# Treating planning flows in patient flows

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# CHAPTER 1

## 1 Introduction

This thesis contributes to both healthcare management literature and operations management literature by expanding the knowledge base on patient flow management in hospitals. In this thesis several operations and supply chain management concepts originally associated with manufacturing are used to study hospitals in order to improve patient flow. This requires a clear perception of the hospital context and a thorough understanding of the operations and supply chain management concepts and practices. Therefore, in the following sections we briefly describe the Dutch healthcare context in which the empirical studies of this thesis were executed and discuss the theoretical concepts used in this thesis. Based on this discussion the research objectives of are further explained. This chapter concludes with a brief thesis outline.

## 1.1 Motivation for this study

The professional delivery of care has been under scrutiny since the establishment of the first hospitals. Discussions on patient admission (Burdett, 1897), hospital design (Young, 1886) and hospital efficiency (Allen, 1906) all predate our modern era and problems of overcrowded care delivery systems seem of all times (e.g. Knowsley Sibley, 1896; Dewar and Grisewood, 1912; Kogel, 1950; Welch, 1964; Smith-Daniels *et al.*, 1988; Chand *et al.*, 2009). Reconciling the supply of care with the demand for care is an important challenge hospital administrators have been facing throughout history. With increasing demand, rising care complexity, and societal pressure on reducing both costs and waiting times this reconciliation process is becoming more and more challenging.

This study addresses the reconciliation of the supply of care with the demand for care from a supply chain perspective and focuses on the planning & control of patients in a care process. The study is motivated by the notion that in a care process patients flow from one resource to the next resource (which does not necessarily belong to the same department) and that the management of these resources is often done irrespective of a patient's care process, resulting in unnecessary and excessive waiting times. This study contributes to improving patient flow, which is regarded crucial for increasing hospital productivity and increasing patient satisfaction (Litvak, 2009; Villa *et al.*, 2009).

Improving flow should be a joint effort of all departments involved in a patient's care process. It is argued that flow improvements of a part of a care process could harm performance in other dependent departments (Haraden and Resar, 2004). Nevertheless, most research on patient flow continues to focus on single stages of internal supply chains (e.g. O'Keefe, 1985; Vissers, 1998; Swisher *et al.*, 2001; Akcali *et al.*, 2006; Edward *et al.*, 2008; Chand *et al.*, 2009; Santibáñez *et al.*, 2009). In order to gain a better understanding of planning & control in hospitals and its effect on patient flow we undertook three empirical studies to: (1) analyze practices employed to plan shared resources, (2) assess whether efforts to integrate planning & control functions help to improve flow, and (3) address the reasons why these efforts are not as widely adopted as one would wish.

## 1.2 Setting the scene: Healthcare in the Netherlands

Most hospitals in The Netherlands are privately owned, not-for-profit foundations. They offer a full range of services (like outpatient clinic, inpatient clinic, emergency room (ER) and intensive care unit (ICU) and comprise all medical specialties. Medical specialists can be employed by the hospital; however, as is more common in The Netherlands, medical specialists are self-employed and organized in a specialist partnership. These specialist partnerships work in the hospital and depend on the hospital's resources but they are not employed by hospital. Despite their independent status the specialist partnerships do have contractual obligations to the hospital and representatives of specialist partnerships often report directly to the hospital's board.

A department in a hospital covers both the outpatient services as well as the inpatient services for a given specialty. Although the medical specialists technically are an autonomous organizational entity, they are considered to be part of the department. Often, departments have nurses which are either dedicated to the clinic (in-patients) or to outpatient services. Wards are often shared with several other specialty departments. The ER and ICU are considered to be autonomous departments within the hospital. The same counts for supporting specialties as Anesthesiology and Radiology. In The Netherlands diagnostics are seen as secondary care. This means that patients require a doctor's referral to obtain an X-ray or a magnetic resonance image (MRI). Unlike many other countries there are hardly any dedicated outpatient clinics providing diagnostics services.

