARIABLES (FIGURE 5 IN PAPER I)

As before, these are not alterations in the variation in patient flow. Nevertheless, the simulation runs demonstrate the robustness of healthcare units in handling increased numbers of patients, decreased numbers of beds, or prolonged treatment times and duration of activities. Hence, it provide insights into the potential impact of variation in acute patient flows, and a second finding can be formulated:

Bed occupancy is highly influenced by variation in patient flows.

These results imply that monitoring bed occupancy and managing the resources they require is important for inpatient wards when handling variation in acute patient flows. These results are also in line with previous research discussing the observation that bed occupancy of approximately 90% is related to substantial problems with queuing and congestion on inpatient wards (Walley et al., 2006). The average bed occupancy for the studied inpatient ward in Paper I was 87%.

5.2.3 IN SUMMARY

Figure 5.3 summarises the findings related to this research question, regarding the impact of variation in acute patient flows on healthcare units.

FIGURE 5.3 – THE FINDINGS RELATED TO THE IMPACT OF VARIATION IN ACUTE PATIENT FLOWS

In the next section, the actions used to handle variation in acute patient flows are explored.

5.3 RESEARCH QUESTION 2

The impact of variation in patient flows is influenced by the ways in which the variation is handled. In previous research, the ability of healthcare providers to handle variation in demand has been questioned. Walley et al. (2006), for instance, argue that healthcare resources are often used inappropriately and are not adapted to the variations in patient flows. Examples of problems are overcrowded EDs (Estey et al., 2003; Schiff, 2011), along with high bed occupancy and bed shortages on inpatient wards (Proudlove et al., 2003). More knowledge is thus needed to understand how variation in patient flows is handled. This section of the analysis chapter hence focuses on answering the second research question:

RQ2: *What actions are used to handle variation in acute patient flows within hospitals?*

The ambition is to provide in-depth knowledge about the handling of variation in acute patient flows. The analysis is centred around the 50 actions used at the university hospital to handle variation in acute patient flows. These actions were identified in Study 2. The analysis discusses them in terms of different types, and at which organisational levels they are used, according to the underlying questions of RQ2:

- a) *What types of action are used?*
- b) *At which organisational levels are these actions used?*

The starting point for the analysis is a comparison between the categorisations of the actions used at a university hospital to handle variation in acute patient flows presented in Paper II and Case study I. It continues with some of the findings from these documents, and thereafter adds a new categorisation of the actions previously identified using the different levels of abstraction in the handling of variation in patient flows developed in Chapter 2 (see

Figure 2.5). This categorisation is analysed in relation to the concepts of lean and agile, used in the categorisation in Paper II. These two concepts, and their combination within a healthcare context, have previously been discussed by a number of authors (e.g. Towill and Christopher, 2005; Aronsson et al., 2011; Rahimnia and Moghadasian, 2010). However, the discussion has remained at a more aggregated and theoretical level, and the concepts have not previously been used to categorise the individual actions used to handle variation in patient flows.

5.3.1 COMPARING PREVIOUS CATEGORISATIONS OF ACTIONS⁷

Fifty actions used at the university hospital to handle variation in acute patient flows were identified in Study 2. These have previously been categorised based on two different approaches, which are presented in Case study I and Paper II. The first categorisation is

⁷ This section is partly based on a section in the licentiate thesis discussing these categorisations (see section 4.2 in Appendix 1)

presented in Case study I, and is designed to fit the empirical findings as well as present the empirical material. It includes the categories Inflow, Internal flow, Outflow and Flexibility. These categories are based on the perspective of the hospital as a system within which various actions are used to handle patient inflow and outflow to/from the hospital. The main difference between the Internal flow and Flexibility categories is that the latter includes actions that are used as a response to variation in acute patient flows, while the actions in the Internal flow category are used proactively. In the second categorisation, presented in Paper II, the categories are developed from the theory on lean and agile as process strategies, with three categories for each process strategy. Table 5.1 displays a matrix in which these two categorisations are combined. The combination is then analysed in order to evaluate the alignment of these categorisations, as well as to identify additional findings regarding the actions used to handle variation in acute patient flows.

TABLE 5.1 – COMBINING THE EMPIRICAL CATEGORIES FROM CASE STUDY I AND THE LEAN/AGILE CATEGORIES FROM PAPER II, FOR THE 50 ACTIONS

		Agile			Lean			Sum
		Extending use	Altering amount, ahead	Altering amount, response	Patient flow standardisation	Reduced need for a resource	Manage external variation	
Empirical category	Inflow	1			1	6	1	9
	Internal flow		4		6		2	12
	Outflow		3	1		5		9
	Flexibility	6	2	11			1	20
	Sum	7	9	12	7	11	4	50

The actions in the category Inflow in Case study I are predominantly categorised as lean in Paper II. These actions are mostly aimed at finding alternatives for inpatient care and avoiding unnecessary admissions, hence ensuring efficient and appropriate care for patients. This resonates with the lean process strategy. The Outflow category in Case study I is comprised of actions from both lean and agile categories in Paper II. Virtually all actions in the Flexibility category in Case study I were placed in an agile category in Paper II, while most actions in the efficient flow category in Case study I were placed in a lean category in Paper II. These results are not surprising, since flexibility is associated with agility (Aronsson et al., 2011; Christopher and Towill, 2000), and the aim to continuously eliminate waste within lean constitutes moving towards efficiency in the primary flow (Womack et al., 1990). Overall, the two categorisations seem to be in line with each other.

5.3.2 THE MAIN FOCUS IS THE EFFECTS OF VARIATION, MAINLY HIGH BED OCCUPANCY

When considering the actions used to handle variation in the acute patient flows in Study 2, only four out of the 50 actions were found to handle external variation directly, the third lean category in Paper II. Nor is it individual variations, such as patient inflow, that are

handled but the combined effect of variation in patient flows. Hence, a finding is that most actions are used to handle the effects of the variation, not the variation itself.

Much time and effort is also spent in handling bed shortages at the university hospital. This was a recurring topic in the interviews in Study 2, with 22 out of the 50 actions identified being used to handle high bed occupancy within the clinical departments. Only two of the 50 actions were used to handle ED overcrowding. An additional finding is thus that many actions are used to handle high bed occupancy, while few are used to handle ED overcrowding. This finding also supports the findings related to RQ1, namely that: *The impact of variation in acute patient flows is smaller for EDs than for inpatient wards and Bed occupancy is highly influenced by variation in patient flows.* Of the 22 actions used to handle high bed occupancy, most (18) are categorised in the agile categories. This demonstrates the need for flexibility in bed management (Proudlove and Boaden, 2005) and resonates with the focus on agility in responding rapidly to changes in demand, in terms of both volume and variety (Christopher, 2000). The number of available beds is easily measured, and is a common indicator of the utilisation of resources; it is therefore not surprising that bed occupancy is given a lot of attention. The utilisation of other resources also varies, but can be more complex to measure, such as personnel, or more difficult to change quickly, such as rooms and buildings.

5.3.3 LEAN AND AGILE ACTIONS USED AT THE DIFFERENT LEVELS OF ABSTRACTION

Before discussing the use of actions at the different levels of abstraction determined in Chapter 2 (see

Figure 2.5), and the combination of the lean/agile categories from Paper II, the separation between actions at the different levels of abstraction will be clarified. Actions at the hospital level (Level 4) are determined as being applied by top management and/or have the aim of bringing positive effects to the hospital as a whole. However, the use of these actions may still be within a clinical department or on an inpatient ward. Examples are to divide acute patients who need admission to an inpatient ward evenly between clinical departments, or to have assistance evaluators located at the hospital, which enables faster and smoother discharge planning. Actions at the healthcare unit level (Level 3) are often developed by a clinical department and used with the aim of generating some improvement for the clinical department that uses the action. Examples include calling in additional nurses or assistant nurses, or discharging patients at weekends and not just on weekdays.

The division of the fourth level of abstraction might also need some clarification. Level 4.1 corresponds to collaborative actions taken by units that provide treatment and care in the same part of a patient flow; for example, inpatient wards at the hospital. One example is the relocation of a patient from one clinical department to another in order to smooth out the bed occupancy. Level 4.2, on the other hand, corresponds to collaborative actions at the interface between units that have consecutive tasks in the flow of patients, for example

the ED and an inpatient ward. An example related to the discharge from hospital is that the municipality may provide a place at a short-term care facility before placement at a permanent care facility is made possible.

In Appendix 5, the actions used to handle variation in patient flows at the university hospital, and the categorisation of these in terms of the level of abstraction and lean/agile categories, are presented. In Table 5.2 the categorisations based on lean/agile and level of abstraction are summarised.

TABLE 5.2 – COMBINATION BETWEEN THE CATEGORISATIONS OF LEAN/AGILE AND LEVEL OF ABSTRACTION

	Agile			Lean			Sum
	Extending use	Altering amount, ahead	Altering amount, response	Patient flow standardisation	Reduced need for a resource	Manage external variation	
Level 1	-	-	-	-	-	-	0
2				6	2		8
3	3	6	6		2	2	19
4.1	3	3	4			1	11
4.2	1		2	1	7	1	12
Sum	7	9	12	7	11	4	50

The combination of these two categorisations provides additional findings:

- Actions used to handle variation in a single patient process (Level 2) are only found in the lean categories.
- Actions used by a single healthcare unit (Level 3) are mostly found in the agile categories.
- Actions used between units that act in the same part of the patient flow (Level 4.1) are mostly categorised as agile.
- Actions at the interface between units that have consecutive tasks in the flow of patients (Level 4.2) are mostly found in the lean categories.

These results are in line with the focus of lean and agile, respectively. Lean focuses on streamlining processes and reducing the resources and time needed to produce a given set of goods or services (Womack et al., 1990). The concept of agility instead focuses more on creating flexibility in order to be adaptable to changes (Aitken et al., 2002) and being robust enough to tolerate variations and disturbances (Goldman et al., 1995; Kidd, 1995). Creating flexibility and robustness is thus of more use in handling many patient processes in parallel, as in a healthcare unit (Level 3) and in the dependence between units providing treatment and care in the same part of a patient flow (Level 4.1). Lean actions seem to be preferred when handling variation in patient processes within (Level 2) and between (Level 4.2) healthcare units.

Twenty-seven of the 50 actions are used at Level 2 or 3. By managing units and patient processes individually, without consideration of the impact on the larger system, there is always a risk of sub-optimisation (Stock and Lambert, 2001). Another finding is thus that there is a risk of sub-optimisation due to fewer actions being taken at Level 4 than at Levels 2 and 3 combined. There may, of course, always be more or less effective actions being developed at all levels of abstraction, but the risk of developing actions that generate sub-optimisation is lower at a hospital level.

The last finding related to the second research question is that no actions were categorised at Level 1. This is not surprising, since personnel and decision-makers at the university hospital base their decisions on information concerning many factors related to patient flows, their co-workers and the situation within other units at the hospital. Attempting to handle variation for each single activity therefore becomes inefficient and is unlikely to influence the situation within the healthcare unit or hospital as a whole.

5.3.4 IN SUMMARY

Figure 5.4 summarises the findings for this research question, regarding the actions used to handle variation in acute patient flows (black font). The figure also includes the findings related to the impact of variation in acute patient flows derived from answering RQ1 (blue font). As discussed in section 5.3.2, these findings are aligned with the finding that many actions are used to handle high bed occupancy, while few are used to handle ED overcrowding.

The next section explores the influence of the organisation and management upon the actions used to handle variation in acute patient flows.

FIGURE 5.4 – THE FINDINGS FROM RQ1–2 COMBINED

5.4 RESEARCH QUESTION 3

To answer the third research question, the influence of the organisation and management on the actions used to handle variation in acute patient flows will be elaborated:

RQ3: *How do the hospital organisation and middle management involvement influence the use of actions to handle variation in acute patient flows?*

The analysis proposes that three main factors, depicted in Figure 5.5, influence the actions used to handle variation in acute patient flows. The analysis illustrates that all of these factors influence one of the findings related to RQ2, namely that there is a *Risk of sub-optimisation due to fewer actions at Level 4 than at Levels 2 and 3 combined*. The analysis hence answers RQ3 by describing how these three factors hinder the development and use of actions at the hospital level (Level 4), while facilitating the development and use of actions at the healthcare unit level (Level 3) and patient process level (Level 2).

FIGURE 5.5 – THE INFLUENCE OF THREE MAIN FACTORS, DERIVED FROM PREVIOUS LITERATURE STREAMS, ON THE ACTIONS USED TO HANDLE VARIATION IN ACUTE PATIENT FLOWS

These factors are interconnected. For example, unanimous decision-making at hospital management level (factor 1) is likely to contribute to the lack of hospital plans for handling

variation in acute patient flows (factor 3). These factors also partly reinforce each other, a relationship that is also probable between factors 2 and 3. However, the connections between these factors are not further elaborated; instead, this section focuses on the factors themselves and how they influence the actions used to handle variation in acute patient flows.

5.4.1 UNANIMOUS DECISION-MAKING AT HOSPITAL MANAGEMENT LEVELS⁸

Due to the continuous developments in the medical field, the focus on how to treat and cure diseases has outweighed the focus on organisational and managerial aspects of care delivery (Bohmer, 2009; Timmermans and Berg, 2003). As a result of this development, healthcare organisations and their professionals have also become increasingly specialised, and healthcare services increasingly fragmented (Coleman, 2003). At the university hospital in Case study I, healthcare services are organised into divisions, which provide specialised healthcare services for the entire region. Hence, there is no one below the Chief Executive Officer who can take hospital-wide decisions. To simplify and improve decisionmaking concerning local and hospital-specific issues, a hospital management team was therefore established, around the year 2003–2004. An emergency flow group, which is subordinate to the hospital management group, was also established, with responsibility to plan, coordinate and develop well-functioning and secure acute patient flows originating from the ED.

All decisions taken by these two groups have to be agreed upon by all members. For the hospital management team, this means all division chiefs, and for the emergency flow group, all department chiefs; among others. This unanimous decision-making therefore makes it difficult to establish a coherent strategy for managing variation in the acute patient flows at the hospital, which at times might entail advantages for some at the expense of others. This is also displayed by the fact that the boundary between which issues should be resolved by which group is imprecise, and issues that are raised by the emergency flow group are often sent back from the hospital management group without a decision. Sending issues up and down the management levels due to unclear mandates and responsibilities is likely to contribute to the development, and use, of many actions for handling variation in acute patient flows within the clinical departments (Levels 2 and 3) and few at the hospital level (Level 4). To clarify, actions at both Level 2 and 3 can be developed and used by clinical departments, but a major difference between the two is whether they are used in order to improve some aspect of healthcare delivery within a patient process (Level 2), or in the clinical department or inpatient ward as a whole (Level 3).

⁸ This section is partly based on a section in the licentiate thesis discussing the influence of the organization upon the actions used to handle variation in patient flows (see section 4.3 in Appendix 1)

5.4.2 EXTENSIVE AUTHORITY OF CLINICAL DEPARTMENTS⁹

Highly specialised clinical departments often guard their decision-making and professional practices against the influence of top management and other organisational structures (Ho et al., 1999). This clinical autonomy rests on the exclusive ability of clinicians to define illness, diagnose patients and decide between appropriate treatments (Dent, 1993).

Physicians who become managers accept the managerial responsibility, but they also protect high levels of medical autonomy and resist attempts to increase managerial control of clinical practice (Kitchener, 2000). As concluded in Paper III, the facilitator role best describes middle management's (department chiefs') involvement in managing the variation in acute patient flows. Overall, middle managers tend to focus on the facilitation and support of their own departmental practices, which results in unique strategies within the clinical departments (Levels 2 and 3). There is also a lack of long-term goals or future states concerning how the variation in acute patient flows should be handled within the hospital, and this hinders the control and coordination of the actions used by different clinical departments. This also inhibits organisational learning at the hospital, both bottom-up and laterally across the hierarchies. In Paper III, it was further concluded that, if organisational learning had been achieved at more appropriate levels within the hospital, feedback loops would have been clearer and the adoption of successful actions between clinical departments more widespread.

Hospitals are generally organised for patients with an organ dysfunction. Sometimes, patients with diffuse symptoms, and often with multiple diseases, do not match one specific medical speciality and thus may be cared for by different clinical departments. At the university hospital in Case study I, it is mainly internal medicine patients who can be admitted to more than one clinical department. The reluctance shown by many clinical departments with an internal medicine speciality to admit acute internal medicine patients with vague symptoms also demonstrates the behaviour of "protecting" the autonomy of doctors' work, as emphasised by Giaimo (2002). Since the responsibility to care for these patients is not specified, and the trust in actors at the ED to manage the acute patient flows is low among middle management, collaboration is hindered. With a lack of collaboration and joint responsibility, it becomes easier for middle management to focus on the facilitation and support of their own departmental practices, as concluded in Paper III, resulting in unique strategies within the clinical departments (Levels 2 and 3).

As described in Case study I, several official positions have been established to handle acute patient flows operationally at a hospital level. With the extensive authority of clinical departments, and vague mandates for these positions, much time is spent discussing and considering appropriate responses to current events, such as which clinical department a patient in the ED should be admitted to. With bed shortages being an almost everyday

⁹ This section is partly based on a section in the licentiate thesis discussing the influence of the organization upon the actions used to handle variation in patient flows (see section 4.3 in Appendix 1)

occurrence for the internal medicine departments, patients often need to be investigated in depth by the ED to enable an organ to be pinpointed so that the clinical department responsible will admit the patient. Similar observations are supported by Proudlove and Boaden (2005). They argue that bed shortages and high bed occupancy often lead to a concentration on juggling the placement of admissions: bed-finding and firefighting. Many of the decisions related to finding short-term solutions involve resolving conflicts, for example the competition for beds between emergency and elective admissions, and the appropriateness of placement versus where beds are available. The results from Case study I show similar patterns. With so many different actors operationally involved in handling acute patient flows, this could in part explain the lack of action taken at the hospital level (Level 4).

5.4.3 LACK OF HOSPITAL PLANS FOR HANDLING VARIATION IN ACUTE PATIENT FLOWS¹⁰

Due to their professional background, “hybrid managers” can add value by merging knowledge of the strategic intent of top management with knowledge of practice on the ground (Burgess and Currie, 2013). Hybrid managers do not only implement strategies from top management (Floyd and Wooldridge, 1992), they are also involved in the development of strategy (Dopson and Fitzgerald, 2006) and broker knowledge to top management within the organisation (Currie and Procter, 2005; Shi et al., 2009). In healthcare, hybrid managers’ strategic knowledge is also positively related to advocating changes and synthesising new information (Pappas et al., 2004).

Despite these characteristics, identified in previous research, Paper III concluded that the facilitator role best describes middle management’s (department chiefs’) involvement in managing the variation in acute patient flows. The following paragraphs argue that this is partly due to the vagueness of, and low adherence to, the hospital’s plans for handling variation in acute patient flows. Therefore, the development of actions within clinical departments (Levels 2 and 3) is stimulated, whereas the development of actions at the hospital level (Level 4) is impeded.

At the university hospital in Case study I, the main document describing the management of variation in acute patient flows is the *Plan of action during bed shortages* (Author’s translation). This lays out a plan of action to secure the availability of beds for the acute patient flows and includes actions to counteract very high utilisation of the hospital’s beds and other resources. The aim is also to simplify the admission of acute patients by providing rapid access to an appropriate bed. It is stated in the *Plan of action during bed shortages* how many beds a clinical department or group of departments, i.e. an on-call group, should have available at 3 pm. If there are fewer beds available within any of the on-call groups, the situation is denoted a potential bed shortage. For the internal medicine on-call group, a

¹⁰ This section is partly based on a section in the licentiate thesis discussing the influence of the organization upon the actions used to handle variation in patient flows (see section 4.3 in Appendix 1)

potential bed shortage is almost an everyday occurrence, and specific actions are not automatically initiated when it occurs. In Paper II, the agile category with the most actions was also the most reactive category. Given that the hospital plan has a proactive orientation, the use of many reactive actions indicates low adherence to the hospital plan and a lack of proactive actions at the hospital level.

The planning concerning how many beds should be open during summer at the university hospital further exemplifies the lack of hospital plans for managing acute patient flows. For details, see section 2.6 in Case study I. In brief, all clinical departments are asked for the number of beds they will have open in 4–5 months' time. After discussing this and compiling the information, the hospital management group concludes that there are not enough beds open. Due to the requirement for unanimous decision-making, however, no decision is made concerning how many beds should be open in total across the hospital, or within each division. Therefore, the department chiefs do not address the issue further.

In the *Plan of action during bed shortages*, responsibilities and authorities for different actors are described, but only in general terms. The responsibility for acute patients who have vague symptoms, and therefore could potentially be admitted to several different departments, is only denoted a "shared responsibility". With each clinical department having separate budgets and performance measurement systems, the focus is therefore directed towards performing as an internal unit, rather than as a collective "organisation" (Plsek and Greenhalgh, 2001). For the elective and acute patients who correspond to the medical speciality of a clinical department, there are performance measurements and results are followed up. The department chiefs therefore prioritise goals and strategies for these patient groups. This is likely to contribute to the unwillingness of many clinical departments within the internal medicine on-call group to admit acute internal medicine patients with vague symptoms and to department chiefs protecting high levels of medical autonomy and thus resisting attempts to increase the managerial control of clinical practice (Kitchener, 2000; Waring and Currie, 2009).

As discussed in Paper III, internally at each department, a managerial group helps the department chief with decision-making. The composition of this managerial group differs between clinical departments. Ideas for improvement are decided by the managerial group and tested on the clinical department's operations. The development of the clinical department's operations is therefore not directed by any organisation-wide plan, which makes it difficult to assess whether the initiated improvement projects are aligned in a single direction. Many of the actions identified at the university hospital are only being used by one or a few clinical departments. Thus, the development of effective actions that spread across the organisation seems insufficient.

Overall, the vagueness of, and low adherence to, the hospital's plans for handling variation in acute patient flows indicates that department chiefs, in general, have not made an identity transition, in which a professional perspective is complemented by a managerial

perspective, as described by Witman et al. (2011). The lack of hospital plans also seems to promote the development of actions by clinical departments (Levels 2 and 3) and impede the development and use of actions at the hospital level (Level 4).

5.4.4 IN SUMMARY

To summarise, the influence of the organisation and middle management on the actions taken to handle variation in acute patient flows is depicted in Figure 5.6. This figure includes the findings related to the actions used in handling variation in acute patient flows (black font), the impact of variation in acute patient flows (blue font), and the influence of the organisation and middle management upon the actions taken (green font).

FIGURE 5.6 – THE FINDINGS FROM RQ1–3 COMBINED

5.5 RESEARCH QUESTION 4

To answer the fourth research question, the results from Paper IV and Reports I and II are analysed. Paper IV analyses waiting times for surgery, radiology scans and pathology analyses before and after the implementation of CCPs. Report I describes the changes that have been introduced while implementing CCPs in urology surgery and computer tomography scans, and relates these to the changes in waiting times. Report II uses parts of Paper IV and Report I to discuss crowding out effects and to analyse possible explanations for the identified changes in waiting times. Hence, all of these results are used in answering RQ4 and the underlying questions, addressing:

RQ4: *How does the implementation of care pathways influence the handling of variation in elective patient flows?*

How does the implementation of care pathways influence waiting times...

- a) *...for care pathway patients?*
- b) *...for other patient groups?*
- c) *...as a whole?*

Overall, RQ4 contributes to the understanding of how the management of variation in a single-patient process (Level 2) influences the ability to manage variation in a healthcare unit (Level 3) (see Figure 5.7). By combining the results from Paper IV and Reports I and II, the analysis in relation to RQ4 provides a more holistic perspective on the influence of care pathway implementation upon the management of variation in elective patient flows.

FIGURE 5.7 – THE RELATIONSHIP BETWEEN RQ4 AND THE FOUR LEVELS OF ABSTRACTION

The structure of the analysis regarding RQ4 is based on the three underlying questions to RQ4. The first section analyses the changes in waiting times for patients included in CCPs. The second section discusses the influence of CCP implementation upon waiting times for patients not included in CCPs, and the third section combines these two groups. The changes in workflow that have potentially influenced waiting times will also be discussed, in order to try to explain how the implementation of care pathways has impacted upon waiting times, and thus the ability to handle variation in elective patient flows (RQ4).

5.5.1 SHORTER WAITING TIMES AFTER CCP IMPLEMENTATION

CCPs were introduced in Sweden in 2015, following a model from Denmark called Pakkeforløb. In Denmark, waiting times have been reduced for most cancer areas following the implementation of CCPs (Probst and Andersen, 2012; Larsen et al., 2013). The case study at Kalmar County Hospital, described in Report I, provides insights into the changes in waiting times after CCP implementation. It also describes the changes in workflow that could be responsible for these patterns.

In urology, the median waiting time decreased from 56 to 39 days for surgery for prostate cancer, and the median waiting time for surgery (TUR-B) for bladder cancer was shortened from 38.5 to 20 days after CCP implementation. In conjunction with the CCP implementation, a number of weekly time slots for urology surgery were reserved for prostate and bladder cancer surgery, to ensure short waiting times, and it is likely that this had a major influence on shortening the waiting times. Patients not documented as being treated in a urology CCP also experienced shorter waiting times for prostate and bladder cancer surgery. The proportion of CCP patients has continuously increased since CCP implementation, indicating an improvement in the documentation routines.

