THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

The hospital-wide patient flow

Looking beyond borders for improved productivity

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Abstract

Demand for healthcare is increasing at a faster pace than hospitals' capacity. In search of new paths to reverse this development policy makers and healthcare managers look for new methodologies or concepts to improve productivity. One such concept is flow efficiency, focusing on how to better support the throughput of patients, and productivity. Therefore, the aims of this thesis are to examine the phenomenon of hospital-wide patient flows and what is preventing or helping the patient flow to become swift and even across the hospital organization.

This thesis builds on a qualitative research design, where process theory and the theory of swift and even flows are used as points of departure when exploring the phenomenon of hospital-wide patient flows. Two papers are presented. The first paper explores barriers to swift and even patient flows and the second paper identifies solutions on how to overcome the identified barriers. This thesis visualizes how important it is to align the hospital around the patient flow for improved productivity. It also explains how hospitals can serve a greater part of their citizens and enable a more sustainable work environment by improving the capacity balance across the hospital to support the patient flow. Lastly, a new framework on how to improve hospital-wide patient flows is developed connecting barriers, root causes, and solutions to swift and even patient flows based on a systematic literature review and on experiences from senior managers at the world's leading hospitals.

Keywords: Healthcare, Productivity, Patient flow, Hospital-wide, Capacity utilization, Barriers, Solutions, Operations Management, Strategy

List of appended papers

Paper 1: Åhlin, P., Almström, P., Wänström, C. (2022). "When patients get stuck: A systematic literature review on throughput barriers in hospital-wide patient processes", Health Policy, Vol 126, Issue 2, pp. 87-98, https://doi.org/10.1016/j.healthpol.2021.12.002

Paper 2: Åhlin, P., Almström, P., Wänström, C. (2022). "Solutions for improved hospital wide patient flow – A qualitative interview study of leading healthcare providers. The paper was submitted to the journal *BMC Health Services Research* and is currently out on review.

The researcher's contribution to the papers

Paper 1: Philip Åhlin was the main author of this paper and conducted much of the work independently concerning conceptualizing the study, developing the methodology, and writing and editing the original draft. Peter Almström supported in the theoretical considerations, in the study selection, and the data extraction. Finally, all authors contributed to the data curation and in the reviewing and editing process.

Paper 2: Philip Åhlin was the main author of this paper and conducted much of the work independently concerning conceptualizing the study, developing the methodology, and writing and editing the original draft. All authors contributed to the data curation and in the reviewing and editing process.

Preface and acknowledgments

Writing this licentiate thesis has been an interesting journey and has provided a good chance to look back and reflect over the roughly two years that have passed since I began my doctoral studies. I have learned so much about what it means to be a doctoral student and what it takes to become a researcher. Embarking on this journey was never an obvious choice but somehow each day makes me more convinced over the rightness of that choice. I would however never have thought about becoming a doctoral student have it not been for my partner Sofia and how she made research sound exciting and reachable.

My research project has been somewhat of a rollercoaster as Covid-19 arrived two weeks into my studies and everything changed. My intended project on how to design a new production system at the Ear, Nose, and Throat clinic at the Sahlgrenska University Hospital in Gothenburg was paused (and still is) and I had to rethink. This frustrating situation led eventually to something good, where I instead got the chance to do two studies on the topic of hospital-wide patient flows with great joy and enthusiasm. Roughly one and a half year has come to pass since this change of direction took place and my two first studies have taught me much about how to conduct sound research, and I have been given the opportunity to delve into the field of healthcare productivity and the concept of patient flow across hospital organizations.

Doing research within the field of healthcare and hospital productivity was never obvious. I was originally focused on pursuing a career within the industry and I have a Master of Science in industrial engineering and management from the faculty of engineering at Lund University. At the end of five years of study, I was somehow not particularly interested in neither the industry nor the otherwise appropriate career as a management consultant. Instead, I started working at Sweden's largest university hospital, Sahlgrenska, as a logistics developer. Consequently, during roughly one and a half years I got first-hand experience of working within a large hospital organization daily confronting the struggles with utilizing available capacity to meet an ever-increasing demand. I saw the problems with an unaligned organization many times suffering from internal rivalry. I understood the inefficiency with insufficient internal structures on how to develop and optimally balance available capacity

across the hospital. I also experienced the consequences for both patients and staff across the hospital of not having a sufficient hospital-wide patient flow perspective. Even so, I realized back then that I had too little on my feet to know where to start and to know how to address these challenges. As my career continued, this experience lingered on, and when an appropriate research project became available, I decided to apply for that position.

Today I stand halfway into my doctoral studies, and I am surprised over how much I enjoy doing this and how much I have learned so far. I have also come to know my supervisors well and feel their strong support for my development as an independent researcher. It also makes me glad to be a part of a big group of doctoral students that by coincidence started at the same time and enables a great forum for reflections and discussions about the Ph.D. process. Lastly, having a partner who embodies my image of the curious, analytical, and critical researcher makes me eager to also explore and indulge in the world of research.

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1. Introduction

This chapter provides background and motivation to my research and presents the general aim and scope of this thesis. This chapter also describes the limitations of this study and ends by outlining the structure of the thesis.

1.1 Background and problem formulation

Healthcare systems around the world stand in front of numerous challenges from changing demographics and rising multimorbidity to budget deficits and chronic healthcare staffing shortages (WHO, 2014, OECD, 2019, OECD, 2020, Eurostat, 2015, Davis et al., 2019, Stadhouders et al., 2019, Lorenzoni et al., 2019). The European Commission estimates that between 2018 and 2050 the proportion of people in Europe above 65 years will increase by 10% whereas, for Sweden alone, the elderly above 85 years will increase by 130% (Eurostat, 2015, SCB, 2015). The World Health Organization (WHO) predicts a future where 40% of the population in Europe, older than 15 years, will suffer from at least one chronic disease, and two out of three, over 65 years, will suffer from at least two chronic diseases, increasing the burden on the national health care systems (WHO, 2014). The demand for healthcare services from an older and sicker population is therefore growing and this trend is further supported by medical and technological advances. As a consequence of this increasing healthcare demand, the health expenditure within the Organization for Economic Cooperation and Development (OECD) is estimated to rise, as a percentage of GDP, from an average of 8,8% to 10,2% between 2018 and 2030. Sweden, as one of the countries within the OECD with the highest rise in health expenditure, is projected to increase its share from 11% to 13% (OECD, 2019). These projections on how healthcare takes a larger share of national GDP make politicians and policy makers uneasy and unwilling to continue injecting the financial support the sector asks for (Kirby and Kjesbo, 2003, Lorenzoni et al., 2019, Rumbold et al., 2015). Moreover, people in Europe must wait longer for their health care services as queues for specialized care are rising when demand increases at a higher pace than available capacity (OECD, 2020, Davis et al., 2019, Siciliani et al., 2014)

Because of increasing demand for healthcare services, rising expectations on service quality, and an increasing fiscal deficit health care systems are put under detailed scrutiny to improve their operations (Rumbold et al., 2015). Healthcare managers are forced to look for new solutions on how to improve hospitals' capacity utilization to increase productivity, without further increasing expenditures. There is, therefore, growing pressure to look for and to adopt methodologies and concepts originating from other sectors in society, like the manufacturing industry (Radnor et al., 2012, Waring and Bishop, 2010, Devaraj et al., 2013, Haraden and Resar, 2004, D'Andreamatteo et al., 2015, Johnson et al., 2020). One such concept is flow efficiency where the two last decades have seen an increased interest in how to improve healthcare productivity by focusing more on the patient flow, i.e. how to enable a higher throughput of patients through hospitals (Rumbold et al., 2015, Devaraj et al., 2013, D'Andreamatteo et al., 2015, Johnson et al., 2020, Improta et al., 2018, Hammond et al., 2009)

Focusing on the flow of patients has been proven to have a good impact on the length of stay (LoS) of patients at hospitals and on the speed with which patients are processed towards discharge (Hammond et al., 2009, Improta et al., 2018, Johnson et al., 2020). A greater focus on the flow of patients may also help in balancing a variable and an unknown number of patients along a continuum of care, constrained by insufficient healthcare resources (Gualandi et al., 2019). Additionally, an increased LoS expose patients to unnecessary risks of medical complications and infection (Devaraj et al., 2013). A greater focus on the throughput of patients is therefore recognized as a critical strategy to not only improve productivity but also medical quality, patient safety, and patient satisfaction (Lovett et al., 2016, Improta et al., 2018).

Radnor et al. (2012) and D'Andreamatteo et al. (2015) highlight how the two last decades have seen a great amount of research focusing on how to improve the flow of patients at hospitals. These projects however rarely encompass complete hospital organizations and the full patient process from admission until discharge. Focus is instead on a more narrow context, studying the patient flow through single units or clinics within the hospital organization (Villa et al., 2014, Gualandi et al., 2019, D'Andreamatteo et al., 2015). This presents a clear gap in the literature, and more research is therefore needed taking a hospital-wide approach when studying the throughput of patients at hospitals (D'Andreamatteo et al.,

2015, Gualandi et al., 2019, Johnson et al., 2020). The hospital-wide perspective points to the need for clinics and medical units within the hospital organization to coordinate their care of patients between admission and discharge. It also points to the need to align their objectives to make the hospital effective and efficient in delivering the right care at the right time and place, and to the right cost (Devaraj et al., 2013, Gualandi et al., 2019).

1.2 Aim, research questions, and limitations

There is today little theoretical, conceptual, or empirical research on the phenomenon of hospital-wide patient flow that can give academics and practitioners a better understanding of how to design more efficient processes at hospitals (Gualandi et al., 2019, Kreindler, 2017, Johnson et al., 2020, Radnor et al., 2012). Simultaneously, the world continuously becomes more complex and other sectors approach this complexity by not just integrating activities across businesses but even across complete chains of actors (Olhager, 2013, Lambert and Cooper, 2000). There are therefore great reasons to explore how healthcare actors can align their activities and how they can use a wider lens when improving their most central flows, i.e. their patient flows. The aim of this research is, therefore:

"To explore what hinders or enables hospitals to improve their organization-wide patient flows, and to better understand how an increased focus on the flow of patients can improve the productivity of hospitals."

This aim demonstrates the intention to identify best practice on how hospitals should approach the challenge of creating an efficient hospital-wide patient flow. It also points to the need of understanding the ecosystem of surrounding activities, and what requirements a flow focus puts on the hospital. The research questions following this aim are, therefore:

RQ1: What barriers are preventing swift and even patient flow across hospitals?

RQ2: What are the best solutions to break the previously identified barriers and to achieve efficient patient flows across hospital organizations?

RQ3: How can an increased focus on hospital-wide patient flow help hospitals to increase their productivity and throughput of patients?

This research has an international focus and is not constrained to a certain geographical region. The reason for this lies in the interest to enable higher generalizability. As no on-site case studies were planned within the scope of this research, there was also never any obvious reason to why there should have been limitations to regional contexts. Moreover, the hospital organization, with its position, views, and characteristics, is the object of study throughout this research. Hence, primary care, after-care services, and rehabilitation care providers will only be examined from the view of the hospital and not from their unique perspective.

1.3 Outline of thesis

This thesis begins by explaining the background to the present healthcare crisis and how more eyes are directed towards the improvement of patient flows from a system-wide perspective, as a means of increasing healthcare productivity. This leads to the presentation of the aim, research questions, and limitations of the study. The first chapter is then followed by an overview of the principles of process theory, the theoretical considerations of swift and even flow, and lastly an explanation of the concept of patient flow. This is then followed by research methodology, illustrating how and why the used research design was chosen. After the chapter on methodology, a summary of the appended papers is presented, followed by a presentation of the results and lastly a general discussion of the results. I then conclude with contributions, implications, and suggestions for future research.

2. Theoretical Framework

This chapter outlines the theoretical framework, which has been used to design and conceptualize the studies, and to analyze the results of the two appended papers. The framework has also provided a lens from which to view and understand the empirical data.