Approximately 80% of hospitals' income originates from health insurance companies, which are funded by all citizens through taxation of income and mandatory health insurance fees (VvAA, 2010). Health insurance for regular medical treatment is obligatory. The system is operated by private health insurance companies which are obliged to accept every resident in their area of activity. Long term treatments (e.g. chronic illnesses) are covered by a state-controlled mandatory insurance. The Dutch health authority sets an annual limit of healthcare costs and within this limit insurance companies and healthcare providers can maneuver their production agreements. To a certain extent these production agreements shape the volume and case-mix of patients provided care to in each hospital. Figure 1.1 provides a stylized overview of the financial flows in the Dutch healthcare system.

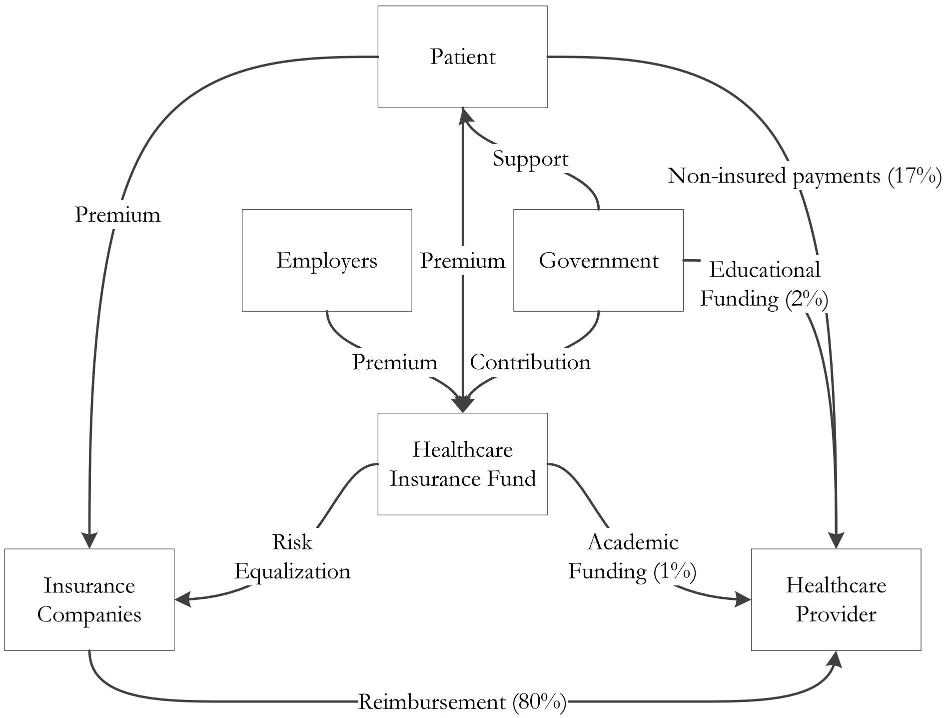


Figure 1.1: Financial flows in the Dutch healthcare system (source VvAA, 2010)

In 2005 a case-mix system was introduced into the Dutch healthcare system, in order to aid the registration and reimbursement of care provided by hospitals and medical specialists. It classifies the patient's demand for health care and accounts for all activities and interventions performed within the hospital required to fulfill this demand. The case-mix system is based on diagnosis-treatment combinations (DTCs) and is related to the more commonly used diagnosis-related-groups (DRGs). However, the DTC system differs from the DRG system in both scale and in scope. The DTC system for example accounts for over 29,000 groups whereas most DRG systems account for approximately 700 groups (Oostenbrink and Rutten, 2006). Further, the DBC system is used for both inpatients as outpatients, contrary to most DRG systems (Steinbusch *et al.*, 2007). Unlike the DRG system, the DTC system is episode-based and each episode/activity performed within the hospital is registered, from the first outpatient clinic visit through to clinical discharge (Steinbusch *et al.*, 2007).