For CT scans, the median waiting time for CCP scans was 3.3 days. This is well below the median waiting times for the other elective priority categories analysed, indicating that these patients have experienced shorter waiting times than they would have faced before CCP implementation. When booking radiology scans, CCP was introduced as a new priority category. For each of the CCPs, a target waiting time for each of the radiology scans being included in the pathway was determined at the hospital. To ensure compliance with the target waiting time, the medical secretary booking the CT scan telephones the patient and they jointly schedule a time. To enable this workflow, reserved time slots are held open for CCP scans.

In Paper IV, reductions in waiting times for CCP analyses/scans/surgery are not assessed. The reason is that it is difficult to establish which pathology analyses, radiology scans or surgical procedures would have been performed under a CCP during the time period before CCP implementation. However, there are reasons to argue that patients receiving surgery, radiology scans and pathology analyses performed in CCPs have experienced shorter

waiting times than they would have before the introduction of CCPs. In radiology, CCP was the priority category with the shortest waiting times after acute patients (Prio1) and inpatients (Prio2), for both CT and MRI. Based on the changes in proportions between the different priority categories for CT scans, it is likely that the CCP category was previously assigned mainly to the Prio4 category. This indicates that patients awaiting these radiology scans have experienced shorter waiting times than they would have before the introduction of CCPs. In pathology, the CCP priority category has the shortest waiting times in histopathology, and the second shortest in cytopathology. With a decreased inflow for both Prio1 and Prio2 categories in histopathology and cytopathology during the after period, it is difficult to assess how the CCP scans would have been prioritised during the before period. For surgery, the changes in proportions between the different priority categories in the before and after periods indicate that a majority of CCP surgical procedures would have been categorised as Prio2 during the before period. Since this priority category has longer waiting times than the CCP group in the after period, it is likely that CCP implementation has decreased waiting times for patients receiving surgery in a CCP. Based on the short waiting times for the CCP category, and changes in the proportions between the different priority categories, Paper IV thus also indicates reductions in waiting times for CCP patients.

Overall, Paper IV suggests that patients assigned to the CCP category experience shorter waiting times after CCP implementation. Report I supports this argument by demonstrating shorter waiting times for prostate and bladder cancer surgery after CCP implementation and describing changes in booking routines that are likely to contribute to shortening the waiting times for urology surgery and CT scans for CCP patients.

5.5.2 LONGER WAITING TIMES FOR OTHER PRIORITISED PATIENTS SINCE CCP IMPLEMENTATION

Introducing CCPs has previously been shown to reduce waiting times for treatment (Probst and Andersen, 2012; Larsen et al., 2013), while prioritising certain patient groups for cancer diagnostics has been shown to increase waiting times for other cancer patients (Hamilton, 2009; Potter et al., 2007). However, the presence and extent of crowding out effects when introducing CCPs have not previously been researched. In analysing associations between changes in waiting times for other patient groups and CCP implementation, Paper IV distinguishes two patterns in the seven studied subspecialties. The first pattern is that none of the lowest priority categories analysed within each subspecialty have experienced increased waiting times when comparing the before and after period. The second pattern is increased waiting times in the after period for the priority category that is immediately below the CCP category. This could be a crowding out effect due to the introduction of CCPs. This pattern is present for three out of the seven subspecialties: histopathology, CT scans and LGI surgery. For the subspecialties that do not fit into this pattern, there are plausible explanations:

- Cytopathology, with shorter waiting times for the overtaken priority category, also displays the largest reduction in inflow, 20%, in the after period.
- MRI has only a 2% proportion of CCP scans. Hence, measurable crowding out effects are unlikely.
- Waiting times for breast surgery for CCP patients might not have been much shortened. When considering the proportions of each priority category, it is likely that the patients who received a surgical procedure within CCP during the after period would have been prioritised to the second priority category during the before period. Waiting times for these procedures have not been much reduced, and the possible crowding out effect is also small.
- For urology surgery, there were two CCPs introduced simultaneously, and thus two different surgical procedures with different target waiting times (see previous section). It is therefore less clear how changes in waiting times are associated with CCP implementation.

Both of these patterns are consistent with a change in prioritisation whereby CCP patients experience shorter waiting times after CCP implementation. The priority category that is overtaken thus becomes downgraded, with longer waiting times as a result, while the least prioritised patients are not affected, since the changes in prioritisation take place among patients who are already prioritised before them. When looking at how the changes in waiting times in pathology and radiology developed between the before, middle and after periods (see the methods section of Paper IV for descriptions of these time periods), it appears that these are also consistent with the two patterns presented above (see discussion section regarding the third research question in Paper IV). For example, waiting times during the middle period for the priority category overtaken by the CCP category in histopathology and CT scans were in between those during the before and after periods, suggesting that waiting times increased gradually with the number of CCP analyses/scans.

Reports I and II analyse changes in waiting times for urology surgery. Report II further discusses the fact that two CCPs were introduced simultaneously for urology cancers, which makes it difficult to assess the changes in waiting times by means of the quantitative before/after study used in Paper IV. For the bladder cancer procedure (TUR-B), the median waiting time for surgery included in the CCP decreased to 14 days after CCP implementation, which is a shorter waiting time than for the previously most prioritised category (prio FF in Reports I and II and prio1 in Paper IV), which had a median waiting time of 19 days after CCP implementation. It is therefore possible that the prio FF category is being overtaken by CCP patients in accordance with the patterns identified in Paper IV. The median waiting time for prio FF patients also increased after CCP implementation, from 14 to 19 days. The changes in waiting times can be seen in Figure 15 in Report I, which also displays other signals indicating increased waiting times after CCP implementation using the run chart method (see Perla et al., 2011).

Report I also analyses the changes in workflow introduced in conjunction with CCP implementation. These are also included in Figure 15 in Report I, which shows that the increase in waiting times coincides with the reservation of a number of weekly time slots for prostate and bladder cancer surgery, the change that was also argued as having a major influence on shortening the waiting times for these procedures. The increased waiting times for prio FF patients also coincide with increased numbers of patients waiting for surgery within this priority category (see Figure 16 in Report I), a pattern that does not seem to be influenced by a clear change in the number of registered patients, or number of surgical procedures.

Reports I and II also analyse changes in waiting times for CT scans. Patients in the priority category Förtur (Prio3 in Paper IV) have the highest priority, and shortest waiting times, of the elective patients (Prio1 are acute patients and Prio2 are inpatients). In Report I, the median waiting time for these patients has increased from 10 to 11 days after CCP implementation. The run chart methodology also displays signals (see Figure 29 in Report I) indicating increased waiting times after CCP implementation.

Report II also includes a chart showing the waiting times for the priority category Förtur (see Figure 1 in Report II). It uses the same division of data into before, middle and after periods as in Paper IV. Since CT scans are included in almost all CCPs, and most of these were implemented stepwise from September 2015 to September 2016, the increases in waiting times between the before, middle and after periods shown in the figure are consistent being with an effect of the CCP implementation.

As described in Report I, CT scans for patients in priority category Förtur and CCP are booked by means of a telephone call between the patient and the medical secretary booking the scans. Since CCP patients have shorter waiting times, it is possible that the choices for patients with priority category Förtur have been reduced since CCP implementation, thus influencing waiting times negatively.

To summarise, the results from Paper IV and Reports I and II demonstrate that CCP patients are experiencing shorter waiting times since CCP implementation, while the priority category that has been overtaken is experiencing longer waiting times, with minor changes in waiting times for the least prioritised patients. These patterns are consistent across pathology, radiology and surgery, and Report I describes plausible changes in workflow that could be responsible for these changes.

Report II also includes a schematic example (see Figure 5.8) explaining why it is plausible that it is the priority category that lies immediately below the CCP category that experiences the largest increase in waiting times. In this example, a new priority category is being included into an existing planning process, without other changes being made.

FIGURE 5.8 – SCHEMATIC FIGURE DEMONSTRATING CROWDING OUT EFFECTS FOLLOWING CCP IMPLEMENTATION (FIGURE 3 IN REPORT II)

The example shows that the mean waiting time changes the most for the overtaken priority category, in the example Prio1. For the other priority categories, Prio2 and Prio3, the extension in the mean waiting time is marginal or zero.

5.5.3 AS A WHOLE, WAITING TIMES ARE NOT CHANGED DUE TO CCP IMPLEMENTATION

In addition to the analyses regarding changes in waiting times for CCP analyses/scans/surgery, as well as other priority categories after CCP implementation, it is of interest to examine how waiting times have changed as a whole. Report I includes the median waiting time for urology surgery, which was 51 days before CCP implementation, and 53 days after, a small difference that could be the result of chance. The signals from the run chart methodology do not indicate any non-coincidental changes in waiting times (see Figure 17 in Report I). Since the changes in waiting times previously addressed are mainly associated with reserving weekly time slots for CCP surgery, it is not surprising that median waiting times for all urology surgical procedures did not change significantly.

For CT scans, Figure 23 in Report I displays waiting times for all the analysed priority categories except for the CCP category. The median waiting time has decreased from 8 to 6 days. From June 2016, the waiting times are significantly shortened, coinciding with the practice of booking patients more densely during the summer months and sending more patients to a nearby hospital for CT scans during the autumn of 2016. These changes are likely to have had a positive influence on the waiting times.

Overall, CCP implementation for urology surgery and CT scans does not seem to have influenced the waiting times as a whole for these subspecialties. However, one of the known effects of prioritisation systems is that it splits demand into subgroups. These subgroups experience higher net variation in arrival rates, increasing the average waiting time in the system (Allder et al., 2011). However, the addition of the CCP priority category in all the specialities studied in Study 3 only increased the number of priority categories by one, while the proportion of CCP patients in comparison to the total number of patients was often rather low. Hence, care pathway implementation is not likely to have had a large

impact on waiting times as a whole when care pathway patients only are being prioritised higher than before.

5.5.4 IN SUMMARY

Overall, the results of the analysis indicate that the implementation of care pathways influences the handling of variation in elective patient flows, mainly based on changes in prioritisation between different priority categories. Prioritising short waiting times within the care pathways, and thus using an action to handle variation within a single patient process (Level 2), limits the possible actions for handling variation in other patient processes (Level 2) as well as the healthcare unit (Level 3). To summarise the findings for this research question, Figure 5.9 displays the results in relation to the four levels of abstraction.

FIGURE 5.9 – THE FINDINGS RELATED TO MANAGING VARIATION IN OTHER ELECTIVE PATIENT FLOWS WHEN IMPLEMENTING CARE PATHWAYS

6 DISCUSSION AND CONCLUSIONS

The conclusions have been divided between theoretical contributions and practical implications. The chapter also summarises the conclusions and discusses the fulfilment of the purpose of this thesis. Lastly, it addresses suggestions for future research.

6.1 THEORETICAL CONTRIBUTIONS

Variation is an important construct in logistics and supply chain management (Chen and Paulraj, 2004). Understanding the impact of different sources of variation is also a cornerstone of effective SCM (Davis, 1993). In healthcare there are many different sources of variation. However, healthcare resources are often used inappropriately and not adapted to the variations that exist (Walley et al., 2006). Hence, there is a need to adapt processes better, based on the available knowledge about variation (McLaughlin, 1996). This section describes the theoretical contributions provided by this thesis, related to the impact and management of variation, within five areas of research. These contributions are described below.

6.1.1 ADOPTING THE CONCEPTS OF LEAN AND AGILE IN HOSPITALS

Previous research in healthcare logistics and SCM have addressed how combinations of the concepts of lean and agile can be used in healthcare supply chains (Aronsson et al., 2011; Mishra et al., 2019; Rahimnia and Moghadasian, 2010; Towill and Christopher, 2005), since these concepts offer two different approaches to handling variation. In short, lean focuses on streamlining processes and reducing the resources and time needed to produce a given set of goods or services (Womack et al., 1990). However, in a healthcare context with much variation in arrival rates, this focus makes it difficult to handle variation in patient flows without excessive waiting times. The agile approach to handling variation in patient flows is to focus on having flexible capacity, requiring that additional resources are available and/or having employees who are able to do different types of tasks.

The research reported in this thesis provides more detailed knowledge about the use of lean and agile in hospitals by categorising the actions used to handle variation in acute patient flows using these concepts. It shows that agile actions are more often used to handle variation when managing several patient processes in parallel, such as in healthcare units (Level 3), or between units that act in the same part of the patient flow (Level 4.1). Many of these actions concern adapting staffing levels and bed numbers, as well as distributing patients and personnel according to variations in patient flow. Being agile thus seems to be of more use when managing several patient processes in parallel. Lean actions, on the other hand, are more widely used when handling variation in patient processes within (Level 2) and between (Level 4.2) healthcare units. These actions mainly focus on improving efficiency in patient flows, both within and between healthcare units. Being lean thus seems to be of more use when managing single patient processes, within and between healthcare units.

These findings are in line with the respective foci of lean and agile presented above. However, it suggests that, in practice, lean and agile actions can be used in other combinations, and at a more detailed level of analysis than has been proposed in previous research addressing lean and agile in healthcare supply chains (Aronsson et al., 2011; Rahimnia and Moghadasian, 2010; Towill and Christopher, 2005). The findings can hence

be used by healthcare managers as a support for decisions when developing and improving actions and strategies to manage variation in patient flows at different levels within the organisation. Thus, the findings extend and refine previous theories (Voss et al., 2002), as well as contributing to theory by addressing these concepts at a new level of analysis (Makadok et al., 2018).

The research reported in this thesis also contributes to the literature on leagile approaches and pipelines in healthcare. Towill and Christopher (2005) discuss the use of standardised and customised care for groups of patients by elaborating upon the use of healthcare pipelines. A pipeline refers to the flow of patients from referral to full recovery and can be compared to the second level of abstraction, managing variation in a patient process. Towill and Christopher (2005) distinguish between lean and agile parts of the pipeline based on the complexity of treatment. The different leagile approaches discussed in Paper II are in line with the healthcare delivery pipelines described by Towill and Christopher (2005), extending this concept by exemplifying the use of healthcare pipelines in practice. By identifying the different leagile approaches used in a university hospital, the research also extends the use of this theory to the university hospital context, something identified by Rahimnia and Moghadasian (2010) as lacking in the literature. The research also explores the use of actions between healthcare pipelines by showing that agile actions are most frequently used in order to handle variation when managing several patient processes in parallel, such as in healthcare units (Level 3), or between units that act in the same part of the patient flow (Level 4.1). By analysing these concepts at a new level of analysis (Makadok et al., 2018), the hospital level, the necessity of including how to combine healthcare pipelines is emphasised. This is a perspective that has not been explored in the other papers addressing how to combine lean and agile in healthcare supply chains (Aronsson et al., 2011; Mishra et al., 2019; Rahimnia and Moghadasian, 2010). One important aspect of how to combine healthcare pipelines is the allocation of resources, e.g. personnel, beds and medical equipment, between different pipelines. Taking an agile approach seems to be most appropriate according to the findings of this thesis.

6.1.2 INCLUDING MORE THAN ONE LEVEL OF ABSTRACTION WHEN MANAGING VARIATION

The coordination of multiple actors has previously been identified as a major challenge in healthcare logistics and SCM (Aronsson et al., 2011; de Vries and Huijsman, 2011; Meijboom et al., 2011; Parnaby and Towill, 2008). Villa et al. (2014) have also concluded that acknowledging the lack of coordination between patient flows and clinical departments is critical for understanding problems with the handling of variation in patient flows. This thesis shows that variation in patient flows is managed at different levels of abstraction (see

Figure 2.5), and demonstrates the importance of including more than one of these levels when analysing the management of variation.

The thesis describes examples where only one of these levels of abstraction has received attention, and the negative effects this entails. One of these examples is the crowding out effect observed in Study 3, which is likely to follow the implementation of care pathways, in particular for the patient groups who are overtaken by the care pathway patients. This effect is not identified when analysing care pathway implementation at the second level of abstraction. The third level of abstraction, which includes how waiting times have changed at the healthcare unit, for different patient groups and as a whole, also needs to be included in the analysis. Another example is the extensive use of actions within clinical departments observed in Study 2, which are used to favour the clinical department (Level 3) and not the hospital as a whole (Level 4) when handling variation in patient flows. To be able to identify these insufficiencies, both these levels need to be included when analysing the management of variation.

By using the framework that includes different levels of abstraction introduced in Chapter 2, and including more than one of these levels, the lack of coordination between patient flows and healthcare units, and the impact it has on the choices for managing variation, is highlighted. This approach hence contributes to theory building (Voss et al., 2002) by identifying that it is important to address the linkages between the different levels of management of variation when managing and analysing variation in patient flows.

6.1.3 THE NEED FOR TOP MANAGEMENT TO SUPPORT HYBRID MANAGERS IN MANAGING VARIATION IN PATIENT FLOWS

Previous research has argued that the challenges of integration and collaboration concerning the management of patient flows are typically hindered by multiple professions seeking to assert control over their own professional practice (Ramanujam and Rousseau, 2006). A remedy for these challenges of integration and collaboration that has been suggested is hybrid managers (e.g. Kitchener 2000; Shi et al., 2009), who are very common in healthcare, in particular at middle management levels. Hybrid managers have been shown to be effective at brokering knowledge across organisational boundaries (Waring et al., 2013), as well as merging top management's strategic intent with knowledge about practice on the ground (Burgess and Currie, 2013). Their strategic knowledge has also been shown to be positively related to advocating change and synthesising new information (Pappas et al., 2004). In order to utilise these capabilities when managing variation in patient flows, the research reported in this thesis highlights the need for support from top management. It thus refines the theory of hybrid managers (Voss et al., 2002) by proposing a prerequisite for when these capabilities can be utilised in managing variation in patient flows. Below are some results from this thesis that support this contribution.

Paper III concludes that the facilitator role (Floyd and Wooldridge, 1992; Wooldridge et al., 2008) best describes middle management's involvement in managing variation in acute patient flows, with middle managers tending to focus on the facilitation and support of their own departmental practices. It further concludes that the other three roles in the

framework developed by Floyd and Wooldridge (1992) are enacted to only a minor extent. In order to extend the roles of middle management, Paper III highlights the need for top management to provide guidance to middle management, by developing goals and overarching strategies for managing variation in patient flows.

Another result from Study 2 is the development of the three factors emerging from RQ3 (depicted in Figure 5.5), which influence the use of actions to handle variation in acute patient flows. These are:

- Unanimous decision-making at hospital management levels,
- extensive authority invested in clinical departments, and
- a lack of hospital plans for handling variation in acute patient flows.

As discussed in section 5.4, all of these factors can be related to the limited support from top management for managing variation in acute patient flows. It is further argued that these factors hinder the development and use of actions at the hospital level (Level 4), while facilitating the development and use of actions at the healthcare unit (Level 3) and patient process (Level 2) levels.

6.1.4 DESCRIBING THE EFFECTS ON WAITING TIMES AFTER CARE PATHWAY IMPLEMENTATION, IN RELATION TO OTHER WAITING TIME INITIATIVES

In a system like healthcare, where different components are highly dependent on each other, it is a well-known problem that focusing on improving just one part of the system can lead to negative consequences and sub-optimisation of the entire system (Grol et al., 2013). Care pathways focus on the treatment of a well-defined group of patients during a well-defined period of time (de Bleser et al., 2006). Since there is a risk of sub-optimisation due to the focus on care pathways, the research reported in this thesis has studied changes in waiting times following the implementation of cancer care pathways. The research shows that waiting times have been shortened for cancer patients, but also increased for other patient groups. The patients who have experienced increased waiting times belong to the priority category that is overtaken by the new care pathway category. This is because a new priority category for care pathway patients has been added. This new category of patients has experienced significantly shortened waiting times. However, no other changes have been made to the planning process to mitigate the negative effects for other patient groups. Since the care pathway patients were previously prioritised within other priority categories, the main effect on waiting times is that of a redistribution (see Figure 5.8 for details), which is a zero-sum game. As a result, crowding out effects are least likely for patients in the lowest priority category, while the implementation of care pathways are not likely to have a large influence on the waiting times as a whole for the healthcare unit.

The identified changes in waiting times following care pathway implementation are similar to the effects of introducing a two-week wait for cancer diagnostics in the UK, where

Hamilton (2009) identified that waiting times for patients with low-risk or vague symptoms of cancer were negatively influenced in favour of high-risk patients. For breast cancer, there is also evidence of longer waiting times for routine referrals when introducing the two-week wait for urgent referrals in the UK (Potter et al., 2007; Cant and Yu, 2000). This was probably due to crowding out effects from the two-week-wait patients. Hence, similar effects on waiting times as those revealed in this thesis have been identified in previous research, when studying other waiting time initiatives.

With waiting times as a whole not being changed for healthcare units after care pathway implementation, these effects are also in line with results regarding changes in waiting times after introducing maximum waiting time guarantees (e.g. Askildsen et al., 2011; Nikolova et al., 2015; Siciliani and Hurst, 2005). When maximum waiting time guarantees were introduced in Norway, for example, Askildsen et al. (2011) found that reductions in waiting times favoured patients who had experienced longer waits, while Gangstoe et al. (2016) suggested that the introduction of maximum waiting times may have contributed to pushing the actual waiting times towards these maximum limits. In Scotland, maximum waiting time guarantees resulted in a change in prioritisation between different patient groups, with patients who had been waiting longer profiting at the expense of those who previously waited for a shorter time (Nikolova et al., 2015). Siciliani and Hurst (2005) also argue that maximum waiting time guarantees can be effective in reducing long waiting times since the provider simply gives higher priority to less urgent patients as they approach the maximum waiting time, while not being effective in reducing mean or median waiting times. Therefore, the main effects seem to be a redistribution of waiting times between different patient groups, similarly to the conclusions for care pathway implementation.

Overall, the research reported in this thesis concerning the changes in waiting times following care pathway implementation extends previous theories on the effects of waiting time initiatives by adding knowledge of a new type, care pathway implementation, to the previously studied policy programmes. It also builds further on the existing theories by proposing a causal mechanism (Makadok et al., 2018) behind the observed effects, and describing this in a schematic way by explaining why it is plausible that it is the priority category that has been overtaken by the care pathway category that experiences the largest increase in waiting times (see Figure 5.8). This schematic also shows that the implementation of care pathways in terms of effects on waiting times in general corresponds to a redistribution of waiting times, extending previous knowledge about other waiting time initiatives (e.g. Hamilton. 2009; Potter et al., 2007; Nikolova et al., 2015; Siciliani and Hurst, 2005).

6.1.5 THE NEED TO RECOGNISE CROWDING OUT EFFECTS AND TO ADDRESS THEM IN THE MODEL PATHWAY

When implementing care pathways, lead-times within the patient process often become the focus, and are shortened, in order to attain swift diagnosis and treatment for patients. There

is, however, a lack of research analysing whether the implementation of care pathways causes crowding out effects in similar ways as those that have been identified within other national policy implementations. With 60–80% of patient groups in general hospitals being appropriate for inclusion in pathways (Vanhaecht et al., 2006), it becomes important to recognise and study crowding out effects. Following the implementation of CCPs in Sweden, longer waiting times for patients with non-cancer diseases have also been the most frequently mentioned risk in regional status reports (Smeds and Poksinska, 2018). Other authors have also speculated about crowding out effects when implementing CCPs (Probst and Andersen, 2012; Schmidt et al., 2018).

The research reported in this thesis extends the understanding of care pathway implementation by identifying its potential negative effects. It confirms the expectations put forward in previous research (Probst and Andersen, 2012; Schmidt et al., 2018) and supports the anticipation of longer waiting times for non-cancer patients when implementing CCPs (Smeds and Poksinska, 2018). Since organisations are multifaceted, complex systems, changes that affect one part are likely to affect at least some of the other parts as well. Identifying how these changes affect other parts of the system is hence an important theoretical contribution (Makadok et al., 2018).

Vanhaecht et al. (2010) describe different types of care pathways related to different levels of the healthcare system. At the most aggregated level is the model pathway; often an organisationally independent policy document or guideline based on international or national evidence-based medicine. At the next level, the operational pathway, an adapted version of the model pathway is developed locally within a hospital and/or clinical department. Care pathway implementation has also been argued to be a complex intervention (Campbell et al., 2007), within which it is important to identify bottlenecks and improve the process by using systematic, continuous improvements during implementation (Vanhaecht et al., 2007b). The research reported in this thesis supports this prior research claiming that care pathway implementation is a complex intervention (Campbell et al., 2007; Vanhaecht et al., 2007b). It also builds further on the theory of the model pathway by proposing that crowding out effects in terms of longer waiting times for other patient groups should be included as a possible output (Makadok et al., 2018) of care pathway implementation. If this possibility is not addressed in the model pathway, as is the case for the model pathway descriptions for CCPs in Sweden, there is a risk that the issue will not be recognised when developing the operational pathway. This seems to be the case in the research reported in this thesis.

6.2 PRACTICAL IMPLICATIONS

This practical implications section discusses two main areas. The first is the need for top management to establish a hospital-wide strategy to support the development of suitable actions for handling variation in acute patient flows. These conclusions are mainly derived

from Studies 1 and 2. The second practical implication concerns crowding out effects following care pathway implementation, and the need to address these in practice.

6.2.1 TOP MANAGEMENT NEEDS TO ESTABLISH A HOSPITAL-WIDE STRATEGY TO SUPPORT THE DEVELOPMENT OF SUITABLE ACTIONS FOR HANDLING VARIATION IN ACUTE PATIENT FLOWS

Villa et al. (2014) concluded that recognising the lack of coordination between patient flows and clinical departments is critical for understanding problems with the handling of variation in patient flows. Furthermore, Ramanujam and Rousseau (2006) argue that the challenges of integration and collaboration concerning the management of patient flows are typically compounded by multiple professions each seeking to assert control over their own professional practice. These difficulties indicate that top management at a hospital needs to be involved in the coordination of actions for handling variation in patient flows.