2.1 The production process

Every organization within each industry runs its unique operations, consisting of inter-related processes to produce the products or services that its customers demand. Consequently, processes are designed in various ways, to fit the unique context, culture, strategy of a certain organization. Even so, there are fundamental and generalizable characteristics on how processes behave and are optimally designed (Holweg et al., 2018, Slack and Brandon-Jones, 2019). These fundamentals are described as the principles of process theory and they are claimed to have stood the test of time, see figure 1.

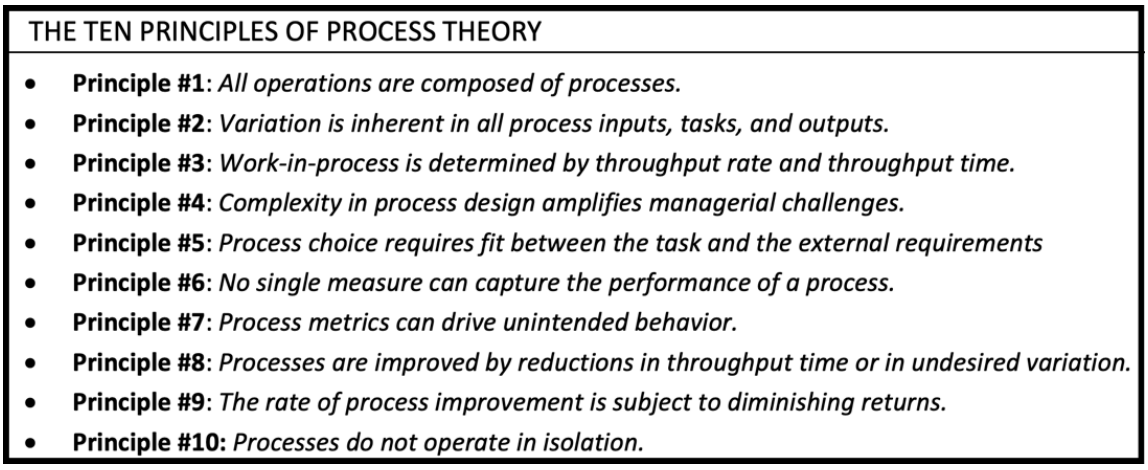

Figure 1: The principles of process theory

Operations within any organization consist of a collection of processes interconnecting with each other to form a network. Each process acts like a smaller version of the whole operation of which it forms a part, and transformed resources flow in between them (Slack and Brandon-Jones, 2019). It is the processes that transform inputs to outputs to satisfy (internal or external) customer needs. Inputs can also come in many forms like materials, components, labor, energy, or data where outputs are the actual products or services that the process is supposed to produce. The conversion in the transformation process occurs when inputs

become work-in-process and moved along process steps towards completion (Holweg et al., 2018). Furthermore, for a process to become efficient and effective it must also be attached to a management system. The management system has the role of running, controlling, and improving the process based on feedback loops about the performance of the process, see figure 2, below.

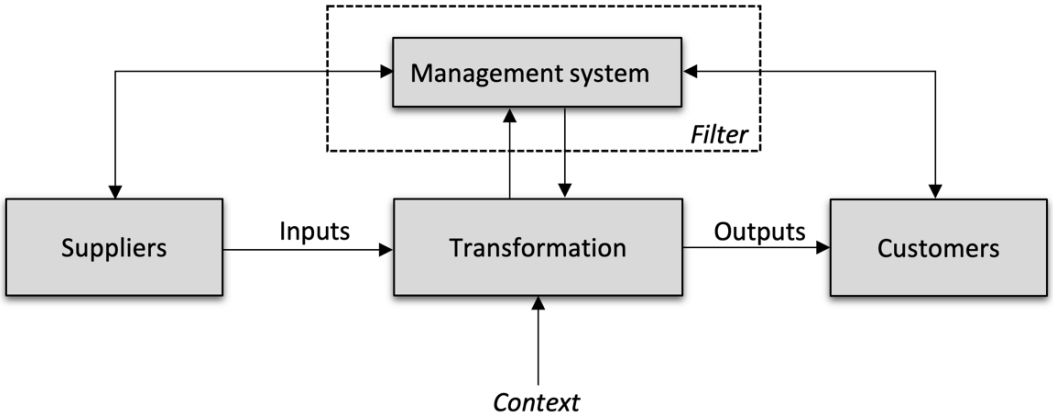

Figure 2: Process model with management system (Holweg et al., 2018)

2.2 Capacity and capacity utilization

The capacity of a production process is seen as the maximum level of value-added activity over a period of time that a process can achieve under normal operating conditions (Slack and Brandon-Jones, 2019). It is also the capability of an individual worker, a work station, or a production system to perform according to its expected function (APICS, 2005). How to measure that capacity comes either in terms of input capacity (*available capacity to a process like the amount of staff, floor area, machine hours and time slots, etc*.) or in terms of output capacity (*numbers of units produced per week in a factory, students graduating per year at school, or passengers per week for a ferry line*). Slack and Brandon-Jones (2019) argue that capacity can be divided into three categories: *design capacity*; *effective capacity*; and *actual output*. *Design capacity* is defined as the theoretical capacity of an operation, as the designers had in mind when commissioning the operation. *Effective capacity* is the capacity of an operation after planned losses have been accounted for. A production line cannot run continuously at its maximum rate, maintenance must be performed, and scheduling difficulties might mean further lost time. The *actual output* is then the capacity of an operation after both planned and unplanned losses are accounted for, like quality problems,

machine breakdowns, absenteeism, and other avoidable problems. Lastly, they describe that capacity utilization is measured by dividing the actual output with the designed capacity and that the efficiency of the process is measured by dividing the actual output with the effective capacity.

Vissers and Beech (2008) offer another description dividing capacity into five different categories: potential; available; usable; utilized; and productive. *Potential capacity* is the theoretical capacity of a process according to how it was designed if all theoretical capacity would have been used. *Available capacity* is the capacity that has been decided to be available for use after non-available capacity has been removed from potential capacity. Within healthcare, this can be seen when operating theatres are not used during evenings or weekends. *Usable capacity* is what is left when non-usable time has been removed, like scheduled maintenance or time reserved for other activities. Within healthcare, reserved operating time and operating theatres for emergent surgeries are two such examples. *Utilized capacity* is the capacity that is actually used for production where the *productive capacity* is finally reached when idle time and non-productive time have been removed. Idle time is the capacity loss when planned operations are canceled or the remaining time when activities end earlier than planned. Non-productive time is non-value adding but necessary time for the production. Within healthcare, this can be found in the setup time between two surgeries.

2.3 Productivity

Productivity can be described as efficiency in production on how much output is obtained from a given set of inputs (Syverson, 2011). As such, it is typically expressed as an output-input ratio (Misterek et al., 1992, Wacker, 2004, Syverson, 2011). Slack and Brandon-Jones (2019) further describe that productivity is the ratio of what is produced by an operation (its outputs) and what is required to produce it (its inputs). Productivity can be measured in many ways and Schmenner and Swink (1998) argue that it is hard to give a complete explanation for the productivity differences between two factories. This reason lies in the vast amount of inputs needed to produce a certain output and that those inputs are generally used to produce multiple types of outputs. Moreover, each production process is subject to a unique set of conditions, seen in the existence of bottlenecks, scheduling capabilities, workforce organization, and variation in quality, demand, and work methods (Syverson, 2011,

Schmenner and Swink, 1998, Slack and Brandon-Jones, 2019). Therefore productivity measures oftentimes come with a more narrow scope like units produced per labor hour, machine hour, material dollar, or per some combination (Schmenner and Swink, 1998). The most used outputs when measuring productivity at hospitals are health services (discharges, length of stay, inpatient days, physician visits in outpatient clinics, and procedures performed) (McGlynn, 2008, Kämäräinen et al., 2016). Diagnoses-related groups (DRGs) are also used to compare hospitals with different case mixes (Clement et al., 2008). Inputs on the other hand are typically divided into either financial or physical categories. Financial inputs are usually costs for the health care service, including both labor and capital. Physical inputs are instead divided into categories like labor time or the total use of beds (capital stock) (Linna et al., 2010).

Productivity can be improved in many ways but requires a process to either produce more output with the same amount of resources or to produce the same amount of output using a smaller amount of resources. This thesis is concerned with productivity in terms of the production of more output, given available resources. More specifically, this thesis is concerned with how an increased throughput of patients across hospitals can be reached and how available capacity can be better utilized to improve the throughput of patients across hospitals.

2.4 Swift and Even Flows

Throughput rate is the rate at which output is made and it defines the speed of a process. The throughput through a production process does therefore greatly impact the productivity of the organization managing that process. Output can of course mean many things. Producing a few units of high value can generate high productivity as well as the production of many units of low value. Even so, the speed of the process is a key element defining the productivity of any process or production line (Holweg et al., 2018, Schmenner and Swink, 1998).

The Theory of Swift, Even Flows (TSEF) is explaining the phenomena of why one service operation or factory is more or less productive, as measured by inputs and outputs (Schmenner, 2012). TSEF explains that: “the more swift and even the flow of materials through a process, the more productive that process is” (Schmenner and Swink, 1998). Swift

flows are associated with short throughput times and even flows are associated with the reduction in variation of quality, quantity, and timing, meaning that the process is steady and foreseeable (Holweg, 2007). Ensuring that information or material flows quickly through a process is also depending on if there are bottlenecks or barriers to the process. This is further articulated by the Law of Bottlenecks (Goldratt et al., 2014) stating that the overall efficiency of a process can only be improved by addressing its major bottlenecks or constraints. When identifying bottlenecks to a process it is proven useful to describe value-adding activities of a process to identify waste. Womack (1996) and Schmenner (2012) describe that waste within a process can be divided into seven different categories of overproduction; waiting; transportation; unnecessary processing steps; inventories; motion; and defects. Reducing the throughput time is then preferably done by eliminating these types of wastes instead of working or running operations faster.

The theory of swift and even flows (TSEF) has been used by several researchers when needing a sound theoretical base to stand on to study their phenomenon. Devaraj et al. (2007) have explored the effects of supply chain integration on operational performance from theory-based hypotheses constructed from TSEF. Karwan and Markland (2006) studied service design in public sectors and employed TSEF to explain how service organizations that survive and thrive over long periods of time seem to be concerned with minimizing throughput time (swift flow) and decreasing the effects of variation that result from customization for and interaction with customers (even flow). Yin et al. (2017) studied the effects of *Seru* (cellular assembly approach) production on manufacturing competitiveness and makes a theoretical comparison between Seru, lean, and agile production systems using TSEF. Eltantawy et al. (2015) looked at supply chain coordination where TSEF provided a theoretical framework when studying the coordination of physical flows among supply chain partners. Germain et al. (2008) explored supply chain variability, organizational structure, and performance and included TSEF to better understand the influence of process variability in a supply chain system. Lastly, Samuel et al. (2015) studied the growth and spread of Lean through the academic and practitioner community over the last 25 years where they used TSEF to support the theoretical underpinnings of Lean as a dominant global operations paradigm. Consequently, the Theory of Swift and Even Flows is useful in various contexts and for various

purposes. It gives focus to what is most essential when designing and improving production processes to increase productivity (Schmenner, 2012).

2.5 Variation in processes

TSEF and process theory explain that processes are subjects to variation which should, as far as possible, be eliminated (Holweg et al., 2018, Schmenner, 2012). Variation can be both predictable (assignable cause) and random (common cause) where predictable variation may be identified and managed, in contrast to the "natural" random variation, requiring fundamental process changes to be reduced (Shewhart, 1932, Holweg et al., 2018, Deming, 1982). Variation has also a strong impact on the throughput of a process and its level of work-in-process, where work-in-process is determined by throughput rate and throughput time. This relationship is termed Little's law, see figure 4, revealing a set of constraints to every process. It directs us to identify waste inherent in a process to increase the throughput rate and thereby gain in productivity (Little, 1961, Schmenner, 2012).