## 1.3 Planning & control in hospitals: a literature review

Planning and control activities provide the systems, procedures, and decisions which bring the different aspects of supply and demand together (Slack *et al.*, 2013). Planning and control activities consist of integrated coordination of resources (staff, equipment and materials) and product flows, in such a way that an organization's objectives are realized (Anthony, 1965). These activities take place on several aggregation levels (e.g. Anthony, 1965; Bertrand *et al.*, 1990). Planning is often associated with the formalization of what is intended to happen in some time in the future and control is seen as the process of monitoring operations activities and coping with any deviations from the plan, which usually involves re-planning activities (Slack *et al.*, 2013). However, the division between planning and control is not clear either in theory or in practice (Slack *et al.*, 2013). For this reason we will refer to planning & control practices in this thesis and when further specification is required we define the specific planning & control practices in the corresponding chapter.

In hospitals, planning & control means to reconcile the demand for care or cure with the supply of capacity of for example medical professionals, rooms, and diagnostic equipment. The reconciliation process in hospitals is more complex than in manufacturing processes as amongst others: the primary process consists of a flow of patients rather than materials, the "end product" is not specified, care cannot be stocked in order to buffer demand fluctuations and the primary process is driven by medical specialists who do not manage that process (De Vries and Hiddema, 2001; Vissers *et al.*, 2001).

The complex processes within hospitals are viewed in several ways. Based on the work of Vissers and Beech (2005) and Hopp (2008) three perspectives on the planning & control of care processes are distinguished: the unit perspective, the chain perspective and the network perspective. Each of these three perspectives will be briefly discussed and illustrated.

### *1.3.1 Three perspectives on hospital planning & control*

*The unit perspective.* Most general hospitals have adopted a functional organizational structure, built around a discipline based specialization (Lega and DePietro, 2005). This functional organization led to a view on hospital operations as a collection of individual resources or service centers (Roth and Van Dierdonck, 1995). The planning & control of each of these resources is performed decentralized and decoupled from planning & control of other resources. Many of the sequential steps are planned independent of each other, creating long lead times for patients. Figure 1.2 provides a graphical representation of the unit perspective on the planning & control in a simplified hospital setting serving three patient groups.

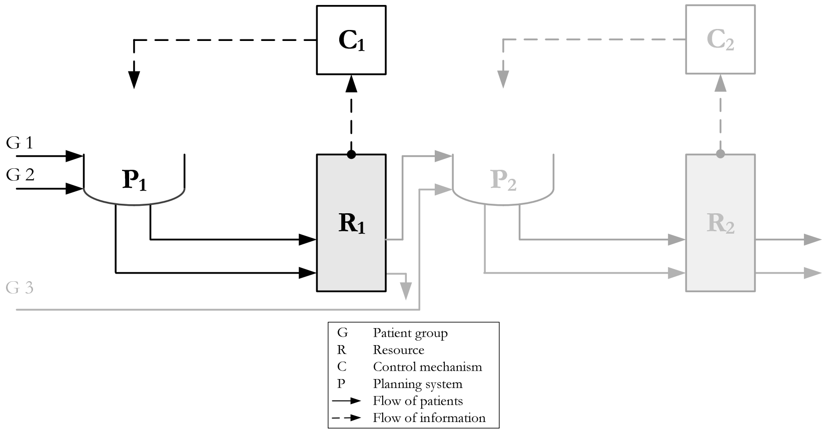


*Figure 1.2: Unit perspective on planning & control of hospital resources*

$R_1$ represents a resource used by two of the three patient groups (G1 and G2). The control mechanism ($C_1$) is designed to monitor the performance of the specific resource (often only capacity utilization is measured and fed back to the planning system) and the planning system ($P_1$) is designed in such a way that it ensures the highest resource utilization. From a unit perspective a patient's flow is secondary to the performance of the resource. A good example for resources which are approached form a unit perspective is diagnostic equipment (e.g. magnetic resonance imaging (MRI) or computed tomography (CT)). Patients are scheduled regardless of preceding or subsequent steps in order to optimally utilize the resource's capacity.

*The chain perspective.* In the chain perspective the total care process for a specific patient group is considered (Vissers and Beech, 2005). The chain perspective finds its origin in product line management, first introduced in healthcare in the early 1980's (Zelman and Parham, 1990). Commonly patient groups are defined based on the treating specialty, however, within a specialty many care processes or chains can be distinguished. Figure 1.3 is a graphical representation of the chain perspective, again in a simplified hospital setting serving three patient groups.