The research reported in this thesis emphasises the importance of a hospital-wide strategy for handling variation in acute patient flows. Below, the practical implication is summarised and the following text elaborates upon it.

1) There is a need for top management to establish a hospital-wide strategy concerning how variation in acute patient flows is handled in order to:

- a) Minimise actions that favour some clinical departments at the expense of others.*
- b) Minimise actions that favour some patient flows at the expense of others.*
- c) Facilitate the sharing and spreading of actions between clinical departments.*
- d) Increase the number of actions that are proactively used to improve performance within the hospital as a whole.*

At the university hospital examined in Study 2, a hospital-wide strategy for handling variation in acute patient flows is lacking. For example, acute patients who have vague symptoms and could potentially be admitted to several different clinical departments are only denoted as a “shared responsibility”, with performance measurements and follow-ups of results lacking for this patient group. Top management decisions regarding how many beds should be open during the holidays are also lacking; instead, every clinical department is essentially allowed to decide on its own. Hospital beds are also an important resource to manage since bed occupancy was shown to be sensitive to changes in patient inflow, treatment times and duration of activities, and much time and effort is being spent on handling bed shortages.

With department chiefs also predominantly acting as facilitators, individual goals and strategies for the clinical departments are prioritised over collective responsibility for hospital performance. Since ideas for improvement are decided by the department chief and tested on the clinical department’s operations, unique actions are developed at the departmental level. The actions used for handling variation in acute patient flows have thus been implemented over time to solve local problems. Due to the lack of financial incentives devoted to acute patients from the ED, there are also negative incentives to develop more

efficient patient flows and outflow for these acute patients because such behaviour would only result in more acute patients, more work and higher costs. Since there is no explicit number of beds that needs to be allocated for acute patients in the clinical departments, this encourages clinical departments to give priority to elective patients over acute patients. These issues thus hinder collaboration and coordination between different clinical departments and patient flows.

There are more actions used to handle variation in acute patient flows within the various clinical departments than at the hospital level. Actions at a hospital level are decided by top management and/or have the aim of promoting positive effects for the hospital as a whole, while actions at a departmental level are taken with the aim of generating some improvement for the clinical department that uses the action. Hence, there is a need for more actions at a hospital level. The risk of developing actions that generate sub-optimisation is also likely to be lower at a hospital level. Many of the identified actions are also reactive, instead of proactive, in relation to the handling of variation in acute patient flows. For example, only four out of the 50 identified actions handle external variation directly, and the most reactive of the agile categories were the ones that were most used within the hospital. These results further highlight the need for top management to establish a hospital-wide strategy and support the development of actions to handle variation in acute patient flows.

6.2.2 IF NOT ADDRESSED PROPERLY, CARE PATHWAY IMPLEMENTATION LEADS TO CROWDING OUT EFFECTS

In a system like healthcare, where the different components are highly dependent on each other, it is a well-known problem that focusing on improving just one component of the system may lead to negative consequences and sub-optimisation of the entire system (Grol et al., 2013). Unintended effects on waiting times have previously been shown for national policy programmes such as the two-week wait in the UK (Hamilton, 2009; Potter et al., 2007; Cant and Yu, 2000), and maximum waiting time guarantees in various countries (e.g. Askildsen et al., 2011; Nikolova et al., 2015; Siciliani and Hurst, 2005). Similar negative effects on waiting times after the introduction of care pathways have not been previously studied in research. There have, however, been concerns about crowding out effects when implementing CCPs in Sweden (*Dagens Medicin*, 2017; Schmidt et al., 2018). Longer waiting times for patients with non-cancer diseases, for example, have been the most frequently mentioned risk in regional status reports (Smeds and Poksinska, 2018).

The research reported in this thesis adds to the understanding of care pathway implementation by identifying the potential negative effects of pathway implementation, and proposes an explanation for the identified effects. Below, the practical implication of this research is summarised, and thereafter the implications are elaborated:

2) If not addressed properly, care pathway implementation leads to crowding out effects

- a) Crowding out effects are most likely for patients in the priority category that has been overtaken by the care pathway patients, and least likely for patients in the lowest priority category.*
- b) Care pathway implementation is not likely to have a large impact on waiting times as a whole within a healthcare unit when care pathway patients only are being prioritised higher than before.*
- c) There is a lack of knowledge about how to counteract crowding out effects when implementing care pathways.*
- d) To counteract crowding out effects, the division of available resources should be reassessed and/or the number of priority categories should be decreased.*

The research performed in Study 3 shows that it is the patients in the priority category being overtaken by the care pathway category who are most likely to experience increased waiting times. This is due to the studied specialities having added a new priority category for care pathway patients, without other changes being made to the planning process. As a result, crowding out effects are least likely for patients in the lowest priority category, while the care pathway does not have a large impact on waiting times as a whole for the healthcare unit. Consequently, by prioritising short waiting times within the care pathways, and thus using an action to handle variation within a single patient process, the possible actions for handling variation within other patient processes, as well as the healthcare unit overall, will be limited. The identified changes in waiting times following care pathway implementation are thus in line with the findings of research on other national policy implementations, which found changes in waiting times for other patient groups. This further emphasises the need for a systems perspective when introducing changes into patient processes, in order to counteract negative effects.

The case study in urology and radiology showed that patients who are not being treated in a care pathway can experience shorter waiting times than before care pathway implementation, when prioritised in conjunction with care pathway patients. Other improvement activities in radiology were also found to influence waiting times, potentially making it difficult to identify crowding out effects. The magnitude and observability of crowding out effects are thus influenced by the number of care pathway patients and other patients prioritised in conjunction with these, changes in patient inflow, staffing or other resources, and other improvement activities. These results further highlight the need to consider actions to counteract crowding out effects when implementing care pathways.

The research reported in this thesis also directs attention towards two actions that can be used to counter crowding out effects when implementing care pathways. The first is to reassess the division of available resources dedicated to different priority categories when implementing care pathways, in order to avoid subjecting the patients in the priority category that is overtaken by the care pathway to increased waiting times. Another way of dealing with this issue is to decrease the number of priority categories, pooling demand,

since this ensures that patients are seen in closer to chronological order, thus decreasing both variation in waiting times and average waiting times (Silvester et al., 2004; Allder et al., 2011).

6.3 SUMMARISING THE CONCLUSIONS AND FULFILLING THE PURPOSE

The first chapter of this thesis argues that there is a lack of research applying a systems perspective when studying how variations in patient flows are managed within hospitals (Aronsson et al., 2011; Parnaby and Towill, 2009). To fill some of that gap, the purpose of this thesis was formulated:

To explore the impact and management of variation in patient flows within hospitals.

In Chapter 2, variation was discussed in terms of two types: internally created and externally created, the latter being related to patients and healthcare personnel, while the former is generated by the way in which work within the organisation is executed. This thesis has focused on managing externally created variation originating from the patients, in terms of variation in arrival rates and service times. However, the behaviours observed within the organisations studied can also be illustrated in comparison to a number of other behaviours in healthcare systems that internally create variation, as described by Allder et al. (2011), and discussed in section 2.3, namely:

1. Artificially increasing variation in arrival rate
2. Introducing capacity variations
3. Prioritisation
4. Generating subspecialities
5. Waiting list initiatives

The addition of the CCP priority category in all the studied specialities, and the effects identified in Study 3, exhibit a significant resemblance to the third behaviour described above, that of prioritisation systems. When demand is split into subgroups, these subgroups experience relatively higher variation in arrival rates, increasing the average wait in the system (Allder et al., 2011). Although Study 3 did not identify any change in average waiting times in the specialities studied, the proportion of CCP patients in comparison to the total number of patients was often rather low.

Some of the behaviours and actions identified in Study 2 can be related to the fourth behaviour described by Allder et al. (2011), namely that of dividing patients into smaller subgroups. For example, the reluctance of many clinical departments to accept general internal medicine patients in need of admission onto a ward from the ED counteracts the sharing of resources that can smooth out variation in arrival rates. Initiatives designed to shorten queues for elective patients, corresponding to the fifth behaviour described above,

were also observed in Study 2. In addition, these initiatives were undertaken without collaboration with other clinical departments, and hence without securing the necessary number of beds for acute patients at the hospital. The lack of joint decision-making regarding the number of open beds during the summer and Christmas holidays at the hospital in Study 2 is an example of the second behaviour described by Allder et al. (2011), of introducing capacity variations. When the number of open beds is allowed to vary, this creates a mismatch between supply and demand for beds.

Although not all the behaviours that internally create variation were observed in the studies reported in this thesis, the internal creation of variation was not the main focus. These examples show, however, that it is important to recognise both internally and externally created variation, and that it might be useful to address these holistically. Having a systems perspective in terms of managing variation in patient flows (Aronsson et al., 2011; Parnaby and Towill, 2009), which acknowledges both externally and internally created variations, could thus be appropriate.

Returning to the overall purpose, *to explore the impact and management of variation in patient flows within hospitals*, this thesis does explore both the impact and, in particular, the management of variation in patient flows. It demonstrates the importance of addressing variation in patient flows at different levels within the hospital organisation, as well as in the gaps between these, and describes the use of actions to handle variation in relation to management concepts adopted by healthcare organisations. The thesis also stresses the importance of middle management's role in managing variation, in collaboration with top management at the hospital. Following the implementation of cancer care pathways, it further shows both the positive and negative implications of CCPs on waiting times, which are similar to other policy programmes introduced into the healthcare systems. Once again, the research reported in this thesis identifies the need for a systems perspective in managing the components of a system as a whole, in order to achieve efficiency and effectiveness (Langley et al., 2008) and avoid sub-optimisation, which otherwise often follows (Stock and Lambert, 2001). To jointly address both externally and internally created variations in healthcare systems could be a part of this puzzle, and here future research is needed for the further exploration of healthcare systems. Below are some additional suggestions for future research.

6.4 FURTHER RESEARCH

The research reported in this thesis is exploratory in its nature and there is a need for further studies regarding the impact and management of variation in patient flows. In Paper I, the influence of alterations in patient inflow, treatment times and duration of activities for an ED and an inpatient ward was simulated. While these simulation runs demonstrated the robustness of healthcare units in handling increased numbers of patients, or prolonged treatment times and duration of activities, these alterations did not change the variations in

arrival rates and service times. Hence, there is a need for additional research addressing how changes in variation in patient flows impact upon healthcare units.

In Study 2, the actions used to handle variation in acute patient flows at a hospital, and the influence of middle management and the organisation upon these actions, were analysed. Study 2 did not, however, evaluate whether or not the actions used to handle variation in acute patient flows are appropriate for the system. With some actions being more appropriate than others, further research concerning what types of action are most appropriate, based on different variables such as costs, time and strain on personnel, is therefore encouraged. In addition, the focus of Study 2 was on clinical departments handling acute patients. One area for further studies is therefore clinical departments that only, or mainly, handle elective patients, for example analysing the actions used by these clinical departments to handle variation in patient flows in terms of their lean and agile characteristics.

There are some avenues for future research regarding the influence of top and middle management on the use of actions to handle variation in acute patient flows. In Paper III, the limited use of the implementation, championing and synthesiser roles among middle management was related to a lack of hospital-wide goals and strategies in the management of variation in patient flows. Hence, further research is required to determine how these goals and strategies should be formulated and communicated within the organisation in order to enable the successful handling of variation in patient flows. To improve the effective management of resources, both the interface and the division of labour and tasks between top and middle management also needs to be further explored.

For the elective and acute patients who correspond to the medical specialities of the clinical departments in Study 2, there are responsibilities, performance measurements and follow-ups of results. The department chiefs therefore prioritise goals and actions for these patient groups, while neglecting their shared responsibility for acute patients with vague symptoms. It is hence apparent that there is a difference in how these clinical departments handle specific and shared goals. A question for future research is therefore how these different goals and responsibilities should be managed collectively. Another challenge for future research is how to formulate these shared responsibilities in order to attain acceptance and adherence within the organisation.

Crowding out effects related to care pathway implementation have not previously been researched. The conclusions derived from Study 3 can hence be viewed as a starting point for further research. This study emphasises the need to consider the interactions between the care pathway intervention and the context, and proposes that crowding out effects should be addressed within the model pathway (Vanhaecht et al., 2010). How to include crowding out effects in the model pathway, and mitigate crowding out effects when implementing care pathways, are consequently areas for future research. To further deepen the understanding of crowding out effects, more quantitative research is also needed to

analyse the patterns identified in this thesis. In addition, other potential crowding out effects, such as crowding out of other parts of the patient pathway (The National Board of Health and Welfare, 2016), also require more attention from researchers.

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APPENDIX 1

LICENTIATE THESIS

Linköping Studies in Science and
Technology, Thesis No. 1682

Managing Variable Patient Flows at Hospitals

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Linköpings universitet

2014

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ABSTRACT

Healthcare is a large industry faced with major challenges, such as decreasing inpatient bed numbers and increases in the share of elderly people, which require improved efficiency and effectiveness. The organisation of hospitals normally comprises highly specialised clinical departments, through which patient flows are managed. Since patient flows often involve several clinical departments, this requires much coordination both in space and time. With every individual patient having different diseases, severity levels and responses to therapy, the variability in patient flows has an impact on the inflow, internal flow and outflow at clinical departments and hospitals. Historically, healthcare resources have not been adapted to these variations. The purpose of this licentiate thesis is therefore to explore how variable patient flows are managed in hospitals. This comprises how variable patient flows affect hospitals as well as how variable patient flows are handled. It also includes the organisational configuration, and the influence it has on the actions used to handle variable patient flows in hospitals.

Both the hierarchical levels, roles and teams that make decisions and manage the flow of patients as well as the actions used to handle variable patient flows at hospitals are included in the research. Hence, an approach where the hospital is regarded as a system is used, an approach often described as a system perspective. Three research methods have been used in this licentiate thesis. The first research method used was simulation modelling, to study how changes in an acute patient flow affected an emergency department and inpatient ward at a small hospital. A case study at a university hospital was performed to study both the actions used to handle variable patient flows as well as the influence of the organisational configuration. Several literature reviews, both structured and unstructured, has also been made to compare and evaluate the results from the empirical data.

There are several effects of variable patient flows. The case study indicates that increased patient flow variability leads to increases in bed utilization variability and thereby problems with bed shortages. Mismatches between patient inflow and outflow, in terms of number of patients, also lead to bed shortages. Literature reviews also show that bed shortages in inpatient wards are a major cause of overcrowding in emergency departments. The results from the simulation model point toward emergency departments being more adapted to variable patient inflow than inpatient wards. To handle these issues there is a need for flexibility when providing healthcare services, something suggested in the literature.

50 actions used at the university hospital to handle variable acute patient flows were identified in the research. A majority of these are used to handle the effects of the variation, not the variation itself. Nor is it effects of individual variations, such as patient inflow, that are handled but the combined effect of the variations in several variables. For

example, much time and effort are spent handling bed shortages. One third of the actions are used at a hospital level, with the aim to have positive effects for the hospital as a whole. Two thirds are used and developed at a departmental level, with the aim to improve the situation at the clinical department by using the action. By having most of the actions used at individual clinical departments, without considering the impact on whole hospital, there is an obvious risk of sub-optimization.

One explanation for many actions being used at a departmental level could be that there is lack of strategic direction and decision-making ability at top management level due to the use of unanimous decision-making in the hospital management group. This hinders the control and coordination of the actions used at different clinical departments, rendering them more similar to separate organisations. Departmental collaboration is also impeded as well as organisational learning at the hospital, both bottom-up and sideways in the hierarchies, encumbering the development and sharing of successful actions for handling variable patient flows.

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1 INTRODUCTION

In order to provide the reader with some insight into the main contents of this licentiate thesis, this chapter addresses the need for improved efficiency and effectiveness in the healthcare industry and how theories, methods and perspectives from logistics and Supply Chain Management can be applied in the healthcare sector. With support from this background, the purpose and research questions of this thesis are specified. In addition, delimitations and definitions of central concepts and terms are presented. Lastly, the outline of this licentiate thesis is stipulated.

1.1 HEALTHCARE IS A LARGE INDUSTRY WITH INCREASING DEMANDS

The Swedish healthcare system employs close to a million individuals (Sveriges Kommuner och Landsting, 2014). The main part of the Swedish healthcare system is managed and financed by 20 county councils and 290 municipalities, while the ultimate responsibility for health policy on a national level is held by the Swedish Government and Parliament. The Swedish healthcare system is highly decentralized in comparison to other countries (Sveriges Kommuner och Landsting, 2005).

Providing healthcare to the extent needed is costly. For most countries, health expenditure therefore represents a large share of their gross domestic product (GDP). For the OECD34 countries, average health expenditure in 2011 was 9,3% of GDP, while Sweden's health expenditure the same year was 9,5% of GDP (OECD Health Statistics 2013). The mere size of healthcare as an industry thus motivates the importance of efforts to develop efficiency and effectiveness in healthcare provision and hence be able to provide more and better healthcare for the money spent.

A decrease of approximately 20% in inpatient bed numbers in Sweden has been observed when comparing the years 2000 and 2009. At the same time, the number of hospitalisations has increased by 7-8% (Sveriges Kommuner och Landsting, 2010). In the corresponding period 2001-2009, the average bed occupancy of inpatient beds increased from 80% to 89% (Socialstyrelsen, 2012) and the time every patient spends at the hospital, decreased (Sveriges Kommuner och Landsting, 2010). These developments put pressure on the healthcare system by eliminating the margins that previously existed when there were more beds available and hospitalisations were longer.

A forthcoming challenge also lies in the forecast that by 2050 the share of elderly people in Sweden is expected to increase from 17% to 25%. The cost increases that follow are estimated to be 70% for geriatric care and 30% for healthcare (Socialdepartementet, 2010) due to increased numbers of interventions as well as increased need for caring efforts and preventive actions. To face the challenges of an ageing population, an estimated 225,000 employees need to be recruited within the next 10 years. Approximately 90,000 of these are needed due to an increase in demand for healthcare and geriatric care (Sveriges Kommuner och Landsting, 2014). In addition to increased health expenditure due to an

increasing share of elderly people in the Swedish population, the technological development in advanced treatments and pharmaceuticals also increases demand for healthcare services. By 2050, the costs for Swedish healthcare are expected to increase by 80% due to possible new treatments, increased aspiration levels and more patients (Socialdepartementet, 2010).

To summarize, healthcare is a large industry where one of the main objectives is to provide as much health services as possible at as low a cost as possible, while present and future developments exert even more pressure to do more with less. Improved efficiency and effectiveness in healthcare services is thus needed in the present and in the future.

1.2 THE NECESSITY FOR A SYSTEM PERSPECTIVE IN HEALTHCARE

To improve efficiency and effectiveness in healthcare the patient flow needs to be focused (Parnaby and Towill, 2008) since it is central to an organisation's capacity to provide healthcare services, while other operations provide support with the aim of creating conditions for an efficient and effective patient flow. A holistic view of the whole patient process is therefore needed (Aronsson et al., 2011; Meijboom et al., 2011; Parnaby and Towill, 2009). Nor will overall quality in healthcare processes improve until all those involved in providing care for a patient see themselves as part of the same team, regardless of organisational affiliation (Bringewatt, 1998).

The need for a systemic perspective has also been put forward as a prerequisite for finding possible solutions to major issues in healthcare provision. One conclusion from a literature review concerning the causes of and solutions to overcrowded EDs was that potential solutions would need a multidisciplinary system-wide support (Trzeciak and Rivers, 2003). This conclusion was supported by participants in a focus group study, who claimed that different causes of overcrowding could not be tackled independently, but should be addressed with a holistic approach (Estey et al., 2003). The problem of overcrowding is system-based and related to lack of incentives, or even perverse incentives for hospital administrators concerning delivering inpatient beds and other resources for acute patients, as concluded by the Physician Hospital Care Committee (2006). Solutions to overcrowded EDs will mainly be found in appropriate bed management strategies, including the use of step-down and community resources, so that appropriate inpatient beds remain available for acutely sick patients (Richardson and Mountain, 2009).

Ineffective patient transfers are also a contributing factor to the high bed occupancies in inpatient clinics. These inefficiencies are strongly related to ineffective inter-departmental interaction, ineffective information handoffs, and ineffectiveness of current information technologies (Abraham and Reddy, 2010).

Another issue that requires a holistic approach is that of bed-blocking. A blocked bed can be defined as: “.. *a bed occupied by a patient who in the consultant’s opinion no longer require the services provided for that bed, but who cannot be discharged or transferred to more suitable accommodation*” (Hall and Bytheway, 1982, p. 1987). Bed-blocking can be a problem if patients from a specialised inpatient unit cannot be transferred to a revalidation unit when they are ready for that, since they block beds for patients in need of the specialised treatment (Andersson and Karlberg, 2000). Such “bed-blockers” would not only cost the system much less when placed in a less-specialised facility, they would also receive more appropriate care and services. (Meijboom et al., 2011). Bed-blocking also often occurs when elderly people with high care needs cannot be accepted by permanent care facilities. The issue of high bed occupancy within acute hospitals thus partly stems from a mismatch between demand and supply for spaces in permanent care facilities, and thus cannot be fully comprehended by viewing the hospital system in isolation from other sectors that support the health and well-being of elderly people (Travers et al., 2008).

There are many issues in healthcare that originates from a lack of system perspective. A system perspective has however been a theoretical foundation for logistics (Bowersox, 1978; Novack et al., 1992) and Supply Chain Management (Mentzer et al., 2001; Sanders; 2007) research. The potential of applying logistics and Supply Chain Management (SCM) in a healthcare context will therefore be discussed in the following section.

1.3 THE PROSPECT OF APPLYING LOGISTICS AND SCM IN HEALTHCARE

Like any other organisation, a healthcare organisation is a system of components that interact to achieve a number of goals. A foundation in systems theory is that none of these components can act independently of another in a system, that the components are interrelated. A system thus has to be understood and managed as a whole to achieve efficiency and effectiveness (Langley et al., 2008). When components are managed individually, without considering the impact on the larger system, sub-optimization often follows (Stock and Lambert, 2001). Though originating from political science/sociology discipline, systems theory has been used as a base in logistics and SCM research (Stock, 1997).

The concepts of logistics and SCM are flow-oriented (Christopher, 2005). To move towards a flow-oriented system instead of a functionally oriented system, that is typical in healthcare organisations, is needed (Mould et al., 2010) and has the potential to decrease sub-optimization by an end-to-end view when developing the supply chain (Wood, 2004). Poor flow also leads to higher mortality rates and healthcare costs (The Health Foundation, 2013). Focusing on patient flow in health systems is therefore crucial.

Interest in logistics and SCM has increased in recent years as regards how to create a more flow-oriented system (Oskarsson et al., 2013). In a licentiate thesis, Wiger (2013)

shows that healthcare systems can be described as a logistics systems by evaluating a healthcare system in terms of the main features of a logistics system, such as flow-orientation, measurements to capture the entire system's performance and control of the transformation between input and output. These results indicate that applying logistics concepts in a healthcare context is a way to increase efficiency in healthcare services.

As discussed earlier, the flow of patients is the core process in healthcare, while flows of material are secondary (Visser and Beech, 2005). Traditional logistics and SCM research has a physical product focus, since the organisations studied are, and have been, predominantly manufacturing and trade organisations, for which the flow of material is the primary flow. The potential of applying existing concepts, models and practices from logistics and SCM has been emphasised by several authors (Aronsson et al., 2011; de Vries and Huijsman, 2011; Towill and Christopher, 2005). Aronsson et al. (2011) argue that SCM has the potential to work well as a philosophy for a patient flow focus while Towill and Christopher (2005) show that material flow concepts from logistics and SCM can form the basis for effective healthcare delivery systems with a patient flow focus. There are, however, indications that the healthcare sector is behind the industry sector when it comes to implementing SCM practices (McKone-Sweet et al., 2005; de Vries and Huijsman, 2011).

The use of logistics and SCM theories, models and practices in healthcare has been sparsely researched. Shah et al. (2008) claim a lack of academic research in healthcare SCM while de Vries and Huijsman (2011) argue that the body of knowledge regarding the healthcare industry from a supply chain perspective is fragmented. Management philosophies are often implemented together with SCM practices. Research on how management philosophies, such as lean and agile manufacturing, Lean Six Sigma and business process re-engineering, are applied by health care providers and to what extent health care providers can benefit from these practices is therefore also needed (de Vries and Huijsman, 2011).

Before discussing more explicitly how logistics and SCM concepts have been applied in the research reported in this licentiate thesis some characteristics of healthcare services will be deliberated in the forthcoming section.

1.4 CHARACTERISTICS OF HEALTHCARE SERVICES

Grönroos (2007) describes three important characteristics of services in comparison to goods:

- A service is more likely to consists of linked activities (intangible) than goods (tangible)
- A service is produced and consumed at least partly at the same time
- The customer participates at least partly in the service production process

This argument is further built upon by Grönroos and Ravald (2011). They divide the value-creating process into three steps, where the first is a production phase aiming at facilitating value creation where only the supplier is present, for example preparing an operating theatre before a surgical operation. The second phase consists of the interaction between customer and supplier, while the third phase consists of the parts of the process that the customer performs without interaction with the supplier, e.g. exercises for rehabilitation after surgery.

Other characteristics of services is that they are often labour-intensive, difficult to resell, not able to stored and transported due to simultaneous production and consumption, difficult to automate, are often perishable (unused capacity is capacity lost forever) and have a quality dimension that is difficult to evaluate (Arlbjörn and Halldorsson, 2002).