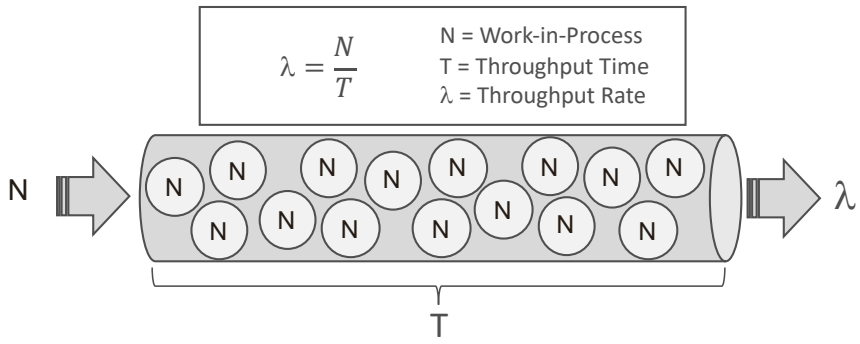

Figure 4: Visualization of Little's law

An extension of Little's law is Kingman's formula. The formula provides dependencies between waiting time, variation, and capacity utilization. This relationship displays that existing variation in a process prevents it from utilizing its maximum capacity. The formula gives a clear example of that at a certain point, when capacity utilization becomes too high for the process to handle the variation, the waiting time increases dramatically, see figure 3 (Kingman, 1966). Hence, to stimulate a high throughput rate in a process, it is important to consider the variation and the capacity utilization rate to ensure it becomes swift and even.

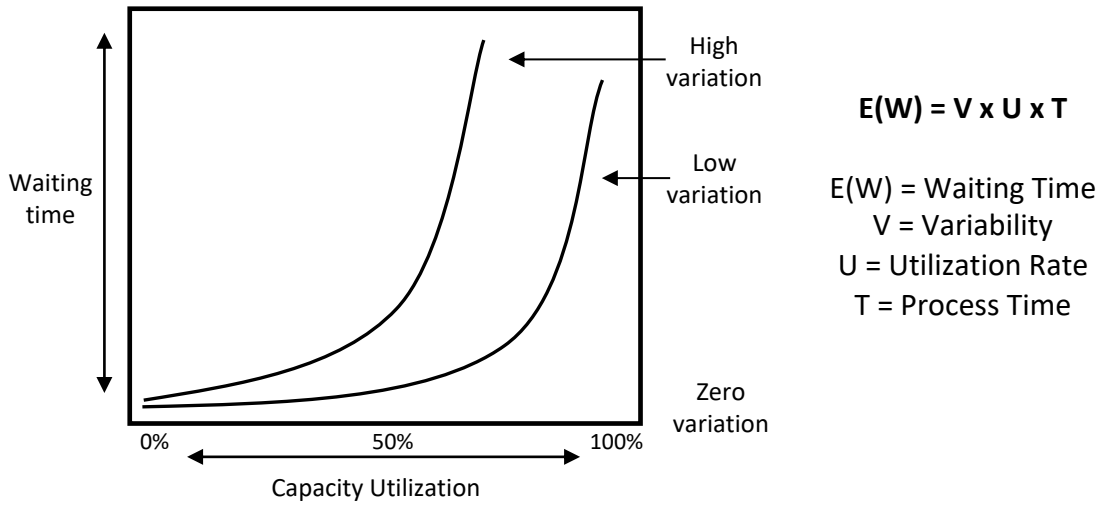

Figure 3: Visualization of Kingman's Formula

Another reason behind not reaching full potential from a process is the existence of bottlenecks that will govern the throughput of any system. They can be separated into two groups: stationary bottlenecks, which stay put irrespective of the production schedule, and moving bottlenecks, which float around depending on demand patterns and production schedules (Goldratt, 1994). The existence of bottlenecks because of process anomalies, addresses the need to reduce complexity to a process, described as a function of the number of static inherent elements. Their heterogeneity and their dynamic interactions can be dealt with by either eliminating complex features or increasing the ability to cope with the complexity (Simon, 1962, Holweg et al., 2018). Moreover, the principles of process theory describe that processes do not operate in isolation and a set of suboptimal solutions can never produce a global optimum. This puts further emphasis on the necessity of reducing bottlenecks and finding process improvements that contribute to overall high-level efficiency. Therefore, alignment across a whole organization for the strategic, tactical, and operational objectives is vital (Lee et al., 1997, Holweg et al., 2018, Schmenner, 2012).

Reducing variation and removing waste to a process can be addressed through quality-improvement methodologies such as Six Sigma and Total Quality Management (TQM) (Sunder, 2013, Dean and Bowen, 1994, De Regge et al., 2019) or through the improvement philosophy of Lean production (Holweg, 2007, Shah and Ward, 2007). These improvement methodologies are customer-oriented focusing on improving processes and productivity to

enable cost reductions. They differ slightly, as Lean focuses on the elimination of waste and the improvement of flows whereas Six Sigma rather aims at reducing variation and enabling defect-free processes. Furthermore, TQM is concerned with the use of statistical methods to identify and monitor processes and to reduce the cost of non-compliance with standards. TQM also strives towards reducing defects and outcome variability. To guide production managers in improving the quality of their processes (Dean and Bowen, 1994) has presented a framework of principles, practices, and techniques that together give neat guidance on how to stimulate good quality to a process by focusing on the need of the customer, continuous improvements and good teamwork. Continuous improvement is then described as the commitment to the constant examination of technical and administrative processes in search of better methods through the use of process analyses, reengineering, fishbone diagrams, and statistical process control (Sousa and Voss, 2002, Dean and Bowen, 1994).

2.6 Patient Flow

Patient flow at hospitals is considered similar to process throughput where attention is directed towards the speed with which patients are processed (treated) towards discharge to improve the productivity of hospitals (Devaraj et al., 2013, Johnson et al., 2020, Roemeling et al., 2017). Bottlenecks in patient processes concerning both administrative and clinical activities can lead to higher costs, lower quality, and unnecessary risks of infection as well as medical complications for patients (Devaraj et al., 2013). Hence, the imperative is strong for reducing process times and achieving better flow management across the hospital organization. The throughput time of interest at hospitals is patients' Length of Stay (LoS) which is the total amount of time the patient stays between being admitted to the hospital until being discharged. The LoS is naturally influenced by numerous factors like the condition of the patient but also procedural delays in the continuing process towards discharge (Johnson et al., 2020, McDermott and Stock, 2007). Hence, to increase the patient flow across the hospital, efforts need to be put on how to improve the throughput of the process by breaking its bottlenecks, and on reducing the internal variation by reducing errors and outcome variability (De Regge et al., 2019).

Researchers point to the problems with overcrowding at hospitals and its impact on the patient flow (Davis et al., 2019, Improta et al., 2018). Overcrowding occurs in hospitals'

emergency departments (ED) when it is not possible to successfully admit and process patients within a given period. It happens when inpatient beds at the hospital have been filled and consequently "block" further transfers from the ED. This might then result in patients being sent to the wrong wards, where the staff might be unfamiliar with their problems, and the overall quality of care will be compromised (McDermott and Stock, 2007, Johnson et al., 2020). Overcrowding may also occur when more patients are admitted to the hospital than what the available capacity is capable to handle. This happens, for example, when patients are given overcapacity beds or "non-available" beds at inpatient wards putting capacity use above 100% (Stjernstedt, 2016, Goldman et al., 1968, Fidler et al., 2007). Furthermore, overcrowding, or a high work in process, puts a great burden on the healthcare system so that the throughput times, or the LoS, becomes even longer and finally overcrowding leads to burnout among healthcare staff (Davis et al., 2019, Improta et al., 2018). This example visualizes the relationship between variation, capacity utilization, and throughput times as seen in Kingman's formula. It highlights the need to manage the bed capacity and the LoS across the hospital to ensure a swift throughput of patients and safe patient care, of high quality (Kreindler, 2017, Johnson et al., 2020, Devaraj et al., 2013).

2.7 Process improvements in healthcare

The last two decades have seen a plethora of healthcare improvement projects, focusing on how to break process barriers and improve the flow of patients. These projects have come in the shape of Lean (D'Andreamatteo et al., 2015, Roemeling et al., 2017, Radnor et al., 2012), Six Sigma (Henrique and Godinho Filho, 2018, Antony et al., 2018, Sunder, 2013), or TQM (Zabada et al., 2010, Mosadeghrad, 2013, De Regge et al., 2019) implementations adapted to a healthcare context. These implementations give growing evidence on positive outcomes in terms of reduced errors, costs, and waiting times in combination with increased patient satisfaction and employee motivation (Roemeling et al., 2017, Radnor et al., 2012, De Regge et al., 2019). Simultaneously, numerous reports state limitations concerning lean projects as the improvement "philosophies" seldomly spread throughout the organizations, compromising their full potential. Instead, the scope of these projects tends to slowly trickle away ending with an implementation of a set of tools having in total a smaller impact on the performance of the organization than initially hoped for (Radnor et al., 2012, D'Andreamatteo et al., 2015).

Another improvement methodology tried at some hospitals is called Value-Based Healthcare (VBH) which takes a slightly different view on how to tackle the challenges facing the healthcare sector. VBH circles around the notion that the healthcare service should, to a much larger extent, focus on value-adding activities and make them measurable, where after healthcare providers are compensated based on the result from these measures (Krohwinkel et al., 2019, Porter, 2013). This would enable health care services to strive towards continuous quality improvements and reduce non-value-adding activities, bringing cost reductions as a consequence (Porter, 2013). The methodology emphasizes the need to organize the healthcare service around the process of the patient instead of around the clinics of the hospital and specializations of doctors. Thus, enabling increased efficiency and a patient-centered process without an economic, geographical, and organizational tussle between intra-hospital clinics, making the patient suffer (Porter, 2010, Krohwinkel et al., 2019, Gray, 2017). The philosophy of VBH has been implemented at a few hospitals around the world, among them Nya Karolinska hospital in Stockholm (Krohwinkel et al., 2019). The objective is to create horizontal patient processes following specific diseases instead of the clinics of the hospital. Even though it's still too early to see clear results from the use of VBH, the methodology has already met fierce opposition from professionals groups and unions. Critiques point at the difficulty to define and measure patient value and that such a strive can undermine professional values and the position of medical knowledge. Further on, as the methodology focuses on measuring, it replaces disproportional trust in professionals with accountability (Krohwinkel et al., 2019). VBH has also been said to fit badly with European healthcare systems as it was developed, having the American system in mind, based heavily on competition between hospitals. Finally, VBH has been criticized for a lack of evidence behind the ideas of the methodology, whereupon its use is questioned (Pendleton, 2018, Krohwinkel et al., 2019).

Lastly, another methodology for patient flow improvements are projects on patient pathways that seek to, from the bottom up, define and improve lead times across healthcare systems for certain well-defined groups of patients (Rotter et al., 2012, De Bleser et al., 2006, Rösstad et al., 2013). The concept of clinical pathways (CPW) aims at creating structured multidisciplinary care plans to standardize the treatment for certain diagnoses by following

well-defined guides or protocols. Even though the evidence on successful CPWs is sparse, there is an association to reduced LoS and costs for the described groups of patients (Rotter et al., 2012). The closely related concept of patient-centered care pathways is furthermore emphasizing the patient's role in the flow across the hospital organization and tries to involve the whole trajectory of care from primary care, through specialist care, until aftercare services and primary care follow up (Rösstad et al., 2013). Patient pathways do however not take a holistic grip on the whole hospital organization as they are restricted to a small number of well-defined patient groups. Consequently, there is a risk that this eliminates congestion in one area for one patient group while building congestion in another area for another group of patients. The hospital-wide complexity arising from the myriad of interchanging planned and emergent patient flows across the hospital organization is thereby seldom addressed, resulting in process deficiencies and sub-optimizations along patients' care journeys (Kreindler, 2017, Johnson et al., 2020, Devaraj et al., 2013, Thomas Craig et al., 2020, De la Lama et al., 2013).