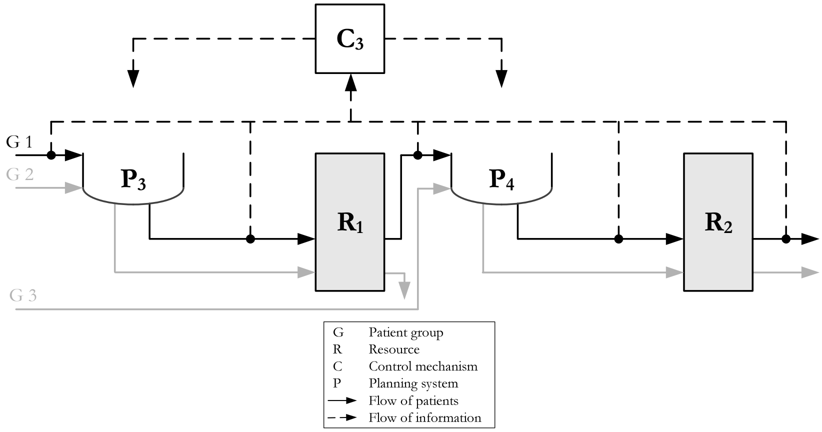


*Figure 1.3: Chain perspective on planning & control of hospital resources*

The focal patient group in this chain perspective is patient group 1. $R_1$ and $R_2$ represent resources used by multiple patient groups. The control mechanism ($C_3$) is designed to monitor access time, waiting time and total lead time for patient group 1 and feeds back information to multiple planning systems ($P_3$ and $P_4$). The planning systems are designed to ensure the shortest total lead time for this patient group. This is often done by means of dedicated time slots, overcapacity or prioritization. The possible consequences of the chain perspective are a loss in resource efficiency and unfairness towards other patient groups (Silvester *et al.*, 2004). The service level for specific patient groups (in this case G1) can be improved at the cost of the service level for all other patient groups (G2 and G3). From a chain perspective the utilization of the participating resources is secondary to the flow of a specific group of patients. The chain perspective can be observed in for example cancer care where capacities of several diagnostic resources and several consults are coupled in order to help patients through the diagnostics phase of their care process as quick as possible.

*The network perspective.* In order to overcome the disadvantages from both the unit and the chain perspective MacStravic (1986) and Vissers and Beech (2005) propose to approach planning & control in hospitals from a network perspective. Ideally this network perspective combines the unit perspective with the chain perspective and considers all resources and all flows in a hospital. Figure 1.4 is a graphical representation of the network perspective on planning & control in a simplified hospital setting serving three patient groups.