In recent years, the concept of service SCM has emerged and been elaborated conceptually in general (Ellram et al., 2004; Ellram et al., 2007), in a healthcare context (Baltacioglu et al., 2007), and in the municipal sector (Arlbjörn et al., 2011). An important aspect in distinguishing service supply chains is that they are bidirectional, meaning that the customers are also suppliers (Sampson, 2000; Sampson and Froehle, 2006).

Berry and Bendapudi (2007) describe the differences between healthcare and other services. One of the differences is that *customers are sick*. The patients often also live in the service “factory” and the emotions that follow an illness influence their ability to make choices. Further, *customers are reluctant* to use the medical services; they need a treatment but may not want it. The patient often does not want the role of “co-producer” that is often needed for a favourable outcome of a service. Since healthcare services are inherently personal, but not private the *customers relinquish privacy*. Patients may have to disrobe and discuss highly personal matters with clinicians they are meeting for the first time. There is also a need for healthcare personnel to understand each individual customer and customize the service accordingly to the patient’s medical condition, age, mental condition, personal traits, preferences and family circumstances. In other words, *customers need “whole person” service*, which puts pressure on the clinician’s ability and willingness to combine knowledge of medicine with knowledge of the individual patient. Another difference between healthcare and most services is that *customers are at risk*. A profession that is supposed to heal too often causes harm. Hospital-acquired infections, medication errors and communication errors harm millions of patients every year worldwide. A last major difference is that *clinicians are stressed*. Serving acutely ill people is exceedingly stressful work and doctors as well as nurses are often visibly tired and fatigued. The work shifts are long and include, especially for nurses, “heavy” work such as lifting or turning patients. The emotional stress of serving people with serious illnesses and delivering bad news to patients and families further contributes to a stressful environment for clinicians.

The complexity of healthcare services discussed above also generates variations when providing healthcare services. A labour-intensive healthcare service with simultaneous production and consumption as well as diffuse quality dimension is for example subject to several types of variation that are not present when producing a ballpoint pen. Variability is therefore of specific interest to study in healthcare services and is therefore discussed below.

1.5 VARIABILITY IN HEALTHCARE SERVICES

In this thesis, variability, or in other words variation, is labelled as a deviation from the mean value of a certain variable. For example, the deviations in the number of patients that arrive at an emergency department are henceforth described as variation. The variation for a certain variable can be dependent on the variations of components making up the variable. The arrival pattern of patients at an emergency department, are for instance influenced by the day of the week, weather and demographic distribution. The variation can also be measured on different levels, where the number of patients arriving at an emergency department is highly variable when comparing different hours of the day, while the monthly number of patients is fairly constant. Since variation, as a concept, is complex, different types of variation that are important to recognise in healthcare will be described below, to help the reader understand the concept. In the next section (1.6), the types of variability that are studied in this thesis will be chosen.

From the perspective of an organisation, variability can be divided into two groups: externally created and internally created. The former is strongly related to the customers and suppliers. The latter is created by the way work within the organisation is done. Allder et al., (2011) describe a number of behaviours in healthcare systems that internally create variability:

1. *The system artificially increases demand variation (arrival variability)* – First appointment referral requests are often batched between general practitioners and secondary care, creating artificial ups and downs in demand.
2. *Capacity variation is introduced into the system* – Queues are made worse by the discontinuous scheduling of specific clinics on only one or two days per week. The capacity to discharge is also often decreased during holiday periods, due to an increased share of inexperienced physicians that are reluctant to discharge patients.
3. *Prioritisation increases variation* – One of the known effects of prioritisation systems, such as basic forms of triage, is that it splits demand into subgroups. These subgroups experience relatively higher net demand variation, increasing the average wait in the system.
4. *Specialties generate increases in variation* – Any form of ring-fencing, such as the creation of a new specialist clinic, increases delay in a very similar way to that of prioritisation since it creates smaller pools of patients. Sharing resources between multiple providers on the contrary smoothes demand and reduces queues.

5. *Waiting list initiatives increase variation* – Adding short-term capacity to try to eliminate queues, increases the demand variation and generates temporary surges in demand that spread through the whole system. This unbalances the system and moves delays from one place to another. Often the initiative simply shifts the delays from one specialty to another, as previously shared resources are diverted.

Customers do not all want service at the same time or at times necessarily convenient for the organisation that provides a service. In many situations it is possible to address arrival variability through appointment systems, but in situations where the customers cannot foresee or delay their needs this solution is not usable (Frei, 2006; Bicheno et al., 2009), an obvious example being acute patients arriving at an emergency department. With every individual patient having different diseases, severity levels and responses to therapy much variability is also introduced (Litvak and Long 2000; Noon et al., 2003). The time a patient spends at an inpatient ward, in surgery or at a doctor's appointment are all dependent on these variables. In addition, the interactions of multiple diseases and the effects of a given treatment make it difficult to foresee the next step in the patient process and sometimes each diagnostic test or test of therapy generates new information that influences future decisions, creating an iterative patient process (Bohmer, 2005).

The fact that customers' desires do not emerge along standard lines poses challenges for practically every kind of service business (Frei, 2006). In healthcare where patients need treatment but may not want it (Berry and Bendapudi, 2007) variation in patients' desires are created.

Another source of variability is the differences in the capabilities that customers possess. It may originate from differences in knowledge, skill, physical abilities, or resources and some customers therefore perform tasks easily while some require hand-holding. Obviously the capability variability becomes more important to handle when the customers are active participants in the production and delivery of a service (Frei, 2006).

When customers must perform some activity in a service interaction, it is up to the customer how much effort they apply to the task (Frei, 2006). In the third phase of the value-creating process (Grönroos and Ravald, 2011) previously described, where customers perform activities without interaction with the supplier, e.g. rehabilitation exercises after surgery, it becomes essential to handle variation in patient effort. The opinions of what it means to be treated well in a service environment also vary among customers. The unpredictability in personal preference makes it complicated to serve a broad base of customers (Frei, 2006).

Of course there is also variability that originates from the service providers. Due to different approaches, preferences and different levels of ability, healthcare personnel introduce variability in service provision (Litvak and Long 2000; Noon et al., 2003). For instance, physicians always make a judgment as a basis for decisions on further treatment.

Due to the inherent complexity and variability discussed above, healthcare managers believe that, unlike manufacturing industry, they cannot control their service production or predict their patient inflow (Jarret, 1998; Vissers et al., 2001). However, this perception is only partially true. Several authors (Allder et al., 2011; Lega et al., 2012; McLaughlin, 1996; Silvester et al., 2004; Walley et al., 2006) claim that much of this variability can be handled by working smarter, through strategies such as capacity management systems and standardised patient processes for homogenous sub-groups of patients. Instead, healthcare resources are often used inappropriately and not adapted to the variations that exist (Walley et al., 2006). It is therefore of interest to study how variations are handled in healthcare. The following section will discuss how a logistics/SCM perspective can be used to address variability in healthcare services.

1.6 HANDLING VARIABILITY FROM A LOGISTICS/SCM PERSPECTIVE

Variability has been an important construct in a number of fields, including organizational theory, marketing and SCM (Chen and Paulraj, 2004). Understanding the impact of different sources of variability is also a cornerstone of effective SCM (Davis, 1993). In a manufacturing context, Hopp and Spearman (2000) have proven a series of fundamental relationships. Two of these are of specific interest for this research:

1. *Increased variability always degrades the performance of a production system.*
2. *Variability in a production system will be buffered by some combination of inventory, capacity or time. In other words, if not handled, variation will affect you in one or more of these three ways.*

The first relationship can be interpreted as stating that variability has a negative effect on a production system. There are therefore potential gains to be had from handling variability in an efficient way. Handling variation in supply and demand is an issue of interest in logistics and SCM research. Variable supply and demand are often handled by having inventory, to protect production from the variation (Lee and Billington, 1992), visualized in Figure 1.1.

FIGURE 1.1 – PROTECTING PRODUCTION FROM VARIATION IN SUPPLY AND DEMAND BY HAVING INVENTORY

By using inventory to buffer variation, only one of three potential ways to handle variation is used. Services, including healthcare services, are not possible to store (Arlbjörn and Halldorsson, 2002); variation must therefore be buffered using capacity or time. As pointed out before, the patient flow is the primary flow in healthcare. Service

supply chains are also bidirectional, meaning that the customers are also suppliers (Sampson, 2000; Sampson and Froehle, 2006). Corresponding visualisation as Figure 1.1 can thus be depicted as Figure 1.2.

FIGURE 1.2 – SERVICE PRODUCTION IN A HEALTHCARE CONTEXT

In the research conducted for this licentiate thesis it has not been possible to address all types of variation described in the previous section. As shown in Figure 1.2, variation in patient inflow and outflow needs to be handled and are related to variation in supply and demand, a subject of interest in logistics and SCM research. The variation in patient inflow can be divided between variation in how many patients arrive per time unit and variations in what type of patients arrive, for instance with different diseases and severity levels. Both these sub-types are included in the research since they both have a major impact on how to organise healthcare resources.

Variations in patient outflow, regarding how many patients are discharged per time unit, is also included in the research. This variation is sometimes dependent on when the next service provider can accept the patient, for instance another inpatient ward at the same hospital or a permanent care facility. With every individual patient having different diseases, severity levels and responses to therapy (Litvak and Long 2000; Noon et al., 2003), the time from arrival until discharge, length of stay (LOS), can be highly variable for patients being treated for the same health issues. The variation in LOS is therefore also included.

Predictability is a concept that is related to variability, and relevant to discuss based on the argument that variations which are predictable might not need specific attention. One example is the patient inflow at emergency departments that often shows clear arrival patterns concerning what time of the day that most patients arrive, with most patients arriving in the afternoon (Walley et al., 2006). This demand variation can be evaluated as being predictable; there may however be large differences when comparing how many patients arrive on a Thursday and the subsequent Wednesday. So even though the arrival pattern is predictable, the number of patients per day is not. In conclusion, predictability can help in handling variability, although it does not exclude variation from being an important element to address when planning and executing healthcare services. Predictability will thus not be explicitly discussed in this thesis.

The organisation of a hospital is normally a complex configuration of highly specialised clinical departments (Mintzberg, 1979), through which patient flows are handled. A

patient process often involves a large number of clinical departments, which requires much coordination in both space and time (Aronsson et al., 2011). Applying a system perspective concerning how variable patient flows are managed at hospitals could therefore be a relevant approach.

1.7 PURPOSE AND RESEARCH QUESTIONS

Based on the discussions in the previous sections, the purpose of this licentiate thesis is:

To explore how variable patient flows are managed in hospitals

A shift towards more flow orientation instead of a functional orientation, that is typical in healthcare organisations, is needed (Mould et al., 2010). The concepts of logistics and SCM are flow-oriented (Christopher, 2005) and the potential of applying these in healthcare has been emphasised by several authors (Aronsson et al., 2011; de Vries and Huijsman, 2011; Towill and Christopher, 2005). There is also a lack of academic research regarding healthcare SCM (Shah et al., 2008) and indications that the health care sector is behind the industry sector when it comes to implementing SCM practices (McKone-Sweet et al., 2005; de Vries and Huijsman, 2011), which makes it relevant to choose the term *explore*.

The term *variable patient flows* means, in this thesis, patient flows under the influence of variation, where the following types of variation, as discussed in the previous section, are encompassed:

- Inflow: number of patients arrived per time unit
- Inflow: types of patients
- Internal flow: LOS
- Outflow: number of patients discharged per time unit

To provide structure and focus, the purpose of this thesis has been divided into three research questions. These will be justified and elaborated below. The term *managed* will be specified in relation to research question 3.

As discussed in section 1.6, healthcare services are not possible to store (Arlbjörn and Halldorsson, 2002) and variation must therefore be handled by using capacity or time. Queues are often used to protect against variation in healthcare, but must be of limited length dependent on the health issue at hand. When treating patients with acute health issues queues are also of limited use. Nor is it an option to refuse healthcare services and admission to a hospital. With every individual patient having different diseases, severity levels and responses to therapy (Litvak and Long 2000; Noon et al., 2003) it becomes difficult to foresee the next step in the patient process (Bohmer, 2005) or plan for the discharge of a patient. In conclusion, these difficulties can be visualised by how the square in Figure 1.2 is influenced by the variability in patient inflow and outflow as well as the

internal flow of patients. To increase the understanding of how these difficulties negatively affect hospitals, the first research question was developed:

RQ1: *How do variable patient flows affect hospitals?*

The impact of variable patient flows is influenced by the way the variability is handled. In similarity with the argumentation above, the variability in patient inflow and outflow as well as the internal flow of patients is handled in the square in Figure 1.2. In previous research, the ability of healthcare providers to handle variation in demand has been questioned. Walley et al. (2006) for instance argue that healthcare resources are often used inappropriately and not adapted to the variations that exist. A primary cause of queuing in the United Kingdom's National Health Service (NHS) has also been attributed to a mismatch between demand and capacity variation (Silvester et al., 2004). To provide knowledge as to why variable patient flows are not satisfactorily handled in healthcare, the second research question was stipulated:

RQ2: *How are variable patient flows handled at hospitals?*

The term *handle* in this thesis means the operational actions used and do not include how the decision to use an action is reached.

In section 1.2 the need for a system perspective was emphasised to overcome issues such as overcrowded EDs (Trzeciak and Rivers, 2003; Estey et al., 2003), ineffective patient transfers (Abraham and Reddy, 2010) and bed-blocking (Andersson and Karlberg, 2000; Travers et al., 2008). With the functional organisation of hospitals, made up of highly specialised clinical departments (Mintzberg, 1979; Mould et al., 2010), there is an obvious risk of sub-optimization (Wood, 2004). That the organisational configuration of a hospital influences the options for handling variable patient flow is thus reasonable. Variable patient flows are handled by actions on all hierarchical levels of the hospital organisation. The actions chosen for handling variable patient flows at the hospital are thus influenced by the organisational configuration. To clarify this relationship, the third research question was postulated:

RQ3: *How does the organisational configuration influence the actions used to handle variable patient flows in hospitals?*

The term *organisational configuration* needs some elaboration as to what is included in the concept. Since the development of actions to handle variable patient flows are performed at both departmental and top management levels, as well as intermediate levels, these levels are included. Both long-term and short term planning is also included as well as the operational decision-making regarding which actions to choose in different circumstances. Concepts such as mandates, authority and information sharing are also encompassed. In one of the appended papers, denoted Paper IV in this thesis, another term was used with the same meaning as organisational configuration, namely *planning and decision-making*.

The final delimitation at this stage is the term *managed*, included in the purpose. In this thesis it encompasses both the actions used to handle variable patient flows as well as the organisational configuration that influences it. In the appended Paper III and IV and case report, the term was used to discuss both the actions as well as the organisational configuration related to handling variable patient flows. The previously defined *handle*, was thus not used to denote operational actions in these papers. To complicate things further, in the appended case report, operational actions used for handling variable patient flows were denoted by either actions or *strategies*.

The choice to include all the aspects discussed above in the thesis is connected to the choice to *explore* in the purpose, in turn due to the lack of previous research. The exploratory orientation will be further elaborated in the next chapter.

1.8 THESIS OUTLINE

First and foremost, it is important to clarify that this thesis is a compilation thesis, consisting of four papers and a case report. The objective of the main part of the thesis (thesis frame) is to link the other parts to each other and thereby provide additional contributions that the papers and case report do not provide on their own. Although the aim of the thesis frame is to provide sufficient descriptions and discussions of the findings in the papers and case report, the reader may occasionally need to review a paper for a more detailed picture. Below the chapters of this licentiate thesis is presented:

CHAPTER 1: INTRODUCTION

The first chapter sets out to provide the reader with some insight into the reasons for performing the research reported in this thesis. With support from this background, the purpose and research questions are specified. Delimitations and definitions of central concepts and terms are also presented in the chapter.

CHAPTER 2: RESEARCH METHODOLOGY

The aim of the second chapter is to describe the overall research approach used for the research presented in this licentiate thesis. In addition to describing the research design and the methods used, the organisations studied are presented. A description of how the research questions have been answered concludes the chapter.

CHAPTER 3: SUMMARY OF APPENDED PAPERS

In this chapter a summary of each of the four appended papers is presented, allowing the reader to acquire basic understanding of the content of each paper. The summary of each paper follows a certain structure. After presenting the purpose of a paper, the main results and contributions of the paper are described.

CHAPTER 4: ANSWERING THE RESEARCH QUESTIONS

This chapter seeks to find answers to the three research questions developed in the first chapter. The research questions are analysed one by one, with input from the four

appended papers as well as the case report. Individual contributions and synthesis of the contributions from the papers and case report are mixed when exploring a research question.

CHAPTER 5: CONCLUSIONS AND PROPOSITIONS

In this chapter the conclusions from each research question are combined and related to each other in order to answer the purpose of the thesis. The second part of the chapter provides propositions for future research and practice. These propositions are primarily based on the author's evaluation and identification of patterns in the research material reported in this thesis.

2 RESEARCH METHODOLOGY

The aim of this chapter is to describe the overall research approach used for the research presented in this licentiate thesis. It includes the research design as well as the methods used and organisations studied. A description of how the research questions have been answered concludes the chapter.

2.1 RESEARCH DESIGN

Research design can generally be described as the logical relationship between a study's research question and the data that needs to be collected. But before deciding upon research design, the type of research that shall be conducted must however be deliberated, since the existing knowledge within a research field affects the appropriateness of different types of research and thus research designs (Yin, 2009). Ellram (1996) describes three objectives of research depending on the maturity of the research field: exploratory, descriptive and explanatory. Exploratory research is used when limited prior knowledge exists within a research field and basic understanding of a phenomenon is needed. The field of healthcare logistics and SCM is in its infancy (De Vries and Huijsman, 2011) and an exploratory objective is thus appropriate.

The exploratory objective of the research conducted in this thesis guided the author to adopt a research approach similar to abductive reasoning. Described as a combination of inductive and deductive reasoning, abductive reasoning allow the author to adopt an iterative research process and thus go back and forth between the empirical and theoretical worlds (Dubois and Gadde, 2002; Kovács and Spens, 2005). With an abductive research process, the starting point is often empirical observations that do not match existing theories, initiating an iterative process where finding new theoretical frameworks or extending existing ones are the objective (Kovács and Spens, 2005). It is also recommended when the researcher's intent is to understand an observed phenomenon and its context using the lens of an existing theory (Shah et al., 2008). With the new field of healthcare logistics and SCM, where existing theories have been sparsely tested in a healthcare context, the use of abductive reasoning, with the aim to increase understanding by adding a new perspective is relevant. The research design thus used an iterative process, deliberating existing literature through the use of literature reviews and empirical evidence from simulation modelling and a case study. Going back and forth between these worlds has been a crucial part of the research process, allowing deeper understanding of the research field and more generalizable conclusions from this thesis.

2.2 RESEARCH METHODS

As briefly mentioned above, three research methods have been used in this licentiate thesis. The first research method used was simulation modelling. Thereafter several literature reviews were conducted, both structured and more iterative. Not all of the literature reviews were used in the research for the appended papers, but the use of the literature reviews will be discussed later. A case study was also performed and the

collected data compiled into a case report appended to this thesis. Using different theoretical frameworks, Papers III and IV analysed complementary parts of the case material. The full account of the research methods used in the appended papers is shown in Table 2.1.

TABLE 2.1 – RESEARCH METHODS APPLIED FOR THE APPENDED PAPERS

	Case study	Literature review	Simulation model
Paper I			X
Paper II		X	
Paper III	X	X	
Paper IV	X	X	

2.3 THE RESEARCHER’S CONTRIBUTION TO THE PAPERS AND CASE REPORT

PAPER I

Olsson, O. and Aronsson, H. (2012), “Understanding the impact of variation on healthcare systems” The paper was presented at the *World Conference on Production & Operations Management* in Amsterdam, Netherlands in 2012.

Contributions in Paper I: The outline of the paper was discussed together with my supervisor and co-author Håkan Aronsson. I was responsible for the design, development and validation of the simulation model as well as analysis and writing the paper. Håkan Aronsson provided feedback when needed.

PAPER II

Olsson, O., Wiger, M. and Aronsson, H. (2014), “Developments in the field of healthcare logistics and SCM – A patient flow focus” In manuscript.

Contributions in Paper II: The paper is an expansion and development of the paper “Healthcare logistics – A patient flow focus” by Wiger and Aronsson (2012). I am responsible for the expansion, which includes introducing a third search phase into the literature review. All analyses are also replaced and I performed the new ones and wrote the corresponding new parts of the paper.

PAPER III

Olsson, O., Aronsson, H. (2014) “Managing a variable acute patient flow – categorising the strategies” Submitted after first review round in *Supply Chain Management: An International Journal* in October 2014.

Contributions in Paper III: The design of the paper was discussed together with my supervisor and co-author Håkan Aronsson. For division of work related to data collection, see the corresponding description for the case report. I was responsible for conducting the analyses and literature reviews and for writing the paper. Håkan Aronsson provided feedback on several drafts of the paper and made small additions to the text.

PAPER IV

Olsson, O., Aronsson, H. and Sandberg, E. (2014) "Managing a variable acute patient flow – planning and decision-making" Submitted to *Journal of Health Organization and Management* in May 2014.

Contributions in Paper IV: All three authors collaborated concerning the design of the paper. For division of work related to data collection, see the corresponding description for the case report. The literature review as well as analysis and conclusions were my responsibility, with assistance from Erik Sandberg.

CASE REPORT

Olsson, O., Aronsson, H. (2014) "Managing a variable acute patient flow at a university hospital".

Contributions in case report: The data collection was my responsibility, and Håkan Aronsson assisted during most data collection activities. I transcribed the interviews and wrote the case report.

2.4 ORGANISATIONS STUDIED

One of the healthcare organisations studied in this thesis is the hospital in Hässleholm, a part of Hässleholm's hospital organisation. With operations in four towns in Skåne (a county in the south of Sweden), Hässleholm's hospital organisation has approximately 500 employees and a turnover of just over SEK 600 million (Hässelholms sjukhusorganisation, 2013). They have responsibility for all internal medicine, orthopaedics, psychiatry, diagnostic imaging and rehabilitation in Hässleholm's catchment area (70,000 inhabitants) and for all orthopaedics and psychiatry in Kristianstad catchment area (100 000 inhabitants) as well as the main responsibility for orthopaedic artificial joint surgery and highly specialized psychiatry in half of Skåne (500,000 inhabitants). Hässleholm hospital is the largest part of the organisation and operates the entire hospital.

The university hospital in Linköping is the second healthcare organisation studied in this thesis. In addition to organ transplants, the university hospital provides diagnostics, consultation and treatment within every medical speciality. The catchment area for highly specialised care consists of three counties, with a total of approximately one million residents. In some cases the catchment area is even bigger, i.e. the whole country. The university hospital profiles itself through an advanced emergency and trauma care and a focus on highly specialised care and research.

To provide an overview, some general figures for the two hospitals are provided in Table 2.2. The figures for Hässleholm hospital are provided for 2011 since the organisation was mainly studied during 2011. The study of the university hospital in Linköping was

initiated during 2012 and figures for both 2011 and 2012 are thus provided to enable comparison.

TABLE 2.2 – THE TWO HOSPITALS IN FIGURES

	Hässleholm, 2011	Linköping, 2011	Linköping, 2012
Production	110 beds	570 beds	572 beds
	6,000 hospitalisations	42,000 hospitalisations	43,000 hospitalisations
	4,000 operations	15,000 operations	17,000 operations
	36,000 outpatient visits to physician	270,000 outpatient visits to physician	285,000 outpatient visits to physician
Employees	570 in total	5,100 in total	5,200 in total
	Nurses 26%	Nurses 35%	Nurses 35%
	Assistant nurses 25%	Assistant nurses 22%	Assistant nurses 22%
	Physicians 17%	Physicians 16%	Physicians 17%
	Management/administrative 17%	Management/administrative 10%	Management/administrative 10%
	Other 13%	Other 17%	Other 17%

2.5 CASE STUDY

Case study research is both applicable and desirable when a lack of theory exists, or when the environmental context is different from previous development and usage of theory (Stuart et al., 2002). Strengths with case study research are that it can be used for exploratory investigations, where many variables are still unknown and limited previous knowledge of phenomena exists (Meredith, 1998). The use of logistics and SCM theories in a healthcare setting is a novel area of research (de Vries and Huijsman, 2011). A case study approach therefore seems suitable to explore the applicability of logistics and SCM theories in a healthcare context.

Meredith (1998) also concludes that case studies can be used to increase understanding in fields where the subject matter is complex. Healthcare systems are one of the most complex systems known to contemporary society, and hospitals in particular are considered to be exceptionally complicated organizations (Glouberman and Mintzberg, 2001). At hospitals acute patients arrive continuously at the emergency department (ED). In comparison to elective patients, whose care episode is planned ahead by each clinical department individually, the acute patient flow is more challenging to manage efficiently, mostly due to the unpredictability of the patient inflow as regards time, health issue and response to treatment. At a clinical department admitting acute patients from the ED, the patient inflow is therefore difficult to predict. To describe how the acute patient flow is managed at a university hospital a case study approach thus seems appropriate. Because the phenomenon studied is complex and a hospital includes multiple clinical departments that have many characteristics of independent organisations, a single case study approach was chosen (Yin, 2009).

The choice of organisation to study fell on the university hospital in Linköping. Several of the clinical departments operating at the hospital account for clinical results of top

international standard (Landstinget i Östergötland, 2014). Geographical proximity as well as access to information also contributed to the choice of organisation. In a comparison between the university hospitals in Sweden assessing medical quality, financial performance, customer satisfaction, waiting time and hygiene, the university hospital in Linköping also came out with a clear first place (Dagens Medicin, 2013). Consequently, the ability of the university hospital in Linköping to manage a variable acute patient flow was anticipated to be of similar relative quality compared to other university hospitals.