In the light of the above stated problems modern hospitals are facing, several researchers highlight the lack of hospital-wide approaches when improving the throughput of patients across the hospitals which, in the best of cases, results in local efficiency but not a high throughput of patients across the whole hospital organization (Kreindler, 2017, Johnson et al., 2020, D'Andreamatteo et al., 2015, Gualandi et al., 2019).

3. Research methodology

This chapter provides a description of the methodological considerations of this thesis and the strategy followed to answer the research questions. The methodology for each study is outlined and the chapter closes with a discussion on limitations and research quality.

3.1 Research strategy and design

Studying the patient flow from a hospital-wide perspective has up to this day been studied very sparsely and presents therefore a gap in the literature. To study this phenomenon, I choose to follow a qualitative research strategy. Qualitative research is good when trying to understand a new phenomenon and to provide rich explanations on what actors do, how they do it, and why they do it (Flick, 2014). Concerning qualitative research, an inductive approach is also considered one of the key components (Bell et al., 2019) focusing on building theory based on observations and findings. In this research, I employ an inductive approach by exploring the phenomenon of hospital-wide patient flows, how it comes to expression and how it is enabled.

The data collection relies on two sources: a systematic literature review and a semi-structured interview study. Collecting secondary data through literature reviews enables the researcher to get a comprehensive understanding of a phenomenon and to map out its general patterns. Booth et al. (2016) further describe the strength of systematic literature reviews as "*a systematic, explicit and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners*". Conducting a systematic literature review, therefore, seemed like a good strategy for my purpose. Concerning the second source, collecting primary data through interviews provides the possibility to in-depth understand a certain phenomenon through the eyes of the practitioners. Semi-structured interviews, as used in this research, are also very helpful as it allows for variation and follow-up questions when needed (Kvale, 2007). This interview technique was used as the participants varied much in their managerial position, professional background, and pre-understanding of the concept of hospital-wide patient flows.

3.2 Reflection on ontology and epistemology

The research methodology and the theoretical framework used in this research come with assumptions about the nature of science and of the world. These assumptions do naturally have an impact on the results of this research as it guides the ideas and thoughts of the researcher. With the purpose of studying how hospitals can achieve an efficient throughput of patients across their hospitals, there are objective truths on the nature of processes and the concept of flow, simultaneously their designs are bound to context, culture, and surroundings. As such, structures can be both tangible and intangible, meaning that actors create and shape the world, simultaneously as the world shapes them (Bell et al., 2019, Saunders, 2019). The qualitative approach in this thesis which relies on a literature review and on an interview study as data collection methods, suggests an ontological and epistemological perspective of interpretivism and critical realism. This means that the theoretical framework used in this thesis shapes my understanding of the phenomenon I study as it gives me pre-conceptions of how processes and flows behave and are best developed. I do however also regard them as something that must be understood based on the unique context of the healthcare environment, and from interviewing the actors who interact with the patient flow, and impact how it has come to be.

3.3 Research method for each study

This thesis is based on two studies: (1) a systematic literature review on hospital-wide patient process throughput barriers and (2) a semi-structured interview study with top managers at the world's leading hospitals on how they improve their hospital-wide patient flows.

3.3.1 A systematic literature review

When uncovering what is preventing the throughput of patients across hospitals, to be swift and even, little empirical research was to be found. The prospects for researchers to initiate and participate in organizational-wide patient flow improvement projects are seemingly not only small in Sweden but also globally. There is almost no empirical research on patient process throughput barriers taking a hospital-wide perspective. Simultaneously there is a myriad of both published and ongoing studies around the world on how to break process barriers and improve the patient flow through parts of the hospital. This provides therefore a

rich body of literature on the theme of patient flow. Accordingly, a motif to aggregate all these perspectives into a hospital-wide perspective, through a systematic literature review, had appeared and laid the foundation of this study.

To conduct a systematic literature review I followed a procedure based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement by (Moher et al., 2009). I used the databases of PubMed, Scopus, and Web of Science to identify useful Medical Subject Headings (MeSH) and related free-text keywords, and to screen for relevant articles. Two rounds of screening were conducted by me and one co-author: a first on titles, keywords, and abstracts, and a second on full papers, based on predefined inclusion and exclusion criteria. The remaining articles were then analyzed according to a thematic synthesis methodology (Dixon-Woods et al., 2004, Booth et al., 2016) line-by-line as 'free codes' where each code represented a unique patient flow barrier. To enable categorization of the large number of identified barriers they were structured in tree diagrams enabling visualization of both larger families of barriers as well as final root causes. This method did fit its purpose well and the systematic selection of articles and detailed thematization of codes resulted in the identification of themes, barriers, and final root causes. To construct the needed hospital-wide perspective, I and the team of researchers grouped barriers and root causes based on within what medical setting it had been conducted.

This systematic literature review resulted in a framework on patient process throughput barriers and served as a point of departure for the second study, evolving from the need to identify solutions to the identified barriers and root causes of the first study.

3.3.2 A semi-structured interview study

The second study started like the first study in the observation of the limited research on hospital-wide patient processes. Similarly, as for barriers to swift hospital-wide patient processes, studies on solutions taking this perspective are almost equally hard to find. Even so, one systematic literature review by Gualandi et al. (2019) can be found exploring solutions to efficient patient flows across hospitals. They do however mostly include studies performed in the emergency department, limiting its possibility of describing the needs of the whole hospital. With the aim to explore solutions to our previously identified patient process

barriers, and considering the literature review by Gualandi et al. (2019) I and the team of researchers concluded that the most suitable study would be to go to the practitioners and interview them on what they do to overcome these barriers. The focus was then directed towards capturing best practice among the world's leading hospitals by interviewing their top managers who have a broad understanding of the patient processes across their hospitals.

When conducting our study, an explorative qualitative study design was followed, based on a thematic analysis of semi-structured interviews (Kvale, 2007, Dixon-Woods et al., 2004, Bell et al., 2019). To find suitable participants the 2020 international hospital ranking by the American magazine Newsweek was used Cooper (2022) where inquiries were sent to the 25 highest ranked hospitals. 18 hospitals decided to participate, and 33 top managers were in the end interviewed. To improve the quality of the interview study, a pilot study was conducted with three regional hospitals in Sweden. The interviews were conducted following a questionnaire based on the patient throughput barriers identified in the previous study. After conducting the interviews, they were transcribed verbatim whereupon all authors familiarized themselves with the content to obtain a sense of the whole. Following this, all interviews were coded into 558 unique meaning units and thereafter thematized and grouped into 50 unique categories of solution.

This semi-structured interview study resulted in a comprehensive description of how hospitals should go about achieving swift patient flows across their organizations. As the second study was built on the first study, identifying barriers to efficient hospital-wide patient processes, the second study expanded the framework of the first study to also include solutions.

3.4 Research quality and limitations

When commenting on the trustworthiness of my research, I decided to use the criteria presented by Bell et al. (2019) for evaluating qualitative research. To evaluate the trustworthiness of a study, it should have credibility, transferability, dependability, and confirmability.

Credibility within research can be ensured through the triangulation of methods, researchers, and data. This thesis is compiled by one systematic literature review and one semi-structured interview study. As such, different sources and methods have been used to collect data. Throughout both studies, two or more authors have independently screened review articles and transcribed interviews to decrease the risk of bias when selecting and thematizing the content. Respondent validation is also important (Bell et al., 2019) to corroborate or refute findings of the research by presenting them to the research participants. Hence, for the second study, each participant was provided an account of what they said during the interviews as well as if they thought their quotes were appropriate to use in the paper.

Transferability concerns the possibility of taking the findings and applying them in another context by, for example, providing rich accounts of context details. The second paper is empirically driven, and it provides plentiful quotes, making it possible to see and appreciate the line of reasoning and it gives others the possibility to judge the transferability to their context.

Dependability is closely linked to the trustworthiness and is reached by ensuring careful documentation of all records and data throughout the study. Concerning the literature review, a careful selection and screening process was followed (Moher et al., 2009) where articles were carefully stored and coded to ensure transparency and order. Concerning the second study, all interviews were recorded and transcribed verbatim, and all documents were saved, as encouraged by Kvale (2007). Furthermore, the coding structure and choices when coding have been saved for both studies.

Confirmability is important, to show that the researcher has acted in good faith and is open about potential bias. Concerning both studies a potential risk of bias comes from the authors

being all from the same discipline, thus increasing the risk to include and prioritize views that confirm previous beliefs and understanding. For the second study, the interviews were conducted by a single researcher, creating the risk of subjective bias and perspectives when posing questions and guiding the interviewees. Hopefully though, concerning both studies sufficiently rigorous methods have been followed reducing the risk of bias as far as possible.

4. Summary of appended papers

4.1 Paper 1: When patients get stuck: A systematic literature review on throughput barriers in hospital-wide patient processes

Paper 1 explores existing research on what factors are preventing swift and even patient throughput at hospitals and synthesizes those factors into themes, main barriers, and underlying root causes. There is today a significant body of literature on patient throughput barriers, but these studies have rarely encompassed complete hospitals. The purpose of this paper has therefore been to explore process barriers to patient flows by taking a hospital-wide perspective addressing a gap previous literature has identified. As such, through a systematic literature review, 92 articles were screened and selected on patient process throughput barriers and aggregated into a hospital-wide perspective. 12 main barriers and 15 associated main root causes to inefficient patient processes across hospital organizations were subsequently identified.

This study has developed a new framework to be used by policymakers and healthcare managers when deciding what improvement strategies to follow to increase patient throughput at hospitals. The framework visualizes connections between the most prevalent barriers and their most prevalent associated root causes. It demonstrates how different throughput barriers can be the consequence of similar root causes as well as how barriers and their associated root causes are intertwined. The review confirms barriers highlighted by previous literature but extends the analysis significantly by ordering them in new levels to better explain the complexity behind inefficient patient processes. Moreover, this paper develops a process model for hospital-wide patient flows by using the categories of processes presented by Holweg et al. (2018). In the adapted model for healthcare contexts, patient process barriers are divided into five different themes: "*Entry*", "*Internal*", "*Management system*", "*Transfer*", and "*Discharge*". These categories give a physical orientation to each barrier, depicting where across the patient process a certain barrier may appear.

Many debates are looming around the world on how healthcare is best developed to meet the challenges of rising demand. This paper addresses these challenges from a hospital-wide view and provides a summary of the most important barriers and associated root causes to focus on. Together, they indicate that root causes of inefficient hospital patient throughput are both resource-related and work-method-related. Even though a lack of resources is a relevant factor, our results indicate that several other root causes are more easily addressed and can lead to capacity improvements without increasing expenditures, a strategy also supported by previous research.

4.2 Paper 2: Solutions for improved hospital-wide patient flow – A qualitative interview study of leading healthcare providers

Paper 2 explores effective solutions to achieve a swift and even throughput of patients across hospital organizations and develops a framework to guide improvements on the hospital-wide patient flow. This paper takes its departure in the lack of research solutions on efficient hospital-wide patient flows. Through an international semi-structured interview study, senior managers at the world's leading hospitals were interviewed to explore how they perceive the patient flow perspective, and how they work to improve the throughput of patients across their organizations. To find suitable participants, the 2020 international hospital ranking by the American magazine Newsweek was used. Consequently, following a pilot study with three regional hospitals, an inquiry was sent to senior managers at the 25 highest ranked hospitals and 18 of them accepted the invitation. 33 interviews were held, with in total 33 hospital managers with various backgrounds, and at various positions.

Findings from the study present a list of 50 unique solutions on what hospitals should do to improve the hospital-wide patient flow. These solutions are together highlighting the need for hospitals to *align their organizations; build coordination and transfer structures; ensure physical capacity capabilities; develop standards, checklists, and routines; invest in digital and analytical tools; improve their management of operations; optimize capacity utilization and occupancy rates;* and *seek external solutions and policy changes.* These solutions are not new nor surprising since they all have been described in previous research, either as needed developments or as already implemented interventions. The novelty from this paper is

therefore to present these solutions together in a hospital-wide perspective emphasizing the need to consider all of them when improving the patient flow.