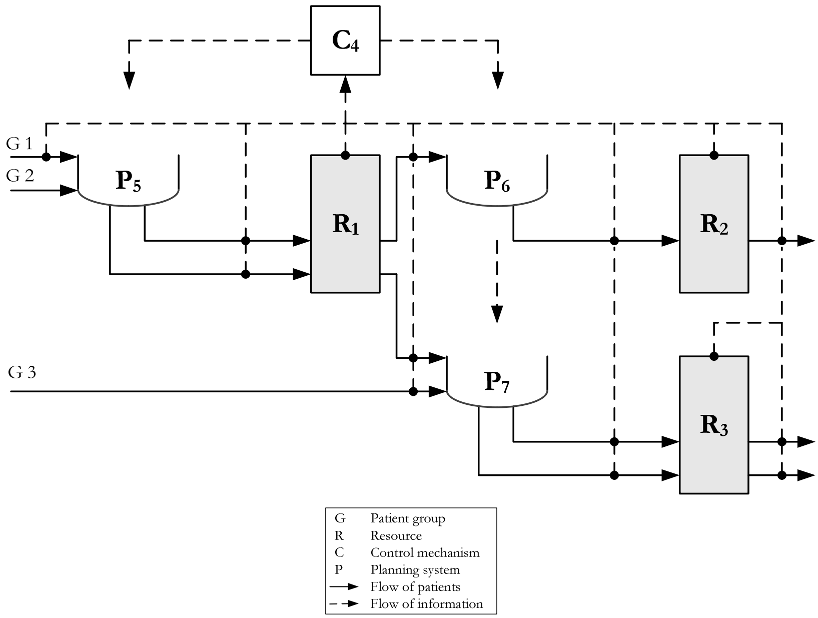


*Figure 1.4: Network perspective on planning & control of hospital resources*

Again there is a hospital with multiple patient groups and multiple resources ($R_1$, $R_2$ and $R_3$).The control mechanism ($C_4$) is designed to monitor (amongst others): access time, waiting time, total lead time of all patient groups, and the utilization of all involved resources. This information is fed back to all planning systems ($P_5$ and $P_6$ and $P_7$) in order to balance flow and resource requirements. The planning systems should be designed in such a way that they ensure the shortest total lead time for all patient groups and the highest resource utilization for all resources. This implies a comprehensive planning & control approach that links all patient groups and all resources. The main drawback of such a system is the inherent complexity posed by all interrelationships and conflicting requirements of both resources and flows (Vissers and Beech, 2005). Achieving a delicate balance of requirements in such an unstable environment as a hospital might even be impossible at the lowest operational level.

In summary, these perspectives give a very broad picture of the different ways to approach planning & control in hospitals. When we zoom in further on the literature, several planning & control frameworks are distinguished, which provide a more detailed picture of planning & control in hospitals. In the following paragraph we will elaborate on the content of the most important frameworks in hospital operations management.

### *1.3.2 Planning & control frameworks in hospitals*

The specific characteristics of hospital care lead to the development of several planning & control frameworks dedicated to hospital operations (see Table 1.1. for the main content and focus of these frameworks). Although the content of the frameworks differs, many similarities can be found between the structure of the frameworks developed for manufacturing and frameworks for hospitals. For example similar to manufacturing the hospital oriented frameworks are decomposed into a strategic, tactical and an operational level (Roth and Van Dierdonck, 1995; Hans *et al.*, 2012). Further, most of the frameworks are based on the ideas of material requirements planning (MRP I) or the more advanced manufacturing resource planning (MRP II) (Rhyne and Jupp, 1988; Butler *et al.*, 1992; Roth and Van Dierdonck, 1995).

*Table 1.1: Frameworks for hospital planning & control*

| Author | Hierarchical levels | Main focus |
|---|---|---|
| Rhyne and Jupp (1988) | Strategic planning<br>Marketing planning<br>Operations planning<br>Master scheduling<br>Capacity planning<br>Material requirements planning | Hospital resources |
| Butler *et al.* (1992) | Strategy formation, product planning, long term capacity planning<br>Facilities planning, fixed capacity allocation<br>Aggregate operations planning, demand management<br>Systems/procedures for detailed execution of plans | Hospital resources |
| Roth and Van Dierdonck (1995) | Master admissions schedule<br>Aggregate admissions planning<br>Demand management module<br>Rough-cut capacity planning module<br>Bill of resources<br>Hospital resource planning process | Hospital resource & Patient flows |
| Vissers *et al.* (2001) | Strategic planning<br>Patient volumes planning & control<br>Resources planning & control<br>Patient group planning & control<br>Patient planning & control | Hospital resources & Patient flows |
| Van Houdenhoven (2007) | Case mix planning, layout planning, capacity dimensioning<br>Allocation of time and resources to specialties, rostering<br>Patient scheduling, workforce planning<br>Monitoring, emergency coordination | Hospital resources |

When looking at the content of the planning & control frameworks, most mainly focus on the planning of the resources available in hospitals. Although Rhyne and Jupp (1988) and Butler and Leong (2000) stress the importance of patient flow, only Roth and Van Dierdonck (1995) actually incorporate flow between resources in their framework. Vissers *et al.* (2001) do mention the importance of flow in their 'patient planning & control' echelon, but do not elaborate on how this flow should be controlled. Van Houdenhoven (2007) suggests to expand the MRP II approach to an enterprise resource planning (ERP) related approach, including medical planning, materials coordination and financial planning. However, the resource capacity planning module in this framework is restricted to efficiently managing hospital resources; mainly by monitoring the resource utilization, rather than improving flow.

Reviewing the hospital planning & control framework literature shows that planning hospital resources efficiently received more attention than establishing