2.5.1 STUDIED SYSTEM

The purpose of the case report is to provide a description concerning how a variable acute patient flow is managed at the university hospital. Both the hierarchical levels, roles and teams that make decisions and manage the flow of acute patients at the hospital as well as the actions used at the hospital to handle a variable acute patient flow are therefore included. Since the entire hospital is studied, and several clinics treat both acute and elective patients, no distinct limitations are included; instead, an approach where the hospital is regarded as a system is used. The basis for considering the hospital as a system is that it should be able to manage a variable acute patient flow without help from other hospitals. The relationship between the hospital and its environment, mainly the collaboration with primary health care, is included but not explicitly studied. The motivation is that actions that are used to be able to admit fewer patients or enhance the admission process by the local health service can be used to handle a variable acute patient flow.

Many actors influence the handling of the variable acute patient flow. At the management level, the development of long-term goals and strategies are executed, thus empirical evidence from the management level is included in the study. General strategic visions, priorities and plans, which are not clearly realised into action, are not included however. Middle managers often have extensive knowledge of the operations within the clinical department they manage while also having responsibility for strategic development. Together with a position entitled coordinator, having the responsibility for coordinating the patient flow at the clinical department and handling bed allocation as well as division of labour between teams and wards, the actions at a middle management and operational level are included. Activities performed by nurses or physicians to handle their daily task are not included. One reason for this is that variation in individual skills and preferences impedes the standardisation of actions to handle a variable acute patient flow. There are also actors and working teams on management and middle management level, but beside the hierarchical levels, influencing and exploiting actions to manage the variable acute patient flow. These are therefore also included.

2.5.2 DATA COLLECTION

In line with recommendations from Eisenhardt (1989), constructs from the literature were collected prior to data collection. Literature reviews concerning the concepts lean,

agile and leagile as well as strategy formation and middle management strategy involvement were used. These are further described in section 2.6.2. An interview guide that captured the constructs from the identified literature was developed (see Appendix 1 for the interview guide). Not every question was put to every respondent; instead, the interview guide was adapted for each interview. The following subjects were covered:

- Overall strategic direction and aims in managing a variable acute patient flow
- Participating actors
- What decisions are made at the different hierarchical levels
- Goals, documents, planning horizons and budget related to the planning
- Possible improvements, problems and initiatives related to the planning
- Coordination, integration and collaborations between different actors and hierarchical levels as well as external collaborations with regard to both planning and actions used
- Actions related to scheduling, staffing, task and responsibility for different actors, patient distribution and transfers, acute versus elective patients, bed management, handling patient inflow and outflow

Every semi-structured interview was recorded, transcribed and sent to the respondent for confirmation, to increase reliability and validity as recommended by Yin (2009). Unstructured observations and interviews as well as observations from meetings (for a list of the information gathering activities, see Appendix 2) were also used in order to gain an understanding of the context studied as well as actors within the system and achieve triangulation of data (Stuart et al., 2002). Since these activities were performed ahead of the semi-structured interviews, the researchers were able to gain fundamental knowledge of the daily operations, which facilitated sorting of information during the subsequent interviews as well as asking additional questions, thus strengthening validity (Stuart et al., 2002). By observing activities in different parts of the hospital while being shown the premises, during the unstructured observations, it was also possible to triangulate and evaluate statements from respondents in the semi-structured interviews.

In line with the overall research design, an exploratory approach was used during the data collection activities. This means asking open-ended questions during the interviews while also allowing the respondents to interpret the questions by not interfering except when the respondent clearly talks off topic.

During the interviews, observations and meetings, formal strategy and planning documents were not specifically asked for. Instead, specific documents were only asked for if a respondent have mentioned it on their own. Due to the number of interviews performed with respondents from different parts of the organisation, every important strategy and planning document was judged to have been identified. Moreover, formal documents that are not used in planning or decision-making have thus been disregarded.

By reporting partial results to a working team consisting of clinical department chiefs, empirical evidence could be verified. To ensure validity, the final case description was also sent to three key informants, all with in-depth knowledge of the hospitals operations, and feedback was obtained and incorporated in the description.

2.6 LITERATURE REVIEWS

Literature reviews are important components of the research process and can be used for formulation of research questions as well as in the research that follows (Punch, 2005; Tranfield et al., 2003). Several literature reviews have been performed during the research process, both systematic reviews that are transparent, replicable and scientific (Tranfield et al., 2003), together with narrative reviews with broader scopes and more iterative approaches (Bryman and Bell, 2011). In the research conducted for this licentiate thesis, systematic literature reviews have been performed to search literature within a specific subject. Narrative literature reviews have instead been used to find relevant literature that could be used to analyse empirical data. Table 2.3 shows the main literature reviews that have been conducted during the research process, including the type of review and where the findings can be found. Both types of literature reviews will be discussed in more detail below.

TABLE 2.3 – TYPES OF LITERATURE REVIEWS AND THEIR RELATIONSHIPS TO PAPERS AND CHAPTERS IN THIS THESIS

Focus area	Type of literature review		Main results found in
	Systematic	Narrative	
Healthcare logistics and SCM	X		Paper II
Overcrowding	X		Chapter 1, 4
Process mapping		X	Appendix 4
Lean, agile and leagile		X	Paper III
Strategy formation/middle management		X	Paper IV

2.6.1 SYSTEMATIC LITERATURE REVIEWS

Two systematic literature reviews have been executed in the research for this licentiate thesis. The aim of the first review was to identify the healthcare field in logistics and SCM literature, and in particular literature addressing patient flows and not physical product flows. The reason for excluding papers that address physical product flow was that these are mainly support flows to the main flow of patients.

Reviewing specific journals instead of searching in databases has been used in several literature reviews (e.g. Fabbe-Costes and Jahre, 2007; Sachan and Datta, 2005; Spens and Kovács, 2006; Van der Vaart and van Donk, 2008). Published articles that address logistics and SCM issues in health services are scattered over different research fields such as health service management, healthcare management, service management and SCM.

Terms and words are not homogenously used between these research fields. Since papers published in logistics/SCM journals are supposedly best at adopting and using logistics and SCM theories, constructs and tools in a healthcare context, it was deemed suitable to scan all articles in seven logistics/SCM journals from 2000 to 2012. After this first search phase, both the identified article references and the papers that had referred to the papers were also included in the second and third search phases of the review. An overview of the relationship between the papers in the search phases is provided in Figure 2.1. A more detailed description of the literature review is provided in Paper II.

FIGURE 2.1 – THE RELATIONSHIPS BETWEEN THE PAPERS FROM THE DIFFERENT PHASES OF THE LITERATURE REVIEW

The second systematic literature review was aimed at identifying causes, effects of and possible remedies for overcrowded EDs and inpatient wards with high bed occupancy. For this literature review the search engine UniSearch was used, searching in Academic Search Premier, MEDLINE, CINAHL, ScienceDirect and Business Source Premier among others. The term *overcrowding* is strongly associated with EDs but finding corresponding search terms for inpatient wards proved to be more difficult. Many search terms and combinations of these were therefore used (for details on the search terms and number of hits, see Appendix 3). Only full text and scholarly (peer reviewed) papers were included, and only search terms in the abstract were used. The papers were evaluated in two steps where the first step included scanning the title. If the search term appeared to be an important part of the paper’s substance, and it did not focus on a specific patient group, disease or diagnosis, the abstract was read. If the criteria for the title also held after reading the abstract, the paper was classified as relevant (see Appendix 3). Since the author read all papers that were classified as relevant, any references from these articles that met the same criteria were also read. The results from the literature were an important influence and material when writing the introductory chapter of this thesis. Some references are also used in the analysis chapter when analysing RQ2 and RQ3.

2.6.2 NARRATIVE LITERATURE REVIEWS

Narrative literature reviews have been used for three focus areas, as shown in Table 2.3. These reviews build on the snowball approach, meaning that papers or books of relevance have provided references of interest, which in their turn have included references to additional relevant literature. For the narrative literature review on strategy formation, the book “Strategy: Process, Content, Context: An International Perspective” by de Wit and Meyer (1998) was used as a starting point. Since the contribution in Paper IV is not the development of new strategy literature, but instead to extend the understanding of planning and decision-making in healthcare, traditional, well-established literature on the strategy formation process was judged to be sufficient and a systematic literature review therefore excessive.

The literature review of lean, agile and leagile had an initial focus on the concept of leagile. Since the concept has been used to a limited extent, and the published papers can thus account for previous research thoroughly, the snowball approach was an appropriate choice to easily identify influential literature regarding the concept of leagility. The concept is used to describe different combinations of lean and agile as process strategies and thus describes combinations of limited subsets of the concepts lean and agile. Lean, in particular includes both tools, methods and operative development (e.g. Bicheno 2004) as well as strategic and cultural guidance (e.g. Hines et al., 2004). The concept has been used in both industrial and public settings since the concept gained widespread attention through the bestseller “*The Machine that Changed the World*” (Womack et al., 1990). By reviewing references in the papers that described leagility, literature concerning lean and agile as process strategies could be identified.

Process mapping is essential when developing the supply chain (Murphy, 2005) and in healthcare also an important step to improve the understanding of patient needs by mapping the patient pathway (Mould et al., 2010). The literature review covering process mapping tools included searching databases within the areas of management and medicine as well as visiting and searching in libraries and talking to colleagues. The databases used were Academic Search Premier, Business Source Premier and MEDLINE. Among the search terms were; mapping tool, process mapping, flow chart and process analysis examples. The mapping tools identified through the literature review were included in the study if they were used to map a process. Tools used to support project management were however excluded. The literature review also includes the identification of what question/questions the mapping tool can answer and what analysis that the tool enables. If a mapping tool were identified with lacking or vague information about question or analysis further searches to identify these aspects were conducted.

The results from the literature review are mainly found in Appendix 4 and Appendix 5. The former is a work-in-progress paper presented the NOFOMA conference 2011 in Harstad, Norway. The paper presents the process mapping tools identified through the

literature review and also concludes which of these are most appropriate to use in a healthcare setting. The recommendations from this paper have been followed when process mapping tools have been used in subsequent research, e.g. flowcharts have been used in Paper I and III and the case report and the organisation chart was used in Paper IV and the case report. The literature identified was also used when writing a guide to logistics development for healthcare personnel (Appendix 5) commissioned by Hässleholm hospital.

2.7 SIMULATION

Simulation can be used in many situations where interactions between different types of variables is studied, in particular when studying many modern systems, such as service organisations and factories, these are so complex that simulation is one of few tools available (Banks et al., 2005). Simulation has also been successfully used in healthcare systems (Ferreira et al., 2008; Pidd, 2004) and is suitable to study the effect of changes within a system (Banks et al., 2005). Hvitfeldt Forsberg et al. (2010) have also shown that there are few papers using simulation to increase the understanding of complex healthcare systems. With the objective to increase the understanding of what consequences that a change in patient inflow, available resources, treatment times and duration of activities in a healthcare system have on bed occupancy and LOS, an approach based on simulation modelling was chosen. Changing conditions in real systems without considerable understanding of the healthcare system studied can be a risky business (Slovensky and Morin, 1997; Sterman, 2006). Simulation modelling is therefore preferable. To achieve the objective at a detailed level a simulation at an operational level was selected. In line with other simulation studies with a low abstraction level, a discrete event simulation was considered most appropriate (Hvitfeldt Forsberg et al., 2010; Tako and Robinson, 2009).

2.7.1 DESIGN

The simulation model consists of two departments at Hässleholm hospital, the ED and a department treating elderly people with co-existing diseases (department 38). The system was chosen since the arrangement of activities is representative of many healthcare systems. The decision to study Hässleholm hospital was not made by the researcher. Instead, the research group behind the cooperation with the hospital chose its partner. Hässleholm hospital has pursued long-term, dedicated improvement efforts, which have been evaluated by members of the research group, with high-quality results (e.g. Carlsson, 2003; Carlsson and Sarv, 2001). Most of the patients being admitted to department 38 are elderly being transferred from the ED. Elderly people with co-existing diseases are a group of patients who consume substantial healthcare services. According to a study by Hoffman, Rice and Sung (1996) 88% of all older adults in the United States had at least one chronic condition, and 69% had more than one chronic condition, which makes elderly people with co-existing diseases an important group to study. To ensure both practical and theoretical relevance the purpose was developed through a workshop with participants from both management and operational levels at the hospital.

In accordance with recommendations from Law (2007) and Banks et al. (2005) an iterative process comprising phases of data collection, building (in AnyLogic-software) and validating the simulation model was used. Data was mainly collected from interviews with healthcare personnel, observations at the studied departments and data for every patient that visited the ED (11,000 patients) and department 38 (1,400 patients) in 2010.

One way to lessen queue problems is to reduce service time variation, something that can be achieved by streaming patients into groups that exhibit similar service characteristics (Walley et al., 2006). Based on this premise a cluster analysis was performed for all patients admitted to department 38 in 2010. Two significant groups were distinguished, one of these, in relation to the other, consisting of older patients with more co-existing diseases as well as considerably longer LOS. Unfortunately it was not possible for healthcare personnel to medically discriminate between the groups when a patient was being admitted to the department, making it impossible to differentiate the patient flow both in the real world and in the simulation.

2.7.2 VALIDATION

Validation of simulation models is of outmost importance, and this was executed through a number of measures. To ensure high face validity (Banks et al., 2005) the model was built in co-operation with both management and healthcare personnel, something widely recommended (see for example Banks et al., 2005; Law, 2007; Reagan-Cirincione et al., 1991; Wolstenholme, 1993). To achieve transparency, and thereby increases the trust that users have in the model (Pidd, 1996), extensive documentation of the simulation model was also compiled, including the overall logic for the model as well as built in assumptions and simplifications. Representatives of the different personnel categories (management, administrative, nurses, doctors) involved in the healthcare system read the documentation and critically discussed the model's validity at an internal meeting (Banks et al., 2005; Law, 2007). Feedback was gathered and incorporated into the model. Real bed occupancy, 88%, was also compared to the modelled occupancy, $87 \pm 2\%$, and the results were satisfactory. It is important to test the simulation model's validity according to the resemblance between modelled and actual output data (Law, 2007). The Kolmogorov-Smirnov test was used to determine the similarity between modelled and actual LOS for both the ED and department 38. Mean values, confidence interval and standard deviations displayed a solid unity between modelled and actual values. The validation processes used concluded that the model of the existing system was valid.

2.8 UNIT OF ANALYSIS AND HOW THE RESEARCH QUESTIONS WERE ANALYSED

The unit of analysis is a vital component in research design (Yin, 2009), comprising the main entity analysed in a research study. It is important to distinguish whether the unit of analysis is at an individual, division, company or corporate level, depending on the research question (Flynn et al., 1990). In this thesis, the unit of analysis is how variable

patient flows are managed at hospitals. The choice of a hospital level is thus in line with the research questions.

Despite the choice of a hospital level as a level of analysis, other organisational levels are included in the thesis as well as the appended papers and case report. The fact that hospitals are made up of highly specialised clinical departments (Mintzberg, 1979; Mould et al., 2010) motivates this choice. Because of this functional specialisation, variable patient flows are managed at a departmental and hospital level, as well as any organisational level in-between. These levels are thus included. However, how individual actors within the organisation, e.g. a physician or a nurse at an ED, structure their work is not included. To include the individual level would be an overwhelming task, with considerable risk of reaching a complexity in relationships that was vast, with invalid conclusions as a result. An actor can however act as a representative of a departmental or hospital level, and their actions therefore included.

Before describing how the analysis of the research questions was performed a quick recap of the research questions is justified.

RQ1: *How do variable patient flows affect hospitals?*

RQ2: *How are variable patient flows handled at hospitals?*

RQ3: *How does the organisational configuration influence the actions used to handle variable patient flows in hospitals?*

The linkages between the research questions and the appended papers and case report are shown in Table 2.4. Even though two of the four papers are based on the case study, the case report provides in-depth information concerning the empirical material these papers are based on as well as providing information about areas that have not been included or emphasised in the papers.

TABLE 2.4 – THE LINK BETWEEN THE RESEARCH QUESTIONS AND THE APPENDED PAPERS AND CASE REPORT

	RQ1	RQ2	RQ3
Paper I	X		
Paper II	X		X
Paper III		X	
Paper IV			X
Case report	X	X	X

The analysis in this thesis has been structured based on the three research questions. Individual contributions as well as synthesis of these are therefore mixed when exploring a research question. In addition to these contributions, the analysis chapter itself

contributes to answering the research questions and purpose. Except for the literature identified in the literature reviews, no additional literature or theories are used.

The analysis was performed chronologically and thus starts with the first research question. In Paper I and the case report the variations in patient inflow are described. Paper I also studies the effects of changes in patient inflow, treatment times and duration of activities, an analysis used to compare the robustness of an inpatient ward with the ED, when under influence from variability in these variables. Based on conclusions from the case report, Paper II and some references from the literature review on overcrowding, a more qualitative analysis was performed concerning how variability in patient flows is dependent on patient group characteristics and how it influences bed occupancy.

For the second research question, contributions from Paper III and the Case report were analysed, since both describe the actions used at a university hospital to handle variable acute patient flows. The alignment between the two divisions used in Paper III and the case report is compared in the analysis. The terminology developed by The National Board of Health and Welfare concerning definitions of regular beds, overcrowding and relocation were used to expand the analysis and shed some light regarding the appropriateness of actions used. The organisational level on which each action is used, an aspect of interest for answering RQ2, is also analysed.

In the analysis of the third research question, a model was developed that lists a number of factors within organisational configuration at a hospital that influence the use of actions to handle variable patient flows. Causality between these factors is also included in the model. Paper IV and the case report provide the main contributions to the analysis, while Paper II also provides some insightful input. The model was developed by scanning the case report and Paper IV with the aim of finding factors that influenced the use of actions for handling variable patient flows. Both the influence of the factors identified and the relationships between them were evaluated based on the author's in depth knowledge of the empirical data from the university hospital. In comparison to the other research questions, a larger part of the contribution comes from the analysis chapter itself since the model are not included in any of the appended papers or case report.

3 SUMMARY OF APPENDED PAPERS

In this chapter a summary of each of the four appended papers is presented. After presenting the purpose of a paper, the summary focuses on the main results and contributions of the paper. The papers can be found in their entirety in Appendices 6, 7, 8 and 9.

3.1 PAPER I: UNDERSTANDING THE IMPACT OF VARIATION ON HEALTHCARE SYSTEMS

The variation associated with demand and supply of services strongly contributes to operating difficulties in healthcare. Understanding variability helps healthcare providers to more accurately model and address opportunities for improvement (Noon et al., 2003). Using simulation modelling to study how sensitive a healthcare system is to changes in conditions can thereby provide insight regarding the effects of variations. In Paper I, discrete event simulation was thus used with the objective to:

Increase the understanding of what consequences that alterations in patient inflow, available resources, treatment times and duration of activities in a healthcare system have on bed occupancy and length of stay.

The studied system consisted of two departments: the ED and a department treating elderly people with co-existing diseases (department 38), where a majority of the patients admitted to department 38 came from the ED. The consequences of the simulation runs, with alterations in patient inflow, available beds, treatment times and duration of activities on bed occupancy and LOS for department 38 is displayed in Table 3.1.

TABLE 3.1 – THE RESULTS FROM THE SIMULATION RUNS CONCERNING DEPARTMENT 38

Δ Patient inflow	Δ Times	Δ Beds	LOS (Days)	Δ LOS	Bed occupancy (Percentage)	Δ Bed occupancy
-20%	-	-	4.7 $\pm$ 0.2	-4.1%	71 $\pm$ 1	-21.8%
-10%	-	-	4.7 $\pm$ 0.1	-4.1%	79 $\pm$ 2	-9.2%
-	-	-	4.9 $\pm$ 0.2	-	87 $\pm$ 2	-
+10%	-	-	5.5 $\pm$ 0.5	+12.2%	91 $\pm$ 2	+4.6%
+20%	-	-	Cont. increase	-	100	-
-	-20%	-	4.0 $\pm$ 0.1	-18.4%	74 $\pm$ 2	-15.0%
-	-10%	-	4.4 $\pm$ 0.2	-10.2%	79 $\pm$ 2	-9.2%
-	-	-	4.9 $\pm$ 0.2	-	87 $\pm$ 2	-
-	+10%	-	5.8 $\pm$ 0.4	+18.4%	93 $\pm$ 1	+6.9%
-	+20%	-	Cont. increase	-	100	-
-	-	-20%	Cont. increase	-	100	-
-	-	-10%	5.8 $\pm$ 0.4	+18.4%	96 $\pm$ 2	+10.3%
-	-	-	4.9 $\pm$ 0.2	-	87 $\pm$ 2	-
-	-	+10%	4.7 $\pm$ 0.1	-4.1%	78 $\pm$ 2	-10.3%
-	-	+20%	4.6 $\pm$ 0.1	-6.1%	72 $\pm$ 1	-17.2%

For the ED, the results from the simulation runs are summarized in Table 3.2. The bed occupancy at the ED required data that was not obtainable and this measure was therefore excluded from the study.

TABLE 3.2 – RESULTS FROM THE SIMULATION RUNS CONCERNING THE ED

Δ Patient inflow	Δ Times	LOS (Minutes)	Δ LOS
-20%	-	150 $\pm$ 2	-6.5%
-10%	-	156 $\pm$ 5	-2.8%
-	-	161 $\pm$ 3	-
+10%	-	168 $\pm$ 8	+4.7%
+20%	-	184 $\pm$ 1	+8.4%
-	-20%	125 $\pm$ 3	-22.4%
-	-10%	145 $\pm$ 4	-9.9%
-	-	161 $\pm$ 3	-
-	+10%	180 $\pm$ 8	+11.8%
-	+20%	213 $\pm$ 14	+32.3%

From the tables above it was concluded that a high variation in the inflow of patients to the ED combined with highly variable treatment times and only 32 beds in department 38 make the studied departments sensitive to changes. With a bed occupancy in department 38 of approximately 90% (see Table 3.1) queuing and congestion are substantial problems (Walley et al., 2006) that create much additional work for healthcare personnel. Actions and routines used when bed occupancy becomes high therefore need to be developed. To summarize the results about the relationships between the variables studied Figure 3.1 was compiled, where the thickness of the arrows symbolises how strong the relationships between the variables are.

FIGURE 3.1 – RELATIONSHIPS BETWEEN THE SIMULATED VARIABLES

3.2 PAPER II: DEVELOPMENTS IN THE FIELD OF HEALTHCARE LOGISTICS AND SCM – A PATIENT FLOW FOCUS

Interest in healthcare logistics and SCM has increased in recent years. The potential to extend concepts, models and practices from logistics and SCM to health services has also been emphasised by several authors (e.g. Towill and Christopher, 2005; Aronsson et al. 2011; De Vries and Huijsman, 2011). It is though a novel topic. The aim of the paper were therefore to:

Provide guidance in how to develop healthcare logistics and SCM research related to patient flows

The aim was further subdivided into two research questions around which the analysis was structured:

1. What types of research have been conducted in the area of healthcare logistics and SCM?
2. What are the main challenges as identified in previous research in the field of healthcare logistics and SCM?

Paper II adopted an systematic literature review (see section 2.6.1 for description), focusing on patient flow issues, since physical product flows in healthcare are supporting flows to the main flow, i.e. that of patients.

Concerning the first research question, it was addressed by several basic analyses of the identified papers. A majority of the papers addressing healthcare focused on physical product flow, and these were thus excluded from further analyses. The number of articles with a patient flow focus published each year increased from 2003. There is a lack of quantitative studies, only 1 out of the 25 papers were analytical or simulation models, most papers instead describing conceptual models or case studies. Most papers, 20 out of the 25, also used a single unit or supply chain as the level of analysis. Only one paper used a dyadic unit of analysis. A dyadic perspective would otherwise be appropriate to study transfers of patients between clinical departments, relocation of patients or the relationship between primary and secondary care. Most papers with a supply chain focus were conceptual papers, while the papers with a single unit of analysis were predominantly case studies. These results further support the previous argument of a novel research field.

To address the second research question, three main challenges in healthcare logistics and SCM research were identified. A *complex service context* surfaced as a main challenge that needs to be addressed in research. Several factors influenced this assessment, with some examples mentioned below. A patient generates costs for several stakeholders and these costs are often borne by other stakeholders with no direct influence on the service production process, leading to an increased risk of sub-optimization (Kujala et al., 2006). The role of the patient in service production, often both as an object and co-creator (de Vries and Huijsman, 2011), and the fact that waiting times can be both positive, passive and negative for a patient depending on whether their condition is likely to improve, remain stable or deteriorate, also complicate the service context.

To handle several of the difficulties illustrated above, *increased flexibility* at different levels of healthcare provision is needed, an opinion emphasised by many authors (e.g. Aronsson et al., 2011; Bohmer, 2005; de Vries and Huijsman, 2011; Lillrank et al., 2011; Rahimnia and Moghadasian, 2010; Towill and Christopher, 2005). How to combine standardized and customized care both in terms of entire healthcare supply chains (Towill and Christopher, 2005), for individual patients (Bohmer, 2005), and everything in-between

(Aronsson et al., 2011; Lillrank et al., 2011; Rahimnia and Moghadasian, 2010) is a challenge that requires further research from the healthcare logistics and SCM field.