This paper connects to the previous study by extending the previously constructed framework on themes, barriers, and root causes with solutions. Hence, this study extends the previous framework on what barriers hospital managers and improvement agents should focus on by also including what solutions they shall seek to overcome the identified barriers. Moreover, this study highlights that multiple hospital managers consider their patient flows to be constrained by insufficiency in beds and staffing resources. Simultaneously they highlight a myriad of projects and solutions on how to improve their processes without increasing their spending, and how to better utilize available capacity. Together, these hospitals are considering the path forward as both work-method-related, and resource-related, saying that much can actually be achieved without increasing costs. This interview study gives also a strong indication that hospitals need to have designated top managers working with flow-related questions to create a strong support and understanding for hospital-wide process improvements. Lastly, this study points to the need to strategically look at the patients' process as one unified flow, where the available capacity supporting that flow must be balanced, aligned, and integrated between and across all actors, internally and externally.

5. Results

This chapter retraces the initial research questions that have guided the research presented in this thesis and explains how the result from the appended papers helps in answering them.

5.1 Research question 1

The first research question addresses the necessity to understand the constraints behind patient processes before trying to improve them and therefore asks: *what barriers are preventing swift and even patient flows at hospitals?*

In the first paper, 12 main barriers and 15 main root causes were identified under five themes, presenting an extensive variety of problems that hospitals must approach and overcome, see table 1. Of these, long lead times, inefficient capacity coordination, and inefficient patient process transfer are the most prevalent patient process barriers at hospitals. These barriers are subsequently mainly caused by inadequate staffing, lack of standards and routines, insufficient operational planning, and a lack of IT functions.

Table 1: Themes, barriers, and root causes to inefficient patient processes

Themes	**Barriers**	***Root causes***	
Internal	High work in process	Increasing demand	Lack of IT functions
	Inefficient capacity coordination	Insufficient communication	Lack of separate tracks
	Inefficient capacity utilization	Insufficient discharge routine	Lack of staff
	Insufficient capacity	Insufficient facilities and layout	Lack of standards and routines
	Large capacity utilization variation	Insufficient operational planning	Medical quality priorities
	Long lead times	Insufficient transfer coordination	Random internal disturbances
Transfer	Inefficient patient-transfer process	Lack of ancillary services	Unpredictable patient problems
	Inefficient support-transfer process	Lack of beds	
Entry	Changing demand		
	Unpredictable inflow variation		
Discharge	Inefficient outflow process		
Management system	Low interorganizational coordination		

Most barriers are associated with internal problems within each clinic or with problems occurring when patients are transferred between different clinics. There is also a scarcity of studies on barriers associated with the management system thus limiting the generalizability of the findings, as important areas have not been studied sufficiently enough. Hence, paper one answers RQ 1, but is limited to the extent of previous research and cannot, therefore,

give a complete picture. The paper did however provide a good point of departure in trying to answer research question two.

5.2 Research question 2

The second research question builds on the first by asking: *what are the best solutions to break the previously identified barriers and to achieve efficient patient flows across hospital organizations?*

The extensive interview study of the second paper identified 50 solutions on how to overcome the previously identified barriers. Each of the 50 solutions is supported by multiple hospitals and provides therefore a well-underpinned board of suggestions on how to go about when improving the hospital-wide patient flow. The paper highlights a large variety of solutions with largely varying character and focus, albeit with the purpose of having a positive impact on the throughput of patients across the hospital organization, see table 2. The right column in the table presents the 50 solutions and the middle column presents the barriers that the solutions help to overcome. Lastly, the left column presents themes of barriers to visualize where along the patient flow these barriers evolve and consequently where the identified solutions provide support. Superscripts in table 3 indicate that one particular solution has a connection to more than the closest barrier within the same row.

Table 2: Themes, barriers, and solutions to efficient patient flows

Themes	Barriers	Solutions
Entry	Changing demand	*[s1] Strategic planning: make recurring strategic revisions on fit between demand and capacity*
		[s2] Strategic planning: use predictive analytics to forecast demand patterns and capacity needs
	Unpredictable inflow variation	*[s3] Cooperate with other hospitals to ensure bed capacity and to seek appropriate level of care*
		[s4] Ensure capability to reroute less severe ED patients to outpatient, ambulatory or home care
		[s5] Reach, inform and treat patients before they seek acute hospital care
		[s6] Require increased primary care responsibility and support with more knowledge exchange and coordination
		[s7] Use IT-tools and data analysis for standardized admissions, early assessments and reduced no-shows
Healthcare sector	Unaligned and restrained healthcare system	*[s8] Create healthcare system alignment with clear goals and objectives for each healthcare actor*
		[s9] Increase staffing and bed capacity across the whole healthcare system [b]
Internal	High work in process	*[s10] Optimize and smooth occupancy rate levels by admitting patients based on length of stay and ICU risk* [c]
		[s11] Understand the tipping point of hospital's capacity utilization and ensure sufficient capacity buffers
		[s12] Use an OR block schedule per clinic and plan cases based on downstream bed availability [c]
	Inefficient capacity coordination[a]	*[s13] Allocate dedicated capacity for both acute and elective patient flows*
		[s14] Ensure a high OR-utilization with smart case mixes, all day utilization and quick cancellation refill
		[s15] Operational planning: have daily capacity meetings within the department or clinic
	Inefficient capacity utilization	*[s16] Have a structured organization for daily problem solving and capacity optimization* [d]
		[s17] Schedule staff and all clinical activities based on an optimal utilization of the OR-schedule
		[s18] Utilize as much of the week as possible and staff day and week according to real demand patterns
	Insufficient capacity[b]	*[s19] Invest in ancillary service capabilites to minimize bottleneck risks in indirect patient activities*
		[s20] Use external facilities or patient hotels to release hospital bed capacity
	Large capacity utilization variation[c]	*[s21] Improve outpatient processes by implementing standards on schedules and appointments*
		[s22] Improve prioritization schemes and develop standards on procedures, roles and staff ratios [a]
	Long lead times[d]	*[s23] Make all employees understand the importance of having a patient flow focus* [a, c]
		[s24] Give clinics trust and improvement autonomy but follow central process metrics and external benchmark
		[s25] Use more digital tools and new time saving treatment methods to reduce lead times
Management System	Insufficient patient flow focus	*[s26] Connect managers and staff across the hospital to break silo mindsets*
		[s27] Put patient flow focus on top of the agenda across the hospital, to change the culture
		[s28] Share and visualize correct data across the organization to make everyone understand flow implications
	Low interorganizational coordination	*[s29] Align objectives, metrics and patient data systems (EHR & CRM) across the organization*
		[s30] Increase collaboration on capacity between clinics and departments across the hospital
		[s31] Operational planning: have daily capacity meetings with all clinics of the hospital
		[s32] Use a flow command center to optimize capacity use and break hospital flow bottlenecks
		[s33] Use some type of patient coordinators to see and prioritize the needs and process of the patient
		[s34] Tactical planning: have weekly capacity coordination meetings with all clinics of the hospital
	Hospital wide capacity insufficiencies	*[s35] Build up flexible hospital wide capacity to handle peaks or capacity unbalances*
		[s36] Ensure sufficient capacity along the whole patient flow to avoid bottlenecks
		[s37] Use IT-tools to analyze bed capacity use and provide daily real time visibility on hospital capacity
Discharge	Inefficient outflow process	*[s38] Have dedicated discharge coordinators or coordinating teams*
		[s39] Improve the organization around discharge ready patients when planning procedures and activities
		[s40] Prioritize activities and organize staff to ensure early and efficient daily discharges
		[s41] Set early discharge goals and continuously work towards them for every patient
	Insufficient after care capacity or cooperation	*[s42] Enable discharge predictability with more home care solutions and own downstream facilities*
		[s43] Provide follow up appointments at discharge to ensure accountability and continuity
		[s44] Request and work towards increased responsibility from after care services
		[s45] Share objectives, information and real time capacity data with after care services
		[s46] Use mutual staffing collaboration between the hospital and after care services
Transfer	Inefficient patient-transfer process and inefficient support-transfer process	*[s47] Give a specific flow unit or team the task to control and arrange for efficient transfers*
		[s48] Have standardized handoffs, pre-defined destinations and established incentives for efficient transfers
		[s49] Have clear roles with defined mandates concerning transfers between the ED and the receiving clinic
		[s50] Use digital tools to efficiently connect and navigate cleaners, porters, medical staff and patients

a, b, c, d *refers to a connection between a solution and more than one barrier*

Paper two answers RQ 2 by providing an extensive number of solutions to enable an efficient hospital-wide patient flow. Moreover, RQ 1 and RQ 2 are concrete and formulated to seek out the most hampering barriers and the most promising solutions. Paper one and two have consequently provided good results seen to this aim, by providing a list of relevant obstacles and best practice on how to overcome the obstacles. The two papers provide, together with the theoretical framework, however also good possibilities in answering RQ3.

5.3 Research question 3

The third research question lifts the perspective from concrete actions to a more conceptual level by asking: *how can an increased focus on hospital-wide patient flow help hospitals to increase their productivity and throughput of patients?*

The throughput of patients is important for hospitals to address for an improved productivity. To ensure high throughput of patients, as a measure of productivity, requires that high output is obtained from the set of inputs or resources provided by a hospital (Slack and Brandon-Jones, 2019, Kämäräinen et al., 2016, Syverson, 2011). Consequently, the resources used to produce that output must not only be the right ones, they must also be optimally distributed along the value-adding chain of activities supporting the throughput of patients (Vissers and Beech, 2008). Hospitals are also bound to have high utilization of their available resources, i.e. input capacity, as the costs associated with running their operations and paying salaries to their skilled workforce are high. Having a high capacity utilization does however not necessarily mean that hospitals have a high output capacity or productivity. Little's law and Kingman's formula visualize the need for hospitals to find a good balance between resource efficiency and flow efficiency to optimize their productivity (Little, 1961, Kingman, 1966). The theories show that if the capacity utilization becomes too high then the throughput time is greatly increased, reducing the throughput rate and the productivity. The first paper shows that process variation and demand unpredictability are two very present phenomena at hospitals. It further reveals that a high work-in-process caused by overcrowding and boarding of patients at the emergency department creates congestion and reduced throughput of patients. Paper one also highlights the need to better utilize available capacity with less variation over the day and week, as well as to coordinate it more efficiently. Subsequently, the second paper reveals that hospitals experience efficiency tipping points and that they

must have sufficient capacity buffers to avoid unsustainable peaks in their capacity utilization. Hence, an increased focus on the hospital-wide patient flow can help hospitals to better understand the consequences of overutilizing available capacity as well as understanding the relationship between capacity utilization and productivity.

Just as process theory describe that "*processes do not operate in isolation and a set of suboptimal solutions can never produce a global optimum*" (Holweg et al., 2018), the results from paper one and two present a need for hospitals to see their patient flow as one aligned and integrated process. It is important for clinics and units across the organization to improve their cooperation and coordination and to better understand the needs of the upstream and downstream actors. Both papers reveal the need to centrally plan and design the hospital-wide patient flow to make sure that all types of patients are given the best possible conditions to be treated and that it should not be a matter of chance if a patient is entering a swift and even process or pathway aligning their journey through the hospital. Process theory also explains that bottlenecks will govern the throughput of any system (Schmenner and Swink, 1998, Holweg et al., 2018), something that paper one provides many insights into. Paper one reveals that bottlenecks, i.e. the root causes behind patient process throughput barriers, come in numerous shapes and can be seen as both stationary and moving. It is therefore important for each clinic or unit along the patient flow to understand their unique bottlenecks or root causes and what type of impact those might have on the throughput of patients. Moreover, the theory of swift and even flow describes that "*productive processes are steady and foreseeable, and best achieved by reducing variation in quality, quantity and timing*" (Schmenner, 2012). Paper one confirms this by presenting that large variation in capacity utilization is one main patient throughput process barrier and that several root causes are associated with varying practices, as well as insufficient standards and routines. Lastly, paper two presents how important it is to improve predictability along the patient flow, something achieved with the use of new and smart technology as well as from proactive decisions in the daily operational activities.