Treatment of patients often requires input from multiple healthcare providers and the transfer from one provider to the next is generally the weakest point in a system of healthcare providers (Adler et al., 2003; Aronsson et al., 2011; de Vries and Huijsman, 2011; Meijboom et al., 2011; Parnaby and Towill, 2008; Parnaby and Towill, 2009; Saha et al., 2009; Towill, 2006). A holistic view of the whole patient process is therefore stressed by many authors (e.g. Aronsson et al., 2011; Glouberman and Mintzberg, 2001; Kujala et al., 2006; Meijboom et al., 2011; Parnaby and Towill, 2008; Parnaby and Towill, 2009; Towill, 2006) to enable proper *coordination of multiple actors*.

3.3 PAPER III: MANAGING A VARIABLE ACUTE PATIENT FLOW – CATEGORISING THE STRATEGIES

The field of health care SCM is in its infancy; although there are some exemplary initiatives in healthcare there is a lack of academic research (Shah et al., 2008). Paper III was designed to fill some of that gap by applying the concepts of lean, agile and leagile in a study in a healthcare setting, something that has been sparsely explored, even though there are examples (e.g. Aronsson et al., 2011; Towill and Christopher, 2005; Rahimnia and Moghadasian, 2010). In healthcare, there is also a high degree of variability (Ronen and Pliskin, 2006), specifically for acute patients where the patient inflow concerning time, health issues and response to treatment is highly variable. Moreover, healthcare resources are often used inappropriately and not adapted to the variations that exist (Walley et al., 2006). The purpose of this study was therefore:

To explore if actions used at a hospital to manage a variable acute patient flow can be categorised using the concepts of lean, agile and leagile.

A single case study at a university hospital (see section 2.5 for description) was chosen to allow in-depth investigation of the actions used to handle the variable acute patient flow. Many authors discuss the use of a lean or agile strategy as a company-wide strategy or used in different combinations between the two (Kidd, 1995; Mason-Jones et al., 2000; Aitken et al., 2002). Paper III, however, explores and categorises individual actions as being lean or agile. To achieve this, both lean and agile strategies were sub-divided into three categories based on the literature. 50 actions were identified in the collected data and each was placed in one of the three agile or lean categories:

- Agile: Extending the use of a resource (7)
- Agile: Altering the amount of a resource, ahead of demand (9)
- Agile: Altering the amount of a resource, as a response to demand (12)
- Lean: An action that increases patient flow standardisation (7)
- Lean: An action that reduces the need for a resource (11)

- Lean: An action that directly manages external variation (4)

Without going into detail, most actions used can be assigned to the groups below:

- Beds – numbers, distribution between units, bed-equipment, etc.
- Personnel – staffing levels, allocation between positions, division of labour, etc.
- Admissions – distribution of patients between clinical departments, wards and beds, admission process, etc.
- Patient transfers – between clinical departments, wards and beds, division of responsibility, etc.
- Discharges – handover to local health service, discharge process, etc.

After discussing the categorisation of actions as lean or agile, the second part of the analysis discusses the use of leagile approaches, combinations of lean and agile actions, based on a time/space matrix developed by Towill and Christopher (2002). The analysis is summarized in Figure 3.2, where the three different leagile approaches and the empirical evidence for their use at the hospital are shown.

Space	Different	<ul style="list-style-type: none"> - Separating patient flows: <ul style="list-style-type: none"> - enable efficient processes - response to acute inflow - Used mostly to coordinate clinical departments 	<ul style="list-style-type: none"> - Some sub-processes specifically managed, mostly related to: <ul style="list-style-type: none"> - elderly patients - patients with complex needs - Limited usage identified
	Same	Not viable	<ul style="list-style-type: none"> - Base level of staff complemented with possibility to change levels - Admitting patients in excess - Used by clinical departments independently
		Same	Different
		Time	

FIGURE 3.2 – OVERVIEW OF THE LEAGILE APPROACHES USED TO MANAGE A VARIABLE ACUTE PATIENT FLOW

Leagile approaches of all three combinations derived from the literature are used at the hospital. These, however, are not as clear-cut as the examples in the literature and the division between the lean and agile parts of these leagile approaches is indistinct. It can also be argued that many of the actions identified as lean or agile are used to induce a change towards a process orientation by establishing a proper planning and control of the patient flows, something denoted as “lean basics” in the literature (Aronsson et al., 2011). From both parts of the analysis it can thus be concluded that the use of lean, agile and leagile concepts is more complex and not as clear-cut in a healthcare context.

3.4 PAPER IV: MANAGING A VARIABLE ACUTE PATIENT FLOW – PLANNING AND DECISION-MAKING

The organisation of a hospital is normally a complex configuration of highly specialised clinical departments (Mintzberg, 1979), through which patient flows are to be managed. A patient process often involves a large number of clinical departments, which requires a great deal of coordination in both space and time (Aronsson et al., 2011). Paper IV focuses on the management of variability in the acute patient flow, which is another factor that complicates the organisational structure of a hospital. In healthcare, there is a high degree of variability (Ronen and Pliskin, 2006), in particular when it comes to acute patients where the patient inflow fluctuates concerning time, health issues and response to treatment. The purpose of the study was therefore:

To explore the organisation of planning and decision-making of a variable acute patient flow at a hospital

A single case study at a university hospital (see section 2.5 for a description) was chosen to allow in-depth investigation of the planning and decision-making. The study focuses on the top and middle management levels in order to provide empirical evidence of the development of long-term planning as well as decision-making on both hospital and departmental level.

The analysis of the empirical evidence was divided into two parts. First, the strategy formation process was discussed from what have been labelled as two conflicting perspectives; the incrementalism and planning perspectives. Based on the three dimensions plan, people and process, the perspectives and empirical evidence were compared and the results of the analysis were that:

- Plan – An incrementalism perspective predominates concerning the use of vague visions instead of detailed plans.
- Process – The lack of formalised plans and top management decisions, together with the extensive authority of department chiefs creates a bottom-up management at the hospital, which has significant similarities with the incrementalism perspective.
- People – The formulation and implementation of plans and projects are integrated, in line with the incrementalist perspective. Coordination between groups and actors outside the hierarchy is also inhibited by unclear responsibilities and mandates. An incrementalist perspective is therefore predominant at the hospital in managing staff.

The second part explores middle management involvement in the strategy formation process at the hospital, with an emphasis on four different roles of middle management described by Floyd and Wooldridge (1992). These are based on a framework with two dimensions where the first is one that describes the direction of influence, upward or

downward, exerted on strategy by middle managers. The second dimension is one that assesses the extent to which the influence of middle managers alters the organization’s concept of strategy. An integrative influence has a limited effect on the organization’s concept of strategy, while a divergent influence changes it considerably. The roles of middle management at the hospital according to this framework are visualised in Figure 3.3.

		Behavioural	
		Upward	Downward
Cognitive	Divergent	<p>Championing</p> <p>Alters the content of strategy by communicating successful strategies from individual clinical departments and emergency flow group upward.</p>	<p>Facilitators</p> <p>Individualised strategies at the different clinical departments due to the lack of long-term goals and future states on hospital level.</p>
	Integrative	<p>Synthesizers</p> <p>Middle management gathers information on performance and prepares projects and develops bases for decision by top management.</p>	<p>Implementation</p> <p>Implementation of projects, though limited translation of top management strategy into action plans and individual objectives.</p>

FIGURE 3.3 – MIDDLE MANAGEMENT STRATEGY INVOLVEMENT AT THE HOSPITAL (ADAPTED FROM FLOYD AND WOOLDRIDGE, 1992, P. 154)

By comparing the dimensions in the framework by Floyd and Wooldridge (1992) to characteristics of the two perspectives, incrementalism and planning, it can be concluded that a divergent and upward direction of influence is associated with incrementalism and that an integrative and downward direction of influence is linked to a planning perspective. A comparison of the two parts of the analysis hence concluded that these were aligned.

In conclusion, hospitals have, yet again, proven difficult to manage strategically (Mintzberg, 1979; Denis et al., 1995; Ramanujam and Rousseau, 2006; Röthlin, 2013). The decision-making structure, with working teams that must reach unanimous decisions makes it difficult to establish a coherent strategy for managing a variable acute patient flow, while extensive authority of middle management facilitates the development of individualised strategies at different clinical departments. The lack of long-term goals and strategies concerning how the variations in acute patient flow should be managed in the hospital also hinders the control and coordination of the actions used at different clinical departments. Organisational learning thus becomes difficult to achieve both bottom-up and sideways in the hierarchies and the risk for sub-optimization increases.

4 ANSWERING THE RESEARCH QUESTIONS

This chapter seeks to find answers to the three research questions developed in the first chapter. The research questions are analysed one by one, with input from the four appended papers as well as the case report. As described in the methodology chapter, individual contributions as well as synthesis of these are mixed when exploring a research question.

4.1 RQ1: HOW DO VARIABLE PATIENT FLOWS AFFECT HOSPITALS?

The analyses for RQ1 are based on the results from Paper I and II, the case report and a literature review on overcrowding. They might come across as dispersed, therefore Figure 4.3 has been developed to provide an overview of the different conclusions and how they relate to patient flow variability. Every conclusion is summarized in a box in the figure and referred to in the text.

In Paper I, the patient inflow to the ED and an inpatient ward were mainly dependent on the time of day and the day of the week (plotted in Figure 4.1).

FIGURE 4.1 – DAILY ARRIVAL PATTERN FOR THE ED AND AN INPATIENT WARD

For the ED, the inflow is in line with previous studies (e.g. Walley et al., 2006). For the inpatient ward, a majority of the patients came from the ED, and since most patients have

an LOS at the ED of around 2-3 hours most arrivals at the inpatient ward were in the afternoon.

Similar patterns can be seen in the case report. The arrival pattern of patients visiting the ED at the university hospital is rather predictable as regards how it varies during the day and between days of the week. Patients’ health issues, however, are subject to larger variations and are thus more difficult to predict, which affects clinical departments admitting patients from the ED. For the clinical departments that admit most patients from the ED, between 0 and 10 admissions took place during office hours and a similar number during the remaining hours must be handled. For clinical departments admitting few patients/day, the variation in numbers is less problematic to handle (no. 1 in Figure 4.3). There is considerable variation on a weekly basis, but monthly and yearly variations in inflow from the ED are small.

In Paper I changes in patient inflow, treatment times and duration of activities, that can be compared to variability, for an ED and an inpatient ward was tested. The results point towards EDs being more adapted to variable patient inflow than inpatient wards (no. 2 in Figure 4.3). When comparing the effects of a changed patient inflow, the ED was more robust, with less increase in LOS due to increased patient inflow (see Table 4.1). When changing treatment times and duration of activities (Δ Times in Table 4.1), similar, although less clear-cut, conclusions can be drawn.

TABLE 4.1 – EFFECTS ON LOS IN INPATIENT WARD AND ED WHEN PATIENT INFLOW OR DURATION OF ACTIVITIES IS CHANGED

Δ Patient inflow	Δ Times	Inpatient ward		ED	
		LOS (Days)	Δ LOS	LOS (Minutes)	Δ LOS
-20%		4.7±0.2	-4.1%	150±2	-6.5%
-10%		4.7±0.1	-4.1%	156±5	-2.8 %
-		4.9±0.2	-	161±3	-
+10%		5.5±0.5	+12.2%	168±8	+4.7%
+20%		Cont. increase	-	184±1	+8.4%
-	-20%	4.0±0.1	-18.4%	125±3	-22.4%
-	-10%	4.4±0.2	-10.2%	145±4	-9.9%
-	-	4.9±0.2	-	161±3	-
-	+10%	5.8±0.4	+18.4%	180±8	+11.8%
-	+20%	Cont. increase	-	213±14	+32.3%

A high variation in the inflow of patients, highly variable treatment times and only 32 beds in the inpatient ward in Paper I make it sensitive to changes. With an average bed occupancy of approximately 90%, queuing and congestion are substantial problems (no. 3 in Figure 4.3), something also concluded in previous research (Walley et al., 2006).

Queues form when an organisation is unable to handle variation with flexibility (Silvester et al., 2004). The need for flexibility is thus an effect of variable patient flows (no. 4 in Figure 4.3). The need for increased flexibility was address as one of three main challenges

in Paper II. Many authors emphasise the need for flexibility in healthcare provision (e.g. Aronsson et al., 2011; Bohmer, 2005; de Vries and Huijsman, 2011; Lillrank et al., 2011; Rahimnia and Moghadasian, 2010; Towill and Christopher, 2005). Towill and Christopher (2005) discuss the use of standardised and customized care for groups of patients by elaborating the use of healthcare pipelines, where a pipeline refers to the flow of patients from referral to full recovery. Based on the complexity of treatment, where a more complex treatment is subject to more variation, a choice is made between standardised and customised parts of the pipeline (Towill and Christopher, 2005; Aronsson et al., 2011).

In comparison to Paper I, the case study at the university hospital in Linköping looks at a larger system, where several clinical departments and inpatient wards are included. Variation in patient outflow is also included in the study. One pattern identified is that different patient groups entail different amounts of variation. From a hospital perspective, three dimensions were found to be important when distinguishing patient groups. These dimensions are described in the case report, but two are related to variability in patient flows and how it affects hospitals and are discussed below. The third dimension is a separation between local patients, i.e. county residents, and regional patients from other counties.

Patient inflow to the clinical departments can be categorised as acute and elective, where the elective inflow are patients whose arrival is planned at the clinical department and who do not pass the ED. Acute patients are not planned and can arrive both from the ED and without passing the ED. Since the acute patient inflow for clinical departments is highly variable, as discussed previously, it requires flexibility from the clinical departments to handle.

The university hospital studied is organised for patients with organ dysfunction, as most hospitals are. Many patients have health issues where specific organs can be pinpointed and specialised clinical departments provide adequate treatment, which in many instances is made up of an orderly sequence of steps. There are, however, patients with diffuse symptoms, often with multiple diseases, that can be cared for at several clinical departments and since these general medicine patients often have several health issues, they are easily transferred between clinical departments. An internal investigation performed 2005-2006 at the university hospital in the case report concluded that approximately 40% of general medicine patients were transferred between clinical departments at least once during their care episode. With the uncertainty concerning the optimal testing strategy, the effects of a given treatment, the potential interactions of multiple diseases and treatments for these patients, Bohmer (2005) argues for an increased need for customization and a lower possible level of standardization. In contrast to more standardized care, which consists of an orderly sequence of steps, customized care is iterative because each diagnostic test or test of therapy generates new

information that influences future decisions (Bohmer, 2005; Lillrank et al., 2011). The relationship between patient flow variability and the two dimensions discussed above are visualised in Figure 4.2 (no. 5 in Figure 4.3).

FIGURE 4.2 – PATIENT FLOW VARIABILITY IN RELATION TO PATIENT GROUP CHARACTERISTICS

As described in the case report, variation in bed utilization, and specifically bed shortage, is an important issue at the hospital. This problem is demonstrated by having hospital coordinators, with prime responsibility to continuously monitor the bed situation and choose appropriate actions when bed shortages occur. For the internal medicine on-call group at the hospital, lack of available beds is also an almost everyday occurrence. It is the clinical departments within the internal medicine on-call group that care for acute general medicine patients, those with the highest patient flow variability according to Figure 4.2. Increased patient flow variability thus seems to increase variability in bed utilization and thereby problems with bed shortage (no. 6 in Figure 4.3).

Previous research also suggests that patient flow variability is a cause of bed shortage and ED overcrowding. A mismatch between admission and discharge variations over the course of the day and the week, often with most admission activity taking place before a corresponding amount of discharge activity (Proudlove et al., 2003) often creates fluctuating and higher bed occupancy than would be the case if there was a match between the two. Travers et al. (2008) also claim that the issue of high bed occupancy within acute hospitals partly stems from a mismatch between demand and supply as regards places in permanent care facilities, since elderly patients with high care needs cannot be accepted by permanent care facilities and thus block bed at inpatient wards. Bed-blocking can also be a problem if patients from a specialised inpatient unit cannot be transferred to a revalidation unit when they are ready and thus block beds for patients in need of specialised treatment (Andersson and Karlberg, 2000). In all these examples, variation in patient inflow and outflow in terms of number of patients is mismatched, leading to bed shortages (no. 7 in Figure 4.3).

Bed shortages in inpatient wards have also been considered to be a major cause of ED overcrowding (no. 8 in Figure 4.3). In a small survey, where ED personnel estimated the impact of different causes on overcrowding, Schiff (2011) concluded that downstream issues were a major group with on average 63% impact, compared to intra-ED flow with 20% and upstream issues at 18%. Through a systematic literature review in the field of ED overcrowding, Hoot and Aronsky (2008) summarize the most common studied causes of ED overcrowding, and two of six were related to downstream issues, namely inpatient bed-blocking and hospital bed shortage.

As described at the beginning of this section, Figure 4.3 below summarizes the conclusions concerning RQ1. To be clear, there are certainly more relationships between the boxes in the figure and other unidentified “boxes”. The boxes and relationships visualized are those identified in the research performed for this licentiate thesis.

FIGURE 4.3 – HOW VARIABLE PATIENT FLOWS AFFECT HOSPITALS

An overall conclusion is that when the system boundaries are widened and a larger system studied, the inclusion of more variables and thus more relationships between variables rapidly increase the complexity. This became apparent when comparing the simulation with the case study. Having a system perspective also becomes vital in managing the complexity of the larger system.

4.2 RQ2: HOW ARE VARIABLE PATIENT FLOWS HANDLED AT HOSPITALS?

The actions used at the university hospital to handle variable acute patient flows have been categorised based on two different approaches. The first is presented in the case report and is designed to fit the empirical findings as well as present the empirical material clearly. In the second categorisation, presented in Paper III, the categories are developed from theory on lean and agile as process strategies. These two categorisations are thus not developed to be coherent; how they relate to each other will however be discussed, but first the actions used at the university hospital to handle variable acute patient flows will be presented. To shed some light regarding the appropriateness of the actions used, the

terminology developed by The National Board of Health and Welfare concerning definitions of regular beds, overcrowding and relocation will be used.

The actions used at the university hospital to handle variable acute patient flows were divided into four categories in the case report. The categories were based on the perspective of the hospital as a system where the ED's primary task is to investigate and provide a diagnosis that decides into which clinical department a patient is admitted, while the clinical department where the patient is admitted provides further diagnosis, treatment and care and discharges the patient. Hence, the first category were related to handling the patient inflow, e.g. to avoid unnecessary admissions by different actions. Concerning inflow, the actions identified were focused on using other types of healthcare instead of inpatient care in a hospital ward.

Actions that enable efficient acute patient flows within the hospital make up the second category. In this category, many actions concern different ways of adapting the supply of care provision to demand. Distributing admissions evenly between clinical departments is an aspiration, even though it is only general medicine patients that can be admitted to different clinical departments, as discussed in the previous section. Adapting beds and wards to patient needs and adapting staffing to patient inflow are other actions within the category.

The third category relates to working with the outflow. Many actions used to create an efficient outflow concern the timing and planning of the discharge process, for example by preparing discharge in parallel with treatment. Achieving discharges early in the day is another action used to some extent at the hospital.

Like the second category, the fourth category contains actions with the aim of adapting supply of care services to demand, i.e. some sort of flexibility. The main difference between the second and fourth category is that the latter includes actions that are used as a response to variations in demand, instead of being proactive actions like those in the second category. Since it is not explicitly decided how many beds are allocated for acute and elective patients at most clinical departments, the proportion of elective and acute patients is allowed to vary.

A regular bed is defined by The National Board of Health and Welfare (2012, p. 17, author's translation) as "a bed within inpatient care with the physical layout, equipment and staffing necessary to secure patient safety and work environment". When all regular beds are occupied at a clinical department a frequently used action is to admit patients to additional beds. The use of an additional bed is defined as overcrowding by the same institution if the "admitted patient is being cared for under circumstances that do not fulfil those of an regular bed" (The National Board of Health and Welfare, 2012, p. 18, author's translation). At the university hospital, additional beds are often located in rooms intended for other uses, such as communal spaces or offices. The number of additional

beds (see appendix 1 in the Case report for an account for each clinical department) is decided by each clinical department and is considered when deciding staffing levels. The additional beds are often used by many clinical departments and are generally considered to be unproblematic to use. Nevertheless, according to the definition above, the use of the additional beds can be called overcrowding.

A patient is evaluated as being relocated if he or she is “a registered patient who is being cared for at a care unit other than the one that has the medical expertise and medical responsibility for the patient” (The National Board of Health and Welfare, 2012, p. 18, author’s translation). Relocation is an action used at the university hospital in different ways:

- To enable a patient at the ED to be admitted to a bed at an appropriate clinical department.
- A patient can also be placed in a bed at a clinical department directly from the ED as a relocated patient from another clinical department that does not have any available beds.
- Patients can also be relocated in speculation, before there is a patient in need of the bed.

To counteract strain on healthcare resources, a choice can be made to decrease or stop the elective intake at one or several clinical departments. The most extreme action, used to counteract great strain on healthcare resources at the hospital, is to open an entire additional ward. It is only used a few times a year, when the demand for beds exceeds the supply for a longer period of time.

In Paper III, the actions used at the university hospital to handle variable acute patient flows were categorised using three lean and three agile categories. These are listed below, together with the number of actions denoted within each category. Below each category, there is a comment on how the actions were categorised with the four categories in the case report:

- Agile: Extending the use of a resource (7)
 - Predominantly flexibility category
- Agile: Altering the amount of a resource, ahead of demand (9)
 - Mix of the categories efficient flow, flexibility and outflow
- Agile: Altering the amount of a resource, as a response to demand (12)
 - Predominantly flexibility category
- Lean: An action that increases patient flow standardisation (7)
 - Predominantly efficient flow category
- Lean: An action that reduces the need for a resource (11)
 - Evenly between inflow and outflow categories

- Lean: An action that directly handles external variation (4)
 - Mix of the categories efficient flow, flexibility and inflow

As concluded in Paper III, actions from every lean and agile category were used at the hospital. Several actions within the agile category “alter the amount of a resource as a response to demand” were used at the hospital. This can be deduced to insufficient level of the other two agile categories, since they are used more proactively.

Virtually all actions in the flexibility category in the case report were placed in an agile category in Paper III, while basically all actions in the efficient flow category in the case report were placed in a lean category in Paper III. These results are not surprising, since flexibility is associated with agility (Aronsson et al., 2011; Christopher and Towill, 2000), and the aim to continuously eliminate waste within lean constitutes going towards efficiency in the primary flow (Womack et al., 1990). The two categorisations thus seem to be in line with each other.

When deliberating the actions used to handle variable acute patient flows, most are used to handle the effects of the variation, not the variation itself. For example, only four out of the fifty actions handle external variation directly, and thus patient flow variability, as can be seen from the list above. Nor is it individual variations, such as patient inflow, that are handled but the combined effect of the variations in several variables. An effect of variable patient flows is bed shortages, a relationship identified in the previous section and visualized in Figure 4.3. Much time and effort are spent handling bed shortages at the university hospital and this was a recurrent topic in the interviews. The number of available beds is easily measured and a clear indicator of the utilization of resources at the hospital; it is therefore not strange that it has been given a lot of attention. The utilization of other resources also varies of course, but can be more complex to measure, such as personnel, or harder to change quickly, such as rooms and buildings. Nor is it surprising that the difficulties with bed shortages were prominent with the explorative approach used in the data collection (see section 2.5.2).

In Paper III, the fifty actions identified at the university hospital are summarized. The paper does not, however, discuss the organisational level on which each action is used, an aspect of interest for answering RQ2. Summarising the number of actions used at different organisational levels from Appendix 2 in Paper III thus gives Table 4.2

TABLE 4.2 – NUMBER OF ACTIONS USED AT DIFFERENT ORGANISATIONAL LEVELS

Organisational level	Number of actions
Clinical department	29
Between clinical departments	6
Hospital	11
Between hospital and local health services	3
Between hospitals	1

Before discussing the implications of the distribution on different organisational levels among the actions, the separation between actions on hospital and departmental level needs to be explained. Actions on a hospital level are decided to be applied by top management and/or have the aim to have positive effects for the hospital as a whole. The use of the actions can still be at a departmental level. Examples are to divide acute patients that need admission to an inpatient ward evenly between clinical departments or have assistance evaluators located at the hospital, which enables faster and smoother discharge planning. Actions at a departmental level are often developed at a clinical department and used with the aim of some improvement for the clinical department and departments that use the action. Examples include having beds allocated for patients who are expected to be discharged within 24 hours or two clinical departments sharing a joint ward for patients with short LOS and small deviations from expected LOS.

Many actions are used at a departmental level (35), while few (15) are used at a hospital level. As discussed in the introduction chapter managing components individually, without consideration of the impact on the larger system, the risk of sub-optimization is very great (Stock and Lambert, 2001). Hence, there is a need for more actions on a hospital level. There can always be good and less good actions being developed both at a departmental and hospital level, but the risk of developing actions that generate sub-optimization is lower at a hospital level. The fact that many actions are used at a departmental level will be deliberated in the section below when the influence of the organisational configuration upon the handling of variable patient flows are deliberated.

4.3 RQ3: HOW DOES THE ORGANISATIONAL CONFIGURATION INFLUENCE THE ACTIONS USED TO HANDLE VARIABLE PATIENT FLOWS IN HOSPITALS?

Figure 4.4 has been developed to address the third research question. It shows factors within the organisational configuration at a hospital that influence the use of actions to handle variable patient flows. Causality is visualised by arrows, where boxes 5 and 6 are preceded by the other four boxes. These relationships are not comprehensive and other relationships exist. For a description of how the model was developed, see section 2.8.

FIGURE 4.4 – RELATIONSHIPS BETWEEN FACTORS WITHIN THE ORGANISATIONAL CONFIGURATION THAT INFLUENCE THE USE OF ACTIONS TO HANDLE VARIABLE PATIENT FLOWS.

As described in the case report, the operational structure of the county council is arranged around divisions with operations at several hospitals. To simplify and improve decision-making concerning local and hospital specific issues, such as how to handle acute patient flows, the hospital management team was established. The emergency flow group, a subordinate group to the hospital management group was also established, whose responsibility it is to plan, coordinate and develop a well-functioning and secure acute patient flow originating from the ED. All decisions taken by these groups have to be agreed on by all members, making it difficult to establish a coherent strategy for handling a variable acute patient flow at the hospital (box 1 in Figure 4.4).

As concluded in Paper IV, this decision-making structure can be a partial explanation for the lack of long-term goals and strategies concerning how the variations in acute patient flows should be handled at the university hospital (box 2 in Figure 4.4).

In the planning concerning how many beds should be open during summer and Christmas at the university hospital, there is no authority that decides how many beds should be open in total. Instead, every clinical department is basically allowed to decide for themselves. Previous research has also concluded that the organisational configuration of hospitals as professional bureaucracies is difficult to manage strategically (Mintzberg, 1979; Denis et al., 1995; Ramanujam and Rousseau, 2006; Röthlin, 2013), something also concluded in Paper IV. Highly specialised clinical departments (Mintzberg, 1979) often guard their decision-making and professional practices against the influence of top management and other organisational structures (Ho et al., 1999). The lack of strategic direction at the university hospital can hinder the control and coordination of the actions used at different clinical departments, rendering them more similar to separate organisations. The possibility to make decisions on top management level concerning variables important in handling variable acute patient flows; such as beds, personnel, admission, patient transfers and discharges is therefore limited. When deliberating the actions used for handling acute patient flows at the hospital in Paper III and the case report, most actions were on a departmental level. These results point towards clinical departments having extensive authority (box 3 in Figure 4.4).

In Paper II, coordination of multiple actors was identified as one of three main challenges for healthcare logistics and SCM, and the transfer of patients from one provider to the next was generally the weakest point in a system of healthcare organisations (Adler et al., 2003; Aronsson et al., 2011; de Vries and Huijsman, 2011; Meijboom et al., 2011; Parnaby and Towill, 2008; Parnaby and Towill, 2009; Saha et al., 2009; Towill, 2006). Since organisations in a healthcare supply chain typically have no financial exchange for services as a patient moves from one organisation to another, the downstream organisation (who receive patients from upstream organisations) have little power over upstream organisations to dictate the process used to perform the work, the pace at which the work is done, or the quality of the outcome (Saha et al., 2009). At the university hospital, clinical departments that do not have the capacity to admit patients from the ED or another clinical department often hinder the flow of acute patients. In this instance, the downstream member of the supply chain has more power to dictate the process. In either case, the flow of patients is encumbered.

As concluded in Paper IV, shared responsibility for general medicine patients and different funding for acute and elective patients together with the different shares of elective and acute patients for different clinical departments holds incentives for clinical departments to act in ways that are unfavourable for other clinical departments. Unclear responsibility borders and interfaces have the effect that when considering the hospital as a system, the risk of sub-optimization is obvious. Departmental collaboration is thus evaluated as being hindered by the extensive authority of clinical departments (box 4 in Figure 4.4).

As described in the case report, there are several official positions established to operationally handle the acute patient flows on a hospital level (box 5 in Figure 4.4). At the clinical departments, the coordinators, the doctor on duty, if any, and sometimes the department chief are operationally involved. With the extensive authority of clinical departments, and vague mandates for the hospital coordinators, operative managing doctors and chief medical officers spends much time and resources discussing and considering appropriate responses to current events, such as to which clinical department a patient at the ED should be admitted. Similar observations are upheld by Proudlove and Boaden (2005). They argue that bed shortages and high bed occupancy often led to a concentration on juggling the placement of admissions: bed-finding and fire fighting. Many of the decisions related to finding short-term solutions involve resolving conflicts, for example the competition for beds between emergency and elective admissions, and the appropriateness of placement versus where beds are available. Without clear long-term goals and strategic direction for the hospital as a whole it becomes harder to evaluate the interests of clinical departments versus the interests of the hospital, and more time and resources are spent operationally handling the flow of acute patients. The development of actions for handling acute patient flows thus becomes more complicated.

As concluded in Paper IV and in the previous analysis, the extensive authority of middle management facilitates the development of individualised actions at different clinical departments. The lack of long-term goals and future states concerning how the variations of acute patient flows should be handled in the hospital also hinder the control and coordination of the actions used at different clinical departments. This also inhibits organisational learning at the hospital, both bottom-up and sideways in the hierarchies (box 6 in Figure 4.4). In Paper IV it was further concluded that if organisational learning had been on more sufficient levels at the hospital, feedback loops would have been clearer and adoption of successful actions between clinical departments more widely used.

5 CONCLUSIONS AND PROPOSITIONS

In this chapter the conclusions for each research question are synthesised in order to answer the purpose of the licentiate thesis. The second section of the chapter provides propositions for future research and practice. These propositions are primarily based on the author's evaluation and identification of patterns in the research material reported in this thesis.

5.1 RETURNING TO THE PURPOSE

Healthcare is a large industry faced with major challenges, such as decreased inpatient bed numbers (Sveriges Kommuner och Landsting, 2010), increases in the share of elderly patients (Socialdepartementet, 2010) that require improved efficiency and effectiveness. At the same time, the complexity of healthcare services generates much variation, something healthcare resources have not been adapted to (Walley et al., 2006). The primary flow that needs to be handled in healthcare is that of patients. With the functional organisation of hospitals, made up of highly specialised clinical departments (Mintzberg, 1979; Mould et al., 2010), there is an obvious risk of sub-optimization when handling variable patient flows. In this licentiate thesis, an exploratory approach based on a system perspective have therefore been applied to study how variable patient flows are managed at hospitals. The purpose was hence:

To explore how variable patient flows are managed in hospitals

The purpose was further divided into three research questions, namely:

RQ1: *How do variable patient flows affect hospitals?*

RQ2: *How are variable patient flows handled at hospitals?*

RQ3: *How does the organisational configuration influence the actions used to handle variable patient flows in hospitals?*

By addressing the three research questions, understanding of how variable patient flows are managed in hospitals has been increased and the purpose of this thesis thus answered. As discussed in section 1.7, the term ‘managed’ includes both the actions used to handle variable patient flows and the organisational configuration. The first research question also contributes to the purpose by influencing the other two research questions. The relationships between the research questions have not been addressed explicitly so far, and this contribution will therefore be discussed in this section. The relationships are summarized in Figure 5.1, where the major results from each research question are shown.

RQ3: Influence of organisational configuration

FIGURE 5.1 – RELATIONSHIPS BETWEEN THE RESEARCH QUESTIONS

The effects of variable patient flows (RQ1) influence how variable patient flows are handled (RQ2). There are several examples in the research where this relationship is displayed. One effect of patient flow variability, the need for flexibility, is matched by having 28 out of the 50 actions being categorised as agile ones (see Figure 5.1). Bed shortages and overcrowding are effects of patient flow variability that much time and effort are spent handling at the university hospital.

As emphasised in section 1.7, the way the variability is handled (RQ2) also influences the impact of variable patient flows (RQ1). The results from Paper I and the case report support this statement. Being better at handling variable patient flows decreases the negative effects of the variation. EDs and clinical departments with a large share of acute patients for example seem better at handling variable patient flows, preventing them from becoming overcrowded as easily.

The linkage between the second and third research questions is fairly straightforward. The actions used to handle variable patient flows (RQ2) are under the influence of the organisational configuration at the hospital (RQ3). One example is that many actions are used at a departmental level (35), while few (15) are used at a hospital level (see Figure 5.1) since the clinical departments have extensive authority in combination with a lack of long-term goals and decision-making by unanimous decisions at top management levels. The fact that departmental collaboration is hindered by the almost self-governing clinical

departments can be related to only 6 actions are categorised as being used between clinical departments while 35 are used internally at clinical departments (see Figure 5.1).

How variable patient flows affect a hospital (RQ1) is also influenced by the organisational configuration (RQ3). This is particularly true when considering the departmental level of the hospital. As concluded above, being better at handling variable patient flows decreases the negative effects of the variation, e.g. overcrowding. With a lack of long-term goals and vision concerning how variable patient flows should be handled at a hospital level, most actions used at a departmental level are allowed. By allowing clinical departments to not admit patients whom they are not sure have health issues that correspond to their speciality, other clinical departments are obliged to accept these general medicine patients. The variability in patient inflow, and the effect that variability has on the clinical department, is thereby altered by the organisational configuration.

5.2 PROPOSITIONS FOR FUTURE RESEARCH AND PRACTICE

The research performed for this thesis is based on a system perspective where both horizontal and vertical levels are acknowledged, by studying both the vertical organisational hierarchies and horizontal patient flows. Since this thesis is based on research conducted in collaboration with two hospitals, the generalizability can be discussed. However, understanding of the complexity in healthcare provision from a holistic perspective has been acquired. Therefore, propositions, with the aim to guide future research and practice, have been developed. These are primarily based on the author's evaluation and identification of patterns in the research material reported in this thesis. The requirements concerning empirical and theoretical support are therefore less rigid in comparison to the conclusions section presented above. Some of the propositions are closely related to the purpose of this thesis and some are stand-alone observations assimilated during the research process. Relevance to future research and practice has been a guiding principle when developing the propositions.

As concluded in section 4.2, actions from both lean and agile categories are used at the university hospital. With a fairly even division of lean and agile actions, both types of actions for handling variable patient flows appear to be needed. Limited previous research concerning the use of lean (Radnor et al., 2006) and other management philosophies, such as agile, in the healthcare sector (de Vries and Huijsman, 2011) justify some recognition to the conclusion. Hence:

Proposition 1: *Both lean and agile actions are used, and needed in hospitals to handle variable patient flows.*

The use of both lean and agile actions is a positive result; for instance, the use of a base-level of staff and beds, complemented with a preparedness to quickly increase staff and available beds if the need arises, one of four leagile approaches in Paper III, may be an appropriate combination of lean and agile in healthcare services.

Another of the four leagile approaches in Paper III, separating patient flows, was distinguished in many of the actions used to handle a variable acute patient flows at the university hospital. Most of these actions were used when a clinical department could not handle their patient inflow. There were, however, some actions used to separate patient flows to enable more efficient processes. One example was to require clinical departments that normally admit acute patients to cancel their elective intake to protect clinical departments with only or predominantly elective patients from having to do the same, and thereby be given the possibility to adopt more lean processes. An agile approach, designed to accommodate unpredictable demand (Christopher and Towill, 2000) would be more appropriate for clinical departments admitting a larger share of acute patients. Thus:

Proposition 2: *To protect certain clinical departments from variable patient flows, and allowing these to adopt lean processes, by requiring other clinical departments to handle these variable patient flows, by having agile processes, could lead to increased efficiency for the hospital as a whole.*

In the analysis for RQ3, it was concluded that departmental collaboration is hindered by the almost self-governing clinical departments and many positions are therefore operationally involved in handling acute patient flows (boxes 4 and 5 in Figure 4.4). There are also only 6 actions being used between clinical departments, indicating a lack of collaboration (see Table 4.2). To limit the time and effort spent discussing and deliberating the boundaries between the clinical departments' assignments, a clearer separation of these assignments would be appropriate. Basing the assignments for clinical departments on patient group characteristics and thus patient flow variability, as described in Figure 4.2, could be one way of achieving this. As argued in proposition 2, agile actions are suitable to accommodate unpredictable demand while lean actions are more appropriate when handling predictable demand. The third proposition therefore suggests:

Proposition 3: *A clearer separation of patient flows, where acute general medicine patients are handled by agile actions and elective specialist patients by lean actions, could lead to increased efficiency for the hospital as a whole.*

Concerning RQ2, it was concluded that a majority of the actions used in handling variable acute patient flows handle the effects of the variation, not the variation itself. There were only four out of the fifty actions that directly handled patient flow variability (see section 4.2). An effect of variable patient flows is bed shortages, a relationship identified and visualized in Figure 4.3. Much time and effort are spent handling bed shortages at the university hospital. It has been a recurrent topic in the interviews and there are many official positions that have been established to operationally handle the acute patient flows on a hospital level (box 5 in Figure 4.4). These often concentrate on organising the placement of admissions from the ED, where many decisions are related to finding short-term solutions to resolve conflicts, such as the competition for beds between acute and elective admissions or the appropriateness of placement versus where the available beds

are. This has previously been argued by Proudlove and Boaden (2005), and calls for the next proposition:

Proposition 4: *It is predominantly the effects of patient flow variability, and in particular the issue of bed shortages, that are handled at hospitals, not the variability itself.*

From Table 4.2 it can be seen that many actions also are used at a departmental level, while few are used at a hospital level. In section 5.1 this was related to the extensive authority of clinical departments, lack of long-term goals and the fact that decision-making are accomplished by unanimous decisions at top management levels. Many positions are also operationally involved in handling the acute patient flow (box 5 in Figure 4.4) and much time and effort are spent discussing and deliberating the boundaries between the clinical departments. Stock and Lambert (2001) claim that when components are managed individually, without consideration of the impact on the larger system, there is a substantial risk of sub-optimization. Hence, there is a need for more actions on a hospital level since these actions have lower risk of generating sub-optimization. Therefore the following proposition claims:

Proposition 5: *To decrease sub-optimization and protection of boundaries between clinical departments there is a need for more actions on a hospital level for handling variable patient flows.*

As concluded in Paper III, several actions in the agile category that “alter the amount of a resource as a response to demand” are used at the hospital. This can be attributed to an insufficient level of the other two agile categories, since these are used more proactively. With a larger share of proactive actions, the reactive actions are needed more infrequently and thus the work for personnel in employing these actions is decreased. Hence:

Proposition 6: *There is a need for more proactive actions for handling variable patient flows at hospitals.*

The last proposition is based on a finding from analysing RQ3, namely that clinical departments have extensive authority (box 3 in Figure 4.4), rendering them similar to separate organisations. As previous authors have concluded, the organisation of a hospital is also a complex configuration of highly specialised clinical departments (Mintzberg, 1979), with patient flows that often involve a large number of clinical departments, and thus requires much coordination both in space and time (Aronsson et al., 2011). One main challenge, identified in Paper II, is that the transfer from one healthcare provider to the next is generally the weakest point in a system of healthcare providers (Adler et al., 2003; Aronsson et al., 2011; de Vries and Huijsman, 2011; Meijboom et al., 2011; Parnaby and Towill, 2008; Parnaby and Towill, 2009; Saha et al., 2009; Towill, 2006). From a system perspective, it is important to understand and manage a system as a whole to achieve efficiency and effectiveness (Langley et al., 2008). When working with healthcare SCM (defined in Paper II) the findings in this thesis point to the importance of realising

and addressing two levels of systems: one where the hospital is a supply chain entity and one where the clinical department is a supply chain entity. Thus, the final proposition:

Proposition 7: *There is a need to understand and address Healthcare SCM from two standpoints: one where the hospital comprises a supply chain entity and one where the clinical department comprise a supply chain entity*

The propositions presented above were developed with the aim to guide future research and practice. To enhance the applicability of the propositions for further research, the objective has been to develop propositions that are specific. The research and propositions presented above also illustrate the need for a system perspective where both the effects of variable patient flows as well as the actions and how the organisation influence these actions are acknowledged in the research. It also indicates a field in need of further research to increase understanding of how variable patient flows are managed at hospitals.

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APPENDIX 1

INTERVIEW GUIDE

INTERVJUFRÅGOR BRUTTOLISTA

STRATEGIER FÖR ATT HANTERA VARIATION

ÖVERGRIPANDE ARBETE FÖR ATT HANTERA VARIATION

- Kan du övergripande beskriva hur strategierna för att hantera ett varierande akutflöde ser ut?
- I den position som du arbetar i, vad kan du göra för att hantera variation i akutflödet?
 - Finns det några begränsningar i vad du kan göra?

KOORDINERING

- Hur koordineras det arbete du utför för att hantera variation i akutflödet med andra runt omkring dig?
- Har ni något samarbete med andra befattningar/avdelningar/kliniker inom sjukhuset i relation till ett varierande akutflöde?
- Har ni något samarbete med externa aktörer utanför sjukhuset (såsom patientinflödet på akutmottagningen och kommunens agerande) i relation till ett varierande akutflöde?

OPERATIV FLEXIBILITET

- Mäter och följer ni någon typ av variation, exempelvis variation i vårdtid, patientinflöde, beläggning?
- Hur hanteras toppar i beläggning och patientinflöde orsakade av akutflödet?
 - Har ni möjlighet/tid att förbereda er och i så fall, hur långt i förväg?
 - Ringer ni in personal?
 - Flytta personal eller förändra personalens arbetsuppgifter?
 - Strypa det elektiva flödet?
 - Andra åtgärder?
 - Nedanstående hämtade från *Handlingsplan vid vårdplatsbrist*:
 - Tillfälligt upprättande av extra vårdplatser
 - Minskad elektiv verksamhet
 - Vårdplatsmöte
 - Samverkan över länet (flytta patient till motsvarande enhet på annat sjukhus)
 - Utskrivningsklara patienter (flyttas temporärt till annan enhet på sjukhuset)
 - Flyttning av patient till annan klinik
 - Ställningstagande till vård i hemmet
 - Överbeläggning
 - Beredskapsavdelning
- Hur hanteras ett akutflöde som är mindre än ”normalt”?
 - Skickar ni hem personal?
- Finns det någon skillnad i förfarande vid behov av att ringa in och/eller skicka hem personal beroende på vilken personalkategori det gäller?
- Görs någon separation mellan akutpatienter med olika komplexa sjukvårdsbehov på den enhet du arbetar?

SCHEMALÄGGNING

- Vilka övergripande faktorer tas hänsyn till vid bemanningsplanering (ex. beläggning, kompetens, enskilda önskemål)?
 - Anpassar ni bemanningen efter variationer i akutflödet, exempelvis baserat på prognoser av akutinflödet?

PROBLEM OCH MÖJLIGHETER

- Vilka problem ser du med det nuvarande sättet att hantera akutflödet?
- Hur skulle du vilja förbättra det?

PLANERINGSARBETE FÖR ATT HANTERA VARIATION

ÖVERGRIPANDE PLANERING SAMT ER DEL I HELHETEN

- Kan du övergripande beskriva hur planeringen för att hantera ett varierande akutflöde ser ut?
 - Vilka aktörer (personer/befattningar/grupper) är delaktiga?
 - Vilka typer av beslut tas på olika nivåer i organisationen?
- Utifrån bilden nedan, hur kopplas er del i planeringsarbetet med de andras?
 - Vad är det som lämnas över mellan de olika nivåerna
 - Vilka beslut tas på er nivå?
 - Har ni kontakt med andra nivåer som inte är omedelbart ovanför eller nedanför er hierarkiskt?

PROBLEM OCH MÖJLIGHETER

- Vilka problem ser du med det nuvarande planeringsarbetet?
- Hur skulle du vilja förbättra planeringsarbetet?

PLANERINGSARBETET I DETALJ

- Finns det uppsatta mål och/eller vision med i planeringen?
 - Finns det någon budget kopplad till dessa?
- Finns det någon dokumenterad handlingsplan/planering för hur ett varierande akutflöde ska hanteras?
 - Hur har denna tagits fram?
 - Kontrolleras det att planen följs och i så fall hur?
 - Finns det någon budget kopplad till planen?
 - Kan vi ta del av den?

- Kommer handlingsplanen att revideras med jämna tidsintervall?
- Finns det några alternativa handlingsplaner som kan göras verksamma vid specifika omständigheter?
- Varifrån kommer initiativ och förslag på förbättring av den nuvarande strategin?
 - Hur hanteras förbättringsförslag?
 - Om du fick en idé, hur skulle du gå till väga för få möjlighet att testa den?
- Hur tas externa faktorer som ligger utanför sjukhusets kontroll (såsom patientinflödet på akutmottagningen och kommunens agerande) med i planeringen?
- Används några hjälpmedel av något slag i planeringsarbetet?
- Finns det tid avsatt för förbättringsarbete kring dessa frågor?

Hur långt framåt planeras det för (planeringshorisont)?

APPENDIX 2

INFORMATION GATHERING ACTIVITIES

Type	Position/organisational unit	Organisational unit/level	Duration (h)
Observation, meeting	AIM group	Local Health Care Service (division)	1
Unstructured interview	Department Chief	Department of Emergency	2
Observation, meeting	Acute flow group	Hospital	2
Unstructured interview/unstructured observation	Coordinator	Department of Cardiology	4
Unstructured interview	Hospital coordinator	Department of Emergency	0,5
Unstructured interview	Business developer	Department of Emergency	0,5
Unstructured interview	Chief Medical Officer	Hospital	2
Unstructured interview/unstructured observation	Coordinator	Department of Geriatric Medicine	3
Unstructured interview/unstructured observation	Hospital coordinator	Department of Emergency	3,5
Unstructured interview/unstructured observation	Doctor on duty	Department of Emergency Medicine	4
Unstructured interview	Assistance evaluator	Municipality	1
Observation, meeting	Acute flow group	Hospital	2
Semi structured interview	Division Chief	Cardiology and Speciality Medicine Centre (division)	1
Observation, meeting	Acute flow group	Hospital	2
Semi structured interview	Healthcare Director	Hospital	1,5
Semi structured interview	Chief Medical Officer	Hospital	1,5
Semi structured interview	Division Chief	Local Health Care Service (division)	1,5
Semi structured interview	Department Chief	Department of Surgery	1,5
Semi structured interview	Department Chief	Department of Cardiology	1,5
Observation, meeting	Hospital management group	Hospital	2,5
Semi structured interview	Department Chief	Department of Neurology	1
Semi structured interview	Department Chief	Department of Emergency Medicine	1,5
Observation, meeting	Acute flow group	Hospital	2

APPENDIX 3

SEARCH TERMS AND NUMBER OF HITS FOR SYSTEMATIC LITERATURE REVIEW

Search term 1	Search term 2	Search term 3	Hits	Relevant
Health*	Overcrowd*		1017	
"Health care" OR healthcare	Overcrowd*		294	13
Health*	"Bed gridlock"		0	
Health*	"Hospital access"		27	0
Health*	"Access block"		31	0
Health*	"Bed-block"		31	5
Health*	"Inpatient capacity"		35	0
Health*	"Bed crisis"		11	0
Health*	"Resource utilization"		2986	
Health*	"Resource utilization"	bed*	66	0
Health*	"High Resource utilization"		12	0
Health*	"bed utilization" OR "bed utilisation"		0	
Health*	"bed utilization" OR "bed utilisation"		43	0
Health*	"utilization of bed" OR "utilisation of bed"		12	0
Health*	"Utilization pattern" OR "utilisation pattern"		1484	
Health*	"Utilization pattern" OR "utilisation pattern"	bed*	15	1
Health*	"Bed management"		30	1
Health*	"Blocked bed"		4	1
Health*	"Bed flow"		4	1
Health*	"Patient flow management"		3	0
Health*	"Bed occupancy"		140	9

APPENDIX 2

METHODOLOGY FOR SYSTEMATIC LITERATURE REVIEW ON CROWDING OUT

1 SYSTEMATIC LITERATURE REVIEW ON CROWDING OUT

Literature reviews can be used for formulation of research questions as well as in the research that follows, and are important components of the research process (Tranfield et al., 2003). A systematic literature review have been performed around the concept of crowding out, meaning that the literature review strives for transparency, being reproducible and scientifically performed (Tranfield et al., 2003). The literature review has been performed in order to identify previous research addressing crowding out effects and to formulate purpose and research questions in Paper IV. The concept crowding out is mostly used, but since crowding in is another possible effect following changes in patient flows and planning processes, the term crowding has been used in the literature searches. Since the concept crowding out is not widely spread in healthcare and management literature additional searches using combinations of the search terms waiting and priority has also been used in the literature review.

In Table 1.1 the search terms and number of hits for the literature review is listed. The search engine Unisearch was used, searching in PubMed, Academic Search Premier, CINAHL, ScienceDirect and Business Source Premier among others. Only full text and scholarly (peer reviewed) papers were included. If the number of hits was above 1 000, search terms were adjusted (see Table 1.1), and when the number of hits was below 1 000, the titles of all papers was examined. If the title passed the inclusion/exclusion criteria for further review, the abstracts were examined, based on the same criteria. The inclusion/exclusion criteria was:

Only papers addressing a healthcare context and indicating some sort of prioritization and/or management of waiting times or queues of patients were included.

- Papers addressing ED crowding or overcrowding was excluded since it comprises an acute patient flow, instead of an elective patient flow, that are of interest in this review.
- Papers only addressing the medical prioritization, are excluded.

TABLE 1.1 - SEARCH TERM COMBINATIONS, NUMBER OF HITS AND EXAMINED PAPERS

Search terms	Hits	Title	Abstract
Crowding (Abstract)	72,863		
Crowding (Abstract) AND health* (Abstract)	9,691		
Crowding (Abstract) AND health* (All text) AND Waiting (All text)	510	7	3
Waiting (Title)	39,716		
Waiting (Title) AND health* (Abstract)	3,092		
Waiting (Title) AND health* (Abstract) AND priorit* (Abstract)	170	8	6

APPENDIX 3

KOMPLETTERANDE METODBESKRIVNINGAR FÖR KVANTITATIV ANALYS AV VÄNTETIDER

1 METODBESKRIVNINGAR FÖR KVANTITATIVA ANALYSER

AV VÄNTETIDER

I denna bilaga redogörs några detaljerade metodbeskrivningar gällande de kvantitativa analyser som presenteras i Paper IV samt Report I och II. Dessa kompletterar metodbeskrivningen som finns i Paper IV och Report II.