To summarize, an increased focus on hospital-wide patient flow can help hospitals to better understand the connectivity and dependability between different actors along the value chain of activities. This dependability emphasizes the need to make patient processes more

standardized and foreseeable to reduce complexity, miscommunication, and unaligned objectives. Lastly, an increased focus on the patient flow will direct healthcare managers and professionals to understand when further capacity utilization has the opposite effect compared to the intention.

6. Discussion

This chapter discusses the findings and their implications for practice and theory based on the two appended papers in this thesis and previous research. The findings present what hospitals can do and how they should think around improvements of their hospital-wide patient flow, and what that focus can mean for the hospital organization.

The overall aim of this thesis is to explore what hinders or enables hospitals to improve their throughput of patients across their organizations and to better understand how an increased focus on patient flow can improve the productivity of hospitals. The systematic literature review in the first paper revealed that there are a set of main barriers and main root causes that are more central than others when improving patient flows across hospital organizations. It, therefore, provides an evidence-based overview of what problems to focus on. The interview study then revealed that leading healthcare providers have a large set of solutions to tackle previously identified barriers to hospital-wide patient flows. These solutions give a holistic view of the width of activities a hospital must address. Lastly, this thesis gives much food for thought on how an increased focus on patient flow can help hospitals to increase their throughput of patients. The results highlighting these perspectives are synthesized in the following sections of the discussion.

6.1 A patient flow improvement framework

Improving the patient flow across the hospital is important to increase productivity, reduce LoS and reduce waiting times to treatment (Davis et al., 2019, Improta et al., 2018, Johnson et al., 2020, Haraden and Resar, 2004). The flow of patients is the core process through the hospital organization and the speed with which patients are processed from admission to discharge sets constraints on all other inter-related processes (Kreindler, 2017, Gualandi et al., 2019). Hospitals are considered to be among the most complex types of organizations (Glouberman and Mintzberg, 2001), and knowing how to improve the throughput of patients is not easy. Something that can provide good guidance to managers and commissioners when they design their improvement strategies is therefore of great need. In the first paper of this thesis, a model was developed to visualize both the hospital-wide patient process but also the types of barriers that may appear along that process, see figure 5.

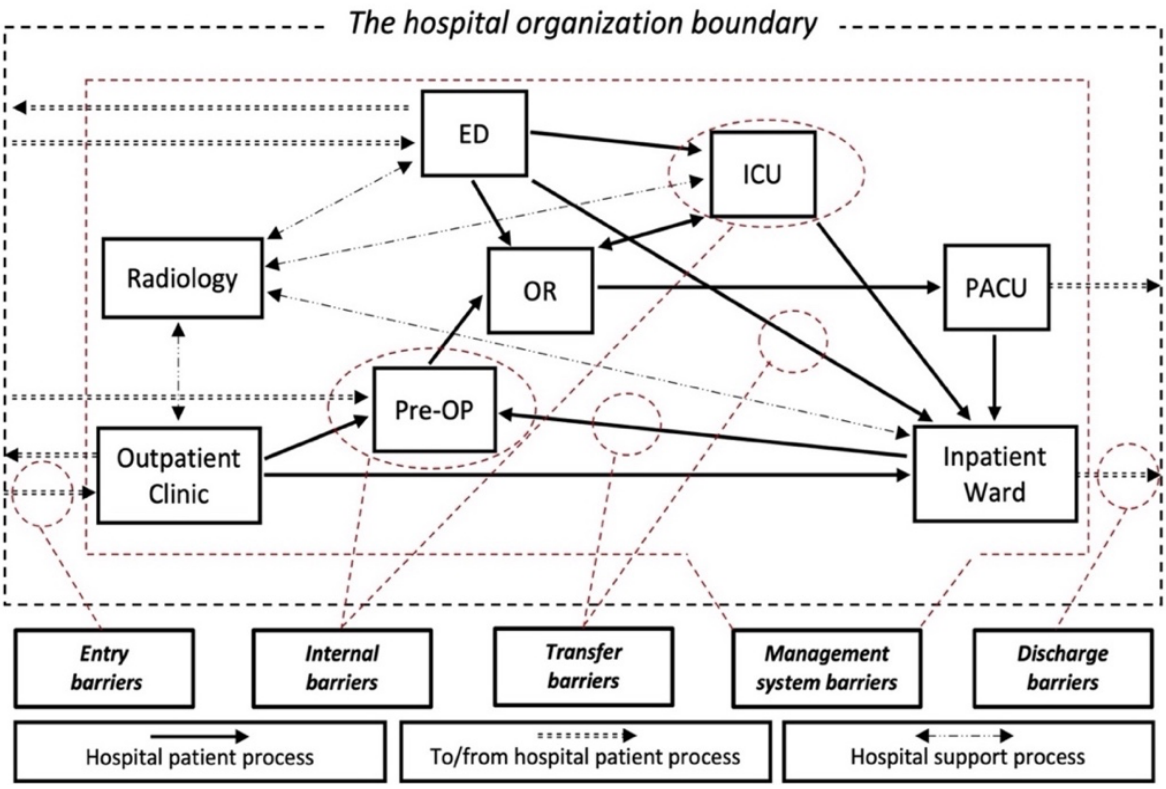

Figure 5: The hospital-wide patient process barrier model

From the analysis of barriers and solutions in papers one and two, this thesis presents an improvement framework visualizing the connections between patient process barriers and their associated root causes (paper one) and connections to promising solutions (paper two), see figure 6. The framework also has a connection to the previously presented process model by visualizing how barriers and solutions are linked to the themes of processes. This framework is important as it gives hospital managers and commissioners the possibility of taking various approaches when trying to improve the hospital-wide patient flow. The framework can be used when identifying a certain root cause or barrier and then looking for appropriate solutions to implement. A different route might be to start by selecting a feasible solution and explore what barriers or root causes it might help to overcome. Yet another approach could be to select some part of the patient process, found in the process model, and see what problems and solutions are associated. Consequently, this framework will be able to provide good guidance when designing new improvement strategies.

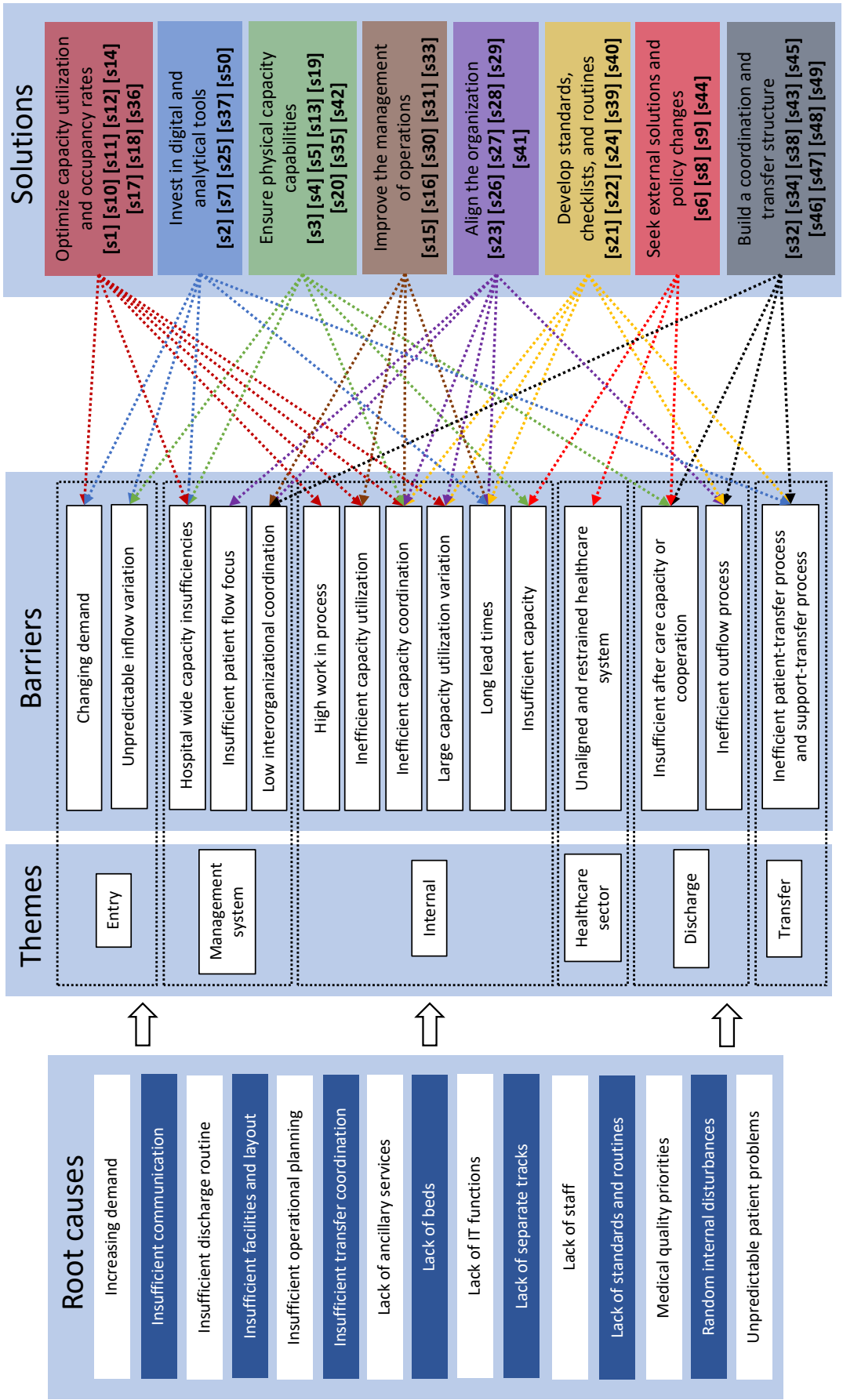

Figure 6: The hospital-wide patient flow improvement framework

6.1.1 Towards a conceptualization

Improving the flow of patients across hospitals poses considerable challenges to managers, commissioners, and healthcare staff. The hospital-wide perspective is challenging traditional views on how the hospital should be managed and organized. It requires clinics to look beyond their borders to jointly plan operations, to systemically make processes more transparent and predictable, and to implement or invest in new capabilities supporting a hospital-wide use of available capacity. The 50 solutions to swift and even patient flows across hospitals have been summarized under eight headlines and further explained below.

Aligning the organization is important and previous studies have emphasized the need for hospitals to improve their throughput of patients from a system-wide perspective and that a stronger integration is needed among actors to improve the flow of patients (Kreindler, 2017, Johnson et al., 2020, D'Andreamatteo et al., 2015, Vos et al., 2011). Krendler (2017) describes that hospitals and the wider healthcare system are suffering from fragmentation and that conflict and competition are built into the system. Consequently, there is a need to break these barriers to better align and integrate the various actors along the flow of patients. Vos et al. (2011) present that hospitals must move from the present functional organization design to a process-oriented design and that everyone across hospitals must be in charge of the patient process instead of just their own tasks. Additionally, Rotter et al. (2012) show that hospitals and patient process pathways can benefit from having well-integrated and clear organizational goals. This thesis confirms these perspectives but adds some detail in that hospitals must make all stakeholders understand the implications from their decisions on the patient flow and that an open and collaborative culture builds on shared visibility and improved transparency.

Building a coordination and transfer structure is central to swift patient flows and emphasized by several studies (Gualandi et al., 2019, Vos et al., 2011, Villa et al., 2014, Johnson et al., 2020, Bahall, 2018). Johnson et al. (2020) describe the need to build up a patient flow department, Gualandi et al. (2019) describe the need to introduce specific transfer coordinators, and Vos et al. (2011) emphasize the need to provide coordinators and flow units with strong mandates to support efficient transfers of patients between clinics and units. In previous research, there is a strong focus on transfer and coordination between internal

actors of the hospital while this thesis also presents a need to improve the collaboration and information sharing between the hospital and external actors for an improved transfer of patients.