1.1 RENSA BORT UTELIGGARE

Efter uttag av data gällande väntetider till analyser/undersökningar/operationer rensades data från uteliggare. Detta görs för att felaktig data inte ska förvansa framförallt medelvärden och standardavvikelser. Inom det data som inhämtades för operationer samt patologianalyser identifierades inga uteliggare. För data från radiologin identifierades en liten mängd uteliggare. I punktlistan nedan redogörs för de uteliggare som identifierades och hur dessa hanterades. I punktlistan särskiljs tidsperioden 2015-2016 och tidsperioden jan-aug 2017. Detta för att enbart den förstnämnda användes i Report I samt att de båda tidsperioderna användes i Paper IV och Report II.

- De undersökningar som har ett registreringsdatum som ligger innan ett år före uttagen tidsperiod exkluderas genom att väntetid till undersökning och definitivsignatur tas bort. Det gäller 15 st MR-undersökningar och 2 st CT-undersökningar under 2015-2016.
 - Ej applicerbart för perioden jan-aug 2017, därför ej använt.
- De undersökningar som saknar definitivsignatur exkluderas genom att väntetid till undersökning och definitivsignatur tas bort. Det gäller 12 st MR-undersökningar och 35 st CT-undersökningar under 2015-2016.
 - Det gäller 1 st MR-undersökningar och 7 st CT-undersökningar för perioden jan-aug 2017.
- De undersökningar som har akut och inneligg som prio.kod från början men längre väntetid till definitivsignatur än en månad, exkluderas genom att akut/inneligg tas bort som prio.kod. Det gäller 4 st MR-undersökningar och 69 st CT-undersökningar under 2015-2016.
 - Det gäller 0 st MR-undersökningar och 4 st CT-undersökningar för perioden jan-aug 2017.
- De undersökningar som har ett undersökningsdatum eller definitivsignatursdatum före registreringsdatum exkluderas genom att väntetid till undersökning och definitivsignatur tas bort. Det gäller 77 st undersökningar, varav alla med CT under 2015-2016.
 - Det gäller 0 st MR-undersökningar och 1 st CT-undersökningar för perioden jan-aug 2017

1.2 VAL AV MÄTPUNKTER FÖR ATT TILLDELA TIDSPERIOD

Den uthämtade datamaterialet innehåller alla analyser/undersökningar/operationer som slutförts från start-datum för föreperioden till och med slutdatum för efterperioden. Utifrån de definierade gränserna mellan före-, mellan- och efterperioden är nästa steg att bestämma vilken mätpunkt som används för att bestämma vilken period en analys/undersökning/operation tillhör. För dem tre olika verksamheterna som analyseras definieras mätpunkterna lite olika, men i grunden handlar det om det datum som det beslutas om att en operation/analys/undersökning ska göras och denna registreras i verksamhetens IT-stöd samt om det datum då en analys/undersökning/operation är slutförd så nästa steg i processen kan påbörjas. Det finns tre olika kombinationer mätpunkter man kan använda för att göra gruppfordelningen, man kan använda registreringsdatumet, datumet för slutförandet eller bara inkludera dem som har både registreringsdatum och slutförandedatum inom tidsperioden. Som stöd för diskussionen gällande vilken av dessa varianter som är mest rättvisande ser man i Figur 1 dem olika kombinationerna av registreringsdatum och slutförandedatum som finns i det uthämtade datamaterialet i relation till gränserna för tidsperioderna. Det bör noteras att inom kirurgin finns ingen mellanperiod, diskussionen gäller dock denna ändå.

FIGUR 1 - VISUALISERING AV VALET AV MÄTPUNKT FÖR PERIODTILLDELNING

Att välja registreringsdatum som datum för periodtilldelning skulle medföra att de som registrerats under föreperioden men slutförts under mellan- eller efterperioden skulle tillhöra föreperioden. På motsvarande sätt de som registrerats under mellanperioden men slutförts under efterperioden skulle räknas till den förstnämnda. Eftersom att data hämtats ut för alla som slutförts från startdatum för föreperioden till och med slutdatum för efterperioden medför periodtilldelning baserat på registreringsdatum att flertalet av de som registreras i slutet på efterperioden men slutförs efter slutdatum för efterperioden missas. Detta kan medföra en obalans i jämförelsen då mellan- och föreperioden inte får samma typ av bortfall.

Om man väljer slutförandedatum som datum för periodtilldelning så kommer dem som registrerats under före- eller mellanperioden men slutförts under efterperioden att tillhöra

en sistnämnda. Både inom kirurgin och radiologin fungerar planeringen av operationer/undersökningar så att man lägger registrerade patienter i en väntelista och planerar in operationer/undersökningar med en planeringshorisont som inom radiologin är cirka en månad och inom kirurgin 2-3 veckor. Undersökningar/operationer som registrerats under föreperioden men slutförs under mellan eller efterperioden kan därmed teoretiskt trängas ut av operationer/undersökningar inom ett standardiserat vårdförlopp (SVF). Inom patologin arbetar man inte direkt med någon väntelista för analyser inom histopatologin och cytologin utan påbörjar arbetat med proverna när dessa inkommer. Väntetiderna är också kortare än inom radiologin och kirurgin, varför skillnaderna mellan valen av mätpunkter för periodtilldelning blir mindre.

Ett tredje alternativ är att analyser/undersökningar/operationer som har registreringsdatum och slutförandedatum i olika tidsperioder exkluderas från analysen. Fördelen är att det blir en tydligare gräns mellan tidsperioderna. Nackdelen är ett större bortfall av analyser/operationer/undersökningar med långa väntetider eftersom att dessa är troligare att gå över någon av periodgränserna. Detta kan ses i Tabell 1, som exemplifierar detta genom att jämföra antalet analyser/operationer/undersökningar och medelväntetider i de olika prioriteringskategorierna under efterperioden baserat på valet periodtilldelning. För de lägst prioriterade kategorierna (markerade med fet stil i Tabell 1) medför en periodtilldelning som exkluderar de analyser/operationer/undersökningar som har registreringsdatum och slutförandedatum i olika tidsperioder ett stort bortfall, och kortare medelväntetider, jämfört med att baserat periodtilldelningen på slutförandedatum. Eventuella förändringar för dessa prioritetskategorier skulle då kunna missas i jämförelsen mellan tidsperioderna.

TABELL 1 – JÄMFÖRELSE MELLAN ATT BASERA PERIODTILLDELNING BASERAT PÅ SLUTFÖRANDEDATUM OCH ATT EXKLUDERA DE SOM GÅR ÖVER GRÄNS MELLAN PERIODER

Specialitet		Efterperioden baserat på slutförande datum		Efterperioden baserat på att exkludera de som går över gräns mellan perioder		% Bortfall
		Antal	Medelväntetid (SD)	Antal	Medelväntetid (SD)	
Patologi						
C	SVF	508	2,84 (2,28)	503	2,80 (2,18)	1
	Prio1	158	2,13 (1,77)	157	2,12 (1,76)	1
	Prio2	2492	3,71 (3,64)	2445	3,65 (3,59)	2
P	SVF	1942	5,64 (3,18)	1915	5,61 (3,16)	1
	Prio1	666	6,06 (4,00)	661	6,04 (3,98)	1
	Prio2	13302	10,81 (4,81)	12807	10,82 (4,82)	4
Radiologi						
CT	SVF	721	9,97 (7,52)	695	9,63 (7,20)	4
	Prio1	8145	3,75 (7,22)	7990	3,56 (6,91)	2
	Prio2	1693	6,15 (8,69)	1640	5,88 (8,51)	3
	Prio3	1251	17,35 (11,24)	1193	17,16 (11,19)	5
	Prio4	731	47,32 (30,06)	599	41,72 (24,97)	18
	Prio5	261	51,67 (25,20)	228	48,65 (24,71)	13

MR	SVF	74	13,49 (13,75)	71	11,85 (10,36)	4
	Prio1	407	7,50 (7,40)	392	6,98 (6,49)	4
	Prio2	1009	6,59 (6,73)	976	6,35 (6,54)	3
	Prio3	755	17,55 (11,20)	713	16,92 (10,67)	6
	Prio4	1298	66,90 (38,01)	1043	63,86 (31,25)	20
	Prio5	623	90,88 (49,15)	424	83,77 (37,52)	32
Operation						
Bröst	SVF	84	17,33 (11,22)	84	17,33 (11,22)	0
	Prio1	26	15,19 (10,28)	25	15,40 (10,44)	4
	Prio2	99	19,57 (13,95)	94	19,56 (14,05)	5
	Prio3	20	63,45 (56,60)	15	42,80 (29,47)	25
NGI	SVF	88	19,92 (15,30)	88	19,92 (15,30)	0
	Prio1	34	11,44 (9,28)	34	11,44 (9,28)	0
	Prio2	138	38,12 (54,94)	122	32,11 (25,64)	12
	Prio3	75	101,11 (82,85)	57	81,02 (59,08)	24
Uro	SVF	101	26,03 (15,26)	101	26,03 (15,26)	0
	Prio1	322	21,38 (21,98)	311	20,06 (16,38)	3
	Prio2	379	65,60 (79,34)	341	53,16 (57,59)	10
	Prio3	156	129,29 (123,52)	133	113,2 (104,3)	15

Utifrån diskussionen ovan väljs periodtilldelningen att göras utifrån slutförandedatum då det matchar hur man planerar in analyser/operationer/undersökningar samt minimerar bortfall.

1.2.1 BERÄKNING AV KÖER, INFLÖDE OCH UTFLODE FÖR DIAGRAM

I Report I används diagram som visar utvecklingen av kön samt antal utförda och inflöde för de studerade prioritetskategorierna. Inflöde motsvarar antal registrerade operationer och undersökningar under tidsperioden. För att få fram denna statistik har data plockats ut på samma sätt, och för samma period, som för den andra statistiken inom urologin och datortomografin, med skillnaden att urvalet för de operationer/undersökningar som inkluderas baseras på de som registrerats, istället för de som utförts, under perioden. Genom att sammanställa antalet utförda samt inflöde månadsvis för de olika prioritetskategorierna kan köns utveckling beräknas. Den initiala kön för den studerade perioden hämtas från datamaterialet över de utförda operationerna/undersökningarna, motsvarande de som registrerats innan tidsperiodens start (1 september 2014 inom urologin och 1 januari 2015 inom datortomografin) och sedan utförts någon gång innan tidsperiodens slut (20 juni 2017 inom urologin och 31 december 2016 inom datortomografin). På detta sätt kan endast patienter som stod i kön innan periodens start och fortfarande står i kön efter periodens slut missas i datamaterialet.

APPENDIX 4

METHODOLOGY FOR CASE STUDY CCP

1 STUDIED SYSTEM

In Denmark, waiting times have been reduced for most cancer areas following the implementation of clinical pathways called *Pakkeforløb* (Probst and Andersen., 2012; Larsen et al., 2013). However, effects on other patient groups have not been addressed when introducing clinical pathways. The concept have since then spread to the other Scandinavian countries and are also considered and implemented for other medical specialties in Sweden (Dagens Medicin, 2019a; Dagens Medicin, 2019b). In Sweden the initiative is denoted *Standardiseade vårdförlopp inom cancervården* and includes for each cancer diagnosis, a target time followed nationally for the total number of days from well-founded suspicion to start of first treatment. With narrow target times these pathways establishes a fast-track for the patients included.

The purpose of the study was to:

Explore which operational changes introduced during CCP implementation that have influence on waiting times for urology surgeries and computed tomography scans

Case study research is both applicable and desirable for exploratory investigations, where many variables are still unknown and limited previous knowledge of phenomena exists (Meredith, 1998), or when a lack of theory in the specific context exists (Stuart et al., 2002). Meredith (1998) also concludes that case studies can be used to increase understanding in fields where the subject matter is complex. Care pathway implementation, such as the introduction of CCPs in Sweden, comprises a dual complexity, where the care pathway itself represents a complex intervention, while the organisational context upon which the care pathway is being implemented is also a complex system (Seys et al., 2019). Acknowledging this twofold complexity includes careful consideration of the interactions between the intervention and the context (Shiell et al., 2008). Since the phenomenon studied, CCP implementation, is complex, a case study approach was chosen (Yin, 2009).

In a progress report concerning the implementation of CCPs in Sweden, support functions regarding diagnostics and treatment, namely pathology, radiology and surgery, are those where crowding out effects are considered most likely, often due to a lack of capacity in these specialties (The National Board of Health and Welfare, 2016). The access to reliable data regarding waiting times are also of importance, and are good for these specialties. Since these specialties are involved in diagnostics and treatment in many CCPs, volumes can become large. Since crowding out effects are more relevant to study if the quantity of CCP-related analyses/scans/surgical procedures is large in relation to the total number of analyses/scans/surgical procedures, these considerations have also guided the choice of analyses/scans/surgical procedures to study for crowding out effects. Among the surgical sub-specialties, urology surgeries were chosen for the case study. Two among the five CCPs first implemented was urological cancers and the surgical procedures performed in these CCPs were easily distinguishable from the other surgeries in this sub-specialty. Computer

tomography (CT) scans were also chosen since the proportion of CCP scans are expected to be the highest for radiology scans. Crowding out effects are also more likely for CT scans than pathology analyses, since there are dedicated personnel working with CT scans on a daily basis, and the personnel working with pathology analyses have a more flexible division of personnel between the different sub-specialties.

2 DATA COLLECTION

2.1 GATHERING INFORMATION REGARDING PLANNING AND BOOKING

To understand the influence of CCP implementation on waiting times for surgeries and radiology scans it is important to understand the different steps in the planning and booking process of surgeries and radiology scans. For this purpose, interviews, shadowing and participation in meeting was used. Below the information gathering activities performed for the mapping of these processes are described.

2.1.1 UROLOGY SURGERIES

Shadowing implies following a person for a longer period, and observing actions and interactions (Czarniawska-Joerges, 2007, McDonald, 2005). One of the benefits of shadowing is that it provides more detailed data in comparison to many other approaches. To gain a deeper understanding of the patient flow and the personnel involved when performing surgeries the author used shadowing by following personnel with different roles in the surgical process, from the personnel working at the pre-surgical area, where the patients arrived before surgery, to personnel working at the post-surgical area, where patients recovered after surgery. The different roles, locations and duration of shadowing activity is listed in Table 2.1 below.

TABLE 2.1 – SHADOWING ACTIVITIES FOR THE SURGICAL PROCESS

Role	Location	Duration (h)
Anaesthesia nurse	Pre-surgical area	5
Assistant nurse	Pre-surgical area	4
Coordinators	Central surgical block	6
Assistant nurse	Central surgical block	4
Anaesthesia nurse	Central surgical block	4
Assistant nurse	Central surgical block	4
Anaesthetist	Central surgical block	2
Medical secretary	Central surgical block	2

Surgeon	Central surgical block	1
Coordinators	Central surgical block	1
Surgeon	Central surgical block	5
Head nurse	Post-surgical area	2

The process of planning and booking urology surgeries are mainly performed by a medical secretary with the role of surgical coordinator. The shadowing activities described above were performed ahead of the interviews with the surgical coordinator, allowing the author to gain fundamental knowledge of the surgical patient flow, which facilitated sorting of information during the subsequent interviews as well as asking additional questions, thus strengthening validity (Stuart et al., 2002). To provide a comprehension of the planning and booking process two shorter unstructured interviews with the surgical coordinator was performed. The author also participated on a meeting with the surgical steering group, a group where clinical department chiefs, among others, discuss and decides upon the division of surgical capacity, in terms of operating rooms and personnel. After these information gathering activities a schematic representation of the planning and booking process (see Figure 3 in Report I) was depicted. It was used to formulate detailed questions regarding each step of the planning and booking process. These questions was addressed during a semi structured interview, performed in combination with a shadowing session, with the surgical coordinator. The shadowing parts included a meeting between the surgical coordinator and a coordinator at the central surgical block, to review the operating room utilization for the coming weeks. The interview notes were documented directly after the interview. Any questions was addressed during a follow-up interview the following week to ensure validity and reliability. In Table 2.2 the information gathering activities are listed.

TABLE 2.2 – INFORMATION GATHERING ACTIVITIES CONCERNING THE PLANNING AND BOOKING PROCESS

Activity	Role	Duration (h)
Unstructured interview	Surgical coordinator	0,5
Participating in meeting	Surgical steering group	1,5
Unstructured interview	Surgical coordinator	0,5
Semi structured interview/shadowing	Surgical coordinator	1,5
Structured interview	Surgical coordinator	0,5

2.1.2 CT SCANS

To provide a deeper understanding of the process of planning and booking CT scans, as well as the patient flow and the personnel involved when performing CT scans a combination of semi structured interviews and shadowing was used. First, a shadowing session following the two radiology nurses and the assistant nurse working at the CT lab for one day was performed. A combined shadowing and interview session with a radiologist reviewing radiograph images for the CT labs was used, focusing on the tasks performed by the radiologists. After documenting the interview notes, some remaining questions was clarified with a short phone call with the radiologist.

The process of planning and booking CT scans are daily performed by one of the two medical secretaries with this competence. A joint shadowing and interview session with one of these medical secretaries was completed while she was receiving and booking CT referrals. The interview notes were documented directly after the interview, and some remaining questions was explained through a short phone call.

After these information gathering activities a flow chart of the planning and booking process for CT scans (see Figure 19 in Report I) was depicted. To ensure validity, the flow chart was sent to department chief of the radiology clinic, and feedback was obtained and incorporated in the description. A proof of the validity of the flow chart is that it has been used as a description of the work and patient flow at an internal conference at the radiology department. In order to understand the changes introduced due to the implementation of CCPs, participation at meetings with the improvement group working with the CCPs, the oncology group, was also used. In Table 2.3 the information gathering activities are listed.

TABLE 2.3 – INFORMATION GATHERING ACTIVITIES CONCERNING THE PLANNING AND BOOKING PROCESS AND PATIENT FLOW

Activity	Role	Duration (h)
Shadowing	CT lab	8
Semi structured interview/shadowing	Radiologist	2,5
Semi structured interview/shadowing	Medical secretary	1
Participating in meeting	Oncology group	1
Participating in meeting	Oncology group	1
Participating in meeting	Oncology group	1

2.2 EXTRACTING QUANTITATIVE DATA

The data used in making charts is the same data as used in Paper IV. The methodology for extracting data is described in Paper IV and Appendix 3.

2.3 DATA ANALYSIS

To explore which operational changes introduced during CCP implementation that have influence on waiting times for urology surgeries and CT scans the priority categories used to prioritize how swiftly a surgery or scans should be performed is utilized. For urology surgeries there are few priority categories and all of these are analysed. For CT scans there are many priority categories. The choice of which to include are discussed in Report I, section 3.3.1.

For urology surgeries, the same time period is analyzed in the case study as in Paper IV. Based on the need for an examination of waiting times for CT scans in relation to CCP implementation, posed by the project group responsible for CCP implementation, the time period analysed for CT scans were 2015-2016, which was slightly shorter than the time period analysed in Paper IV. The waiting time analysed was the time between the acceptance of an electronic referral up to the time when the CT scan is performed. In Paper IV instead the time when the radiologist sends the final referral response was used. This choice is elaborated in Report I, section 3.3.2.

For each priority category included time charts displaying the changes in waiting times, production, inflow and queues were compiled using Microsoft Excel. A one hour workshop was thereafter held with representatives from the sub-specialty addressing the operational changes introduced during CCP implementation that might have influenced waiting times. For CT scans, a group consisting of two radiologists, one of which having the overall medically responsibility for computer tomography, a radiology nurse and a medical secretary that plans and books CT scans. In urology, all doctors working at the urology section were assembled. An interview session with an urologist and the surgical coordinator also were also performed to identify additional operational changes introduced during CCP implementation. The workshops was initiated by drawing a time-line of the CCP implementation process, to identify activities, routines and decisions influencing waiting times. The time charts displaying the changes in waiting times, production, inflow and queues for each priority category were then presented, and the representative were allowed to discuss the charts and add information regarding changes having influence on waiting times.

To demonstrate changes in waiting times Run charts (Perla et al., 2011) were used. The method is used to a number of signals that distinguish occasions when a process displays non-random patterns, and was used on the weekly mean values for the different priority categories included in the study. By including these signals as well as the changes introduced in the sub-specialties the implications of these changes on waiting times can be examined. The median waiting time after CCP implementation was also included in the graphs.

APPENDIX 5

ACTIONS USED IN HANDLING VARIATION IN PATIENT FLOWS AT THE UNIVERSITY HOSPITAL, AND THE CATEGORISATION OF THESE IN TERMS OF LEVEL OF ABSTRACTION AND LEAN/AGILE

#	Action	Level of abstraction	Lean/Agile, Category
1	Balance staffing between different wards and teams	3	(A) Extending use
2	Central staffing function, from which additional personnel can be hired	4.1	(A) Extending use
3	Extended investigations at the ED	4.2	(A) Extending use
4	Relocate patients between clinical departments as a response to demand	4.1	(A) Extending use
5	Care agreement between two clinical departments	4.1	(A) Extending use
6	Flexible number of beds allocated for acute and elective patients	3	(A) Extending use
7	Mixing male and female patients in rooms with two beds or more	3	(A) Extending use
8	Adapting staffing to the inflow of patients	3	(A) Altering amount, ahead
9	Physician staffing is increased during holidays	3	(A) Altering amount, ahead
10	Adapting staffing to demand by compensating work shifts differently	3	(A) Altering amount, ahead
11	Relocate patients between clinical departments in speculation	4.1	(A) Altering amount, ahead
12	Dedicate beds for patients belonging to another speciality	4.1	(A) Altering amount, ahead
13	Decrease or stop elective intake to free up beds for expected acute patients	4.1	(A) Altering amount, ahead
14	Evaluate patients that can potentially be discharged early in the morning	3	(A) Altering amount, ahead
15	Assess patients that potentially can be discharged first	3	(A) Altering amount, ahead
16	Decide upon early discharges the day before	3	(A) Altering amount, ahead
17	Sending personnel home when there is nothing to do	3	(A) Altering amount, response
18	Calling in additional nurses or assistant nurses	3	(A) Altering amount, response
19	Admit patients to additional beds	3	(A) Altering amount, response
20	Admit patients to beds in excess of regular and additional beds	3	(A) Altering amount, response
21	Place patients in beds in the corridor	3	(A) Altering amount, response
22	Have a patient spending the night at home or in a nearby hotel	3	(A) Altering amount, response
23	Open an additional ward	4.1	(A) Altering amount, response
24	Temporarily open up a number of extra beds at a clinical department for acute patients	4.1	(A) Altering amount, response
25	Moving patients between hospitals	4.1	(A) Altering amount, response
26	Moving patients between wards at different hospitals	4.1	(A) Altering amount, response

27	Provide a place at a short time care facility before admittance to a permanent care facility	4.2	(A) Altering amount, response
28	Discharge a patient earlier than otherwise would be the case	4.2	(A) Altering amount, response
29	Beds allocated for patients that are expected to be discharged within 24 hours	2	(I.) Patient flow standardisation
30	Joint ward for patients with short LOS and small deviations from expected LOS	2	(I.) Patient flow standardisation
31	Clinical departments with predominantly elective intake are rarely required to cancel elective intake to accept acute patients	2	(I.) Patient flow standardisation
32	Schedule elective intake to have a fixed number of beds available for acute patients	2	(I.) Patient flow standardisation
33	Stipulated boarder between which patients should be admitted to which clinical department	2	(I.) Patient flow standardisation
34	Bypass the ED for patients with specific heart issues	2	(I.) Patient flow standardisation
35	Ward for patients that are medically ready for discharge but awaits assistance from local health services	4.2	(I.) Patient flow standardisation
36	Discharge patients on weekends and not just on weekdays	3	(I.) Reduced need for a resource
37	Prepare for discharge in parallel with treatment	3	(I.) Reduced need for a resource
38	Assistance evaluators located at the hospital, which enables a faster and smoother discharge planning	4.2	(I.) Reduced need for a resource
39	Summon for discharge planning as early as possible after the patient is medically ready for discharge	4.2	(I.) Reduced need for a resource
40	Discharge planning called for before the patient is medically ready for discharge	4.2	(I.) Reduced need for a resource
41	Changing inpatient care to outpatient care by sending patients home from the ED with a scheduled doctor's appointment	4.2	(I.) Reduced need for a resource
42	Personal care coach assigned for patients that are frequent visitors to the hospital and/or have complex healthcare needs	2	(I.) Reduced need for a resource
43	Specific track on the ED for elderly where all appropriate competences to quickly provide treatment and care are available	2	(I.) Reduced need for a resource
44	Advanced domiciliary services provided around-the-clock for elderly in need of limited medical supervision	4.2	(I.) Reduced need for a resource
45	Provide easily understood verbal and written information to patients with increased risk for readmission	4.2	(I.) Reduced need for a resource
46	Enhanced handoff process between inpatient care and primary care when discharging patients with increased risk for readmission	4.2	(I.) Reduced need for a resource
47	Divide acute patients that need admission evenly between clinical departments	4.1	(I.) Manage external variation
48	Allocate admissions between care teams based on measuring how resource demanding the patients belonging to the care teams are	3	(I.) Manage external variation
49	Requiring patients to wait at the ED for some time before admission to a clinical department where a discharge is needed to free up a bed	3	(I.) Manage external variation
50	The availability of beds at inpatient wards sometimes influence the decision to admit or sending home a patient from the ED	4.2	(I.) Manage external variation

Papers

The papers associated with this thesis have been removed for copyright reasons. For more details about these see:

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