This thesis presents that it is important to *ensure physical capacity capabilities*, something also expressed by other researchers. Bahall (2018) describes the need to ensure sufficient ancillary services to not block the patient flow, Scott (2010) describes the need to expand the number of home care services and short stay wards, and Davis et al. (2019) describe the need for flexible staffing units to meet variable demand. These perspectives have also been highlighted in the second paper of this thesis but where additional emphasis is put on the need for defined pathways away from the ED and from the hospital as a measure to reroute various patients to more appropriate and less resource-heavy locations.

Hospitals need to *invest in more digital and analytical tools.* Devaraj et al. (2007) provide evidence that IT investments support better scheduling, coordination of patients, and the process of setting correct diagnoses. Lovett et al. (2016) present how essential real-time data reporting is to swift and even patient flows and the management of beds. Villa et al. (2014) also conclude that the hospital information system must be redesigned to better support patient flow management strategies. This thesis adds to this chain of evidence that various IT tools can be used to support several activities across the hospital. It however also describes the need to anticipate demand patterns with predictive analytics, the potential from using robots and algorithms for automatic reading and sorting of referrals, and lastly that tools for demand heat mapping can help to optimize the allocation of capacity.

The benefits from *introducing more standards, checklists, and routines* are presented in the two papers of this thesis and confirmed by numerous other studies. De Regge et al. (2019) describe how a higher level of process standardization in operational processes can improve the resource and throughput efficiency across hospitals. Improta et al. (2018) explain the importance of standardizing best practice to eliminate non-value-adding activities and to improve process throughput. Lastly, Gualandi et al. (2019) emphasize the need to standardize the admission and discharge processes to better predict and anticipate patient discharges over the day. This thesis provides additional insights by describing the need to work with

standards related to work tasks, decision making, and nurse-bed rations. Introducing more standards within outpatient clinics are also central to achieving better transparency and utilization of schedules, clinical slots, and use of physician time.

Improving the management of operations is something highlighted by both previous studies and by this thesis. It is important to have a patient flow management center (Johnson et al., 2020, Lovett et al., 2016, Gualandi et al., 2019) or a centralized unit in charge of the patient flow logistics (Villa et al., 2014) for the daily optimization of available capacity to meet existing demand. Subsequently, it is also important to build an improvement culture and to have a focus on continuous improvements across the whole organization (Radnor et al., 2012). This thesis describes, in slightly different terms, that the daily control and management of available capacity in association to present and anticipated admissions should be run by a command center and supported by bed huddles at department levels. Another associated finding is the need to support these meetings with weekly tactical capacity meetings to plan and settle disputes or misalignments.

Optimizing the capacity and balancing the occupancy rates is considered central to enabling a high throughput of patients across hospitals and requires several actions. Haraden and Resar (2004) explain the importance of reducing operational variability along the patient flow and the need of working with external actors to smooth occupancy rates to improve the throughput of patients. They show that planned surgeries constitute the greatest source of variation at hospitals and therefore it is important to smooth the surgical schedule across the services of the hospital. Davis et al. (2019) also explain that overcrowding has a deteriorating effect on the patient flow and may be mitigated by better predictions of overcrowding events to enable appropriate courses of preventive activities. This thesis adds to previous research by explaining the need to forecast and estimate patients' length of stay before settling on utilization plans for ORs, ICUs, and wards. It is also important to, at recurring intervals, make strategic revisions on evolving demand patterns to continuously adapt the available capacity across the hospital to the present demand.

There is a great need in the present healthcare crisis to *seek external solutions and policy changes* as many hospitals and healthcare systems are chronically overburdened. Previous

studies show that there are, and will be for many years to come, dramatic imbalances between present numbers of doctors and nurses and the actual demand for them (Scheffler and Arnold, 2019). They point to that a better work environment and improved job satisfaction are likely needed to reverse this trend. Other studies highlight the need for policy changes concerning what mission the hospital is supposed to have. Evidence shows that the width of services given by hospitals must be reduced by transferring larger portions of the population, like poorly controlled multi-system diseases, over to the primary care (Scott, 2010). Lastly, Kreindler (2017) describes the healthcare system as fragmented and that there is a lack of shared aspirations and directions among various healthcare providers in regards to patient flow. As of today, there are unclear system goals and accountability greatly reducing the efficiency of the system, something that must change to improve the flow of patients across hospitals. This thesis confirms previous findings and complements these views by also highlighting the complex position many hospitals find themselves in when squeezed between a never-ending inflow of patients and difficulties in finding after-care providers willing to accept their discharge ready patients. This problem urges policy makers to either increase downstream capacity, change legislation or introduce new incentive programs.

6.2 Increasing resources or improving methods

An ever-present debate within the healthcare sector is on whether the problems facing hospitals are best solved by increasing the staff and the number of beds or by changing work methods. Politicians are reluctant to increase expenditures and do instead formulate annual efficiency goals as a means of increasing capacity (Lorenzoni et al., 2019, Rumbold et al., 2015, Atella et al., 2019, Kirby and Kjesbo, 2003). How these efficiency goals shall be met are however put on the shoulders of managers and healthcare professionals (Larsson and Plesner, 2019). In the daily reality of healthcare professionals, it may many times be hard to know how to improve work methods to reach the efficiency goals imposed on them. By continuously experiencing hospital overcrowding and colleague burnouts it is also closer at hand for healthcare professionals to conclude that the only road forward is by adding more resources to the healthcare system (Larsson and Plesner, 2019). Both papers one and two of this thesis give evidence that both these perspectives may be right. Paper one highlight that the patient flow through hospitals is hindered by both resource insufficiencies as well as by improper or inefficient work methods. The second paper adds to this perspective by

highlighting that healthcare managers consider the best path forward coming from both investments in new resources as well as from improvement projects on available resources. A conclusion from this might then be that there are two possible solutions to solve the crisis.

I would however argue that there is only one possible path ahead, being related to new and improved work methods and philosophies. The second paper describes that when hospitals are given more resources the added capacity is quickly utilized to the same extent as previously, because of the infinite healthcare demand. Consequently, investments in more resources only give short-term relief before the system is equally restrained as previously. Hence, new and improved work methods to build an efficient structure for a hospital-wide patient flow is, therefore, the only long-term solution. By breaking the barriers found in paper one and implementing the solutions of paper two hospitals can utilize and balance their capacity across the hospital to both treat more patients and to reach a more sustainable work environment. As it is difficult to initiate and execute an ambitious improvement project, it is however probably a wise idea to increase the amount of available capacity, in terms of beds and staff to give space and have sufficient capacity and competencies when improving the flow of patients. Such a solution would likely both give short-term relief to an over-restrained system and long-term cost reductions to a system better equipped to enable stability, predictability, and balance, see figure 7.

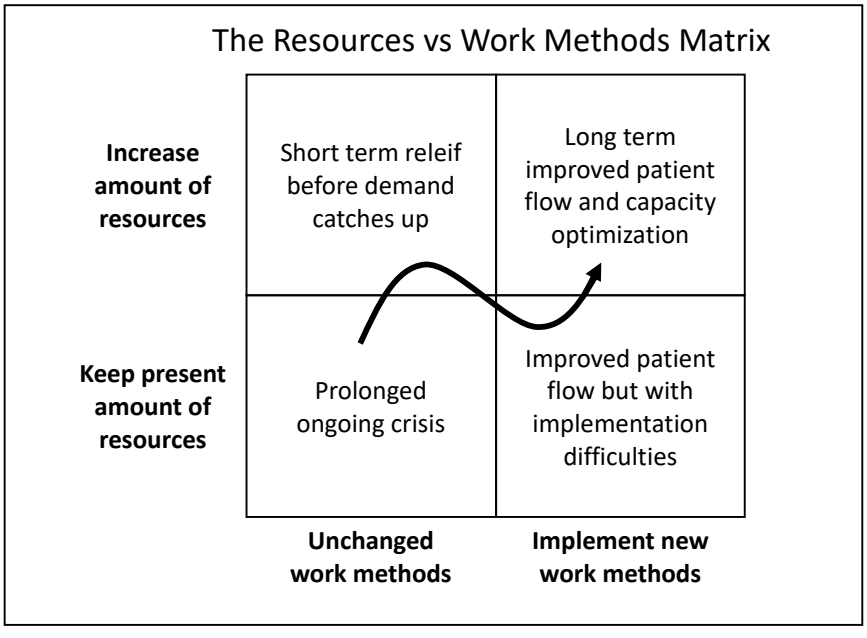

Figure 7: The resource vs work methods matrix

6.3 Widened considerations

This research has taken its departure in suggestions by previous research to look at the patient flow from a broad perspective, and to explore how to better align the hospital and improve the capacity utilization (Gualandi et al., 2019, Kreindler, 2017, Johnson et al., 2020, Vos et al., 2011). Both papers of this thesis have explored this phenomenon and their findings present the importance to build and improve the patient flow from a hospital-wide perspective. They show how all settings across the hospital are interconnected along the patient flow and that an organization-wide synchronization is needed to reduce inefficiency and variation. This confirms thoughts lifted in previous research on the need to better integrate the various actors along the patient process and develop common objectives (Johnson et al., 2020, Vos et al., 2011). Moreover, the first paper visualizes how barriers to efficient patient flows are recurring across the hospital and that various hospital settings are facing similar problems despite very different purposes. The second paper goes one step further by also emphasizing the importance of involving external actors to a larger extent to better support a swift and even patient flow across the hospital. This can be seen in how leading hospitals are collaborating closely with both primary care and aftercare services through the sharing of information, something previous research has described as vital to better coordinate care and improve the patient experience (Dobrzykowski and Tarafdar, 2015, Devaraj et al., 2013). Information sharing must not only encompass the sharing of electronic health records but also real-time occupancy data and early plans on suggested patient treatment pathways. Additionally, the second paper highlights the increasing importance of sharing staff between healthcare providers and that there should be permanent physical representatives at collaborating actors' facilities to improve information exchange and cooperation around common patients.

As described above, healthcare systems are generally fragmented with multiple actors holding different views on how to best conduct healthcare services (Kreindler, 2017, Rotter et al., 2012, Villa et al., 2014). It is central that interacting healthcare providers share objectives, strategies, prioritizations, and supporting systems to enable mutual sharing of electronic health records (Vos et al., 2011, Devaraj et al., 2013, Dobrzykowski and Tarafdar, 2015). Paper two confirms these perspectives and multiple healthcare managers consider it necessary for multiple healthcare providers to share a similar vision to support the flow of

patients throughout the whole healthcare system. They realize that the throughput of patients within the hospital is depending on the throughput of patients outside the boundaries of the hospital. This gives evidence that the chain of activities and services must be aligned between primary care providers, specialized care providers, and after-care service providers. Consequently, the exchange and collaboration between these three actors can be visualized as a triadic network where patient flows between three actors exchanging information, staff, and common goals, see figure 8.

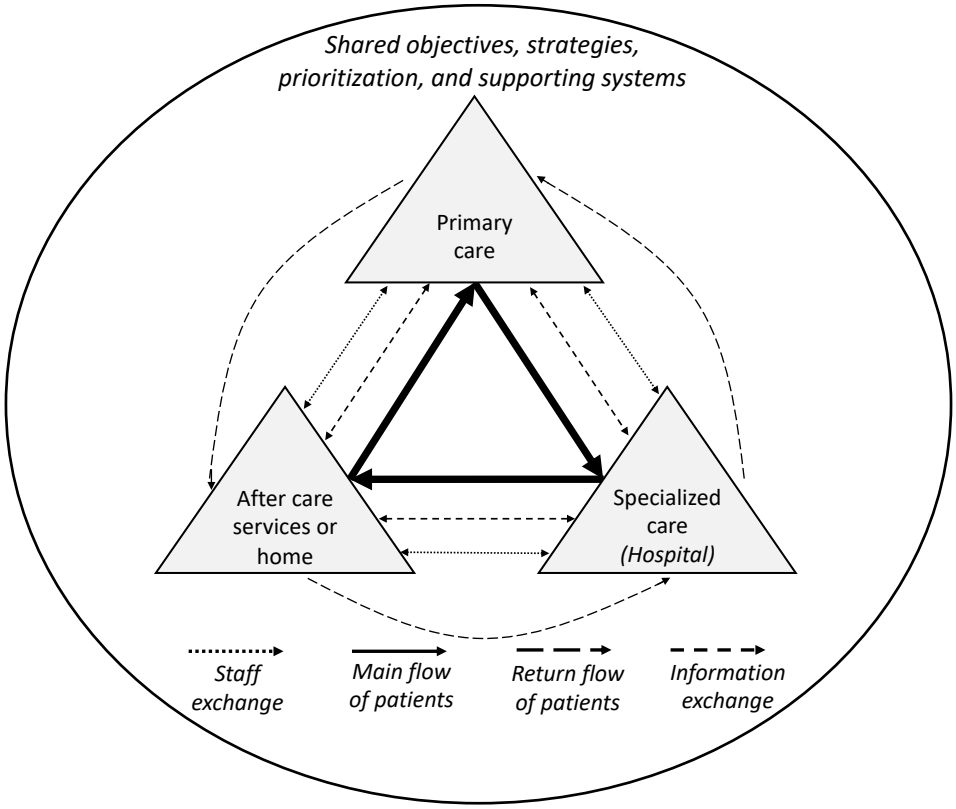

Figure 8: The patient flow service chain perspective

6.4 Identifying the efficient zone

Hospitals are constantly struggling with overcrowding, either ongoing or approaching (Improta et al., 2018, Davis et al., 2019, Stjernstedt, 2016). Overcrowding evolves when there is insufficient capacity to handle the number of patients being treated at the same time (Davis et al., 2019). To have insufficient capacity means that objectives are either not met or that available capacity must be overutilized for objectives to be met. Unused or underutilized capacity is simultaneously very expensive and preferably avoided, and it is not economically viable to keep available resources idle. Paper one highlights the problems with

underutilization by presenting *inefficient capacity utilization* as one of the main barriers to inefficient patient flows. To overutilize available capacity is neither a good idea, which is explained by paper two. It might solve a sudden crisis but in the longer term it makes the system slow as routines are not followed, errors are committed and patient safety is under threat (Stjernstedt, 2016, Davis et al., 2019, McDermott and Stock, 2007, Fidler et al., 2007). To overutilize staff might lead to them resigning, which further escalates the problems with insufficient capacity. There seems to be a prevailing logic that efficiency is not harmed when resources are overutilized, i.e. that it only influences the working climate. Paper two describes how the system becomes slow when too many patients have been admitted to the hospital.

Kingman's formula (Kingman, 1966) provides a theoretical foundation to understand dependencies between waiting time, variation, and capacity utilization. The formula gives a clear example of that at a certain point, when capacity utilization becomes too high for the process to handle the variation, the waiting time increases dramatically. To add Kingman's formula to the discussion on capacity utilization gives a good visual representation of the "efficient zone" where capacity utilization is both economically viable and long-term sustainable, see figure 9. As highlighted in paper two, many hospitals realize that there is a *tipping point* when too high capacity utilization has a deteriorating effect on the patient flow and the efficiency of the hospital. Figure 9 marks this tipping point as the theoretical point where the capacity utilization is as high as possible without having a too negative effect on the working climate and the waiting times along the patient flow. This thesis gives a strong indication that hospitals must increase their understanding of the consequences of crossing their tipping point and the consequences it imposes on the hospital.

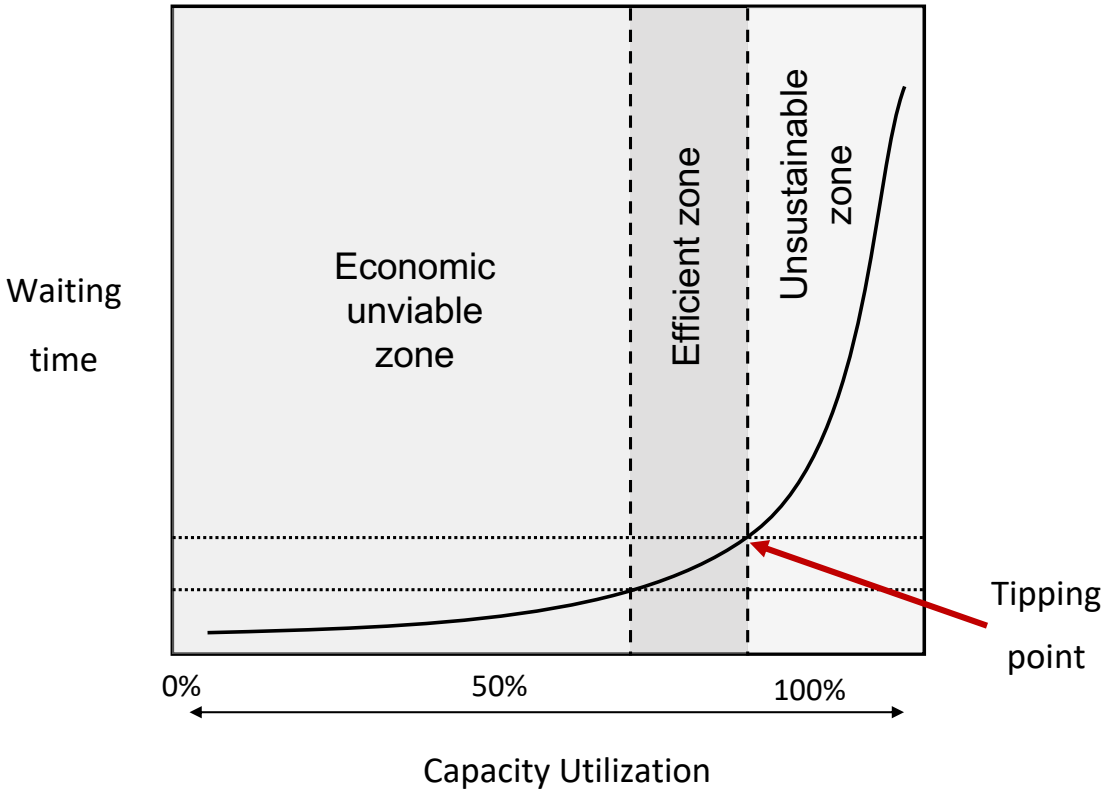

Figure 9: Visualization of the tipping point using Kingman's formula

TSEF and process theory provide a good framework to understand the deteriorating effects from running processes inhibiting much variation (Holweg et al., 2018, Schmenner, 2012). The more variation a process contains the less its capacity can be utilized before the throughput time greatly increases. This thesis has shown that variation in patient processes, hampering the patient flow, is a very common feature at hospitals. The present variation moves the tipping point (*where there is a good balance between productivity and capacity utilization*) towards lower numbers of utilization. This thesis provides however multiple promising solutions that together can help hospitals to move the tipping point in the right direction improving the productivity and the flow of patients across the whole hospital.

Lastly, one inspiring avenue would be to explore how to measure this tipping point. To know more precisely at what level the capacity utilization rate should be to optimize the balance between the throughput of patients, costs, and staff wellbeing. Such an ambition would require hospitals to identify how healthcare staff is optimally employed or utilized seen to both their wellbeing and their efficiency. Identifying this would then require good knowledge

about all the activities that are done or should be done by each professional. It would also require knowledge about the time it takes to conduct each activity. Using this knowledge when making the capacity planning, to not end up outside the efficient zone (figure 9), will help hospitals to better balance and utilize their available capacity. A higher knowledge about activities and time can prevent parts of the organization to run their activities at low rates of capacity utilization while others are pushing their limits well beyond what's reasonable. This quote from the second paper of this thesis provides a good summary of this discussion:

> *"Healthcare largely ignores time. An expectation is set on how many patients to see but we don't have a good sense of the time it takes to see those patients. We don't necessarily know and account for the time it is to check those patients in, schedule their follow up visits or to make calls to transfer them to another unit. Part of the capacity problem is because we've ignored time. We need to get better visibility to that. How long does each step take and then staff to that."* - Chief Improvement Officer, Cleveland Clinic.

7. Concluding remarks

7.1 Conclusions

The world's healthcare systems are put under increasingly higher pressure as demand for healthcare is rising at a faster pace than available capacity. This comes with the hard-felt consequences of longer times to treatment, resigning or burned-out healthcare professionals, and reduced patient safety. Amidst this gloomy outlook, healthcare actors search for new and promising ideas on how to revert the trend. This thesis provides new insight into a scarcely examined phenomenon, the hospital-wide patient flow. It sheds light on the need for hospitals to improve their patient flow from an organizational-wide perspective to better utilize and balance the capacity of the hospital. It confirms previously identified problems associated with the silo-mindsets of clinics at hospitals but expands the understanding of how this mindset is hindering hospitals' possibility to manage and optimize capacity use across their organizations. It also highlights the need for hospital organizations to indulge in closer collaboration with external actors along the patient flow to enable a more transparent and responsive healthcare system. Additionally, this thesis describes a managerial and professional logic that is harmful to the throughput of patients across hospitals.

There is no quick fix to the problems hospitals are facing and the first paper is revealing how barriers to swift and even flows across hospitals are complex and intertwined and must be addressed as such. The second paper extends this perspective to also include numerous solutions coming in great variety, giving an equally complex and comprehensive image over the needed improvement strategies. This thesis presents, from the findings of both papers, that improved patient flows can come from adding more beds and staffing resources to the pressured healthcare system. Simultaneously, both papers reveal that changed work methods, smart data analytics and a cultural journey of change can improve much without increasing expenses for the healthcare system.

When healthcare managers or improvement agents are setting out on the journey of trying to improve patient flows across hospitals it is beneficial to have a blueprint or a handbook on how to think and what to do. However, concerning hospital-wide patient flows, there has been little evidence to follow on what is best practice and few studies to rely on to give good

guidance. Through this thesis, practitioners can appreciate an evidence-based assessment of the most common barriers to inefficient hospital-wide patient flows and receive best practice from the world's leading hospitals on how to go about when trying to overcome those barriers.

7.2 Suggestions for future research: Second half of Ph.D. project

To use a broader lens has been advised in previous studies (Kreindler, 2017, Gualandi et al., 2019, Villa et al., 2014, Johnson et al., 2020) and this thesis confirms the need for more studies taking a broader perspective. One promising venue could be to look at the patient flow using a lens of systems theory to further understand the interaction between the patient flow and the system it belongs to. Socio-technical frameworks on systems theory would then give a good fit when analyzing the interrelated nature of organizational systems (Davis et al., 2014). Studying healthcare systems using this lens would then need perspectives from multiple actors and stakeholders including physicians, nurses, technicians, patients, and managers as well as external actors. Moreover, Hayes and Wheelwright (1979) and Deming (1982) concluded over 40 years ago that for a process to be economically viable and technically feasible it must be optimally designed based on volume and product variety. To analyze the volume and product variety of a process is important when identifying how to optimize flow design, layouts, labor requirements, and level of automation. This concept has not been applied to patient flows across hospitals and therefore it constitutes another promising venue when studying how hospitals can or may improve their patient flows. Last, a third interesting and potential venue that this thesis is highlighting is the need to further explore how hospitals operationalize their patient flows. The two papers presented in this thesis explain that several barriers must be addressed, and multiple solutions should be employed. Even so, this thesis does not give deep insights into the daily activities performed at hospitals and all the quick decisions that must be taken to ensure that the hospital-wide patient flow is not disrupted or constrained. Consequently, future research should more closely study how healthcare operations are planned and executed on an operational and tactical timeframe to optimally utilize available capacity across the organization.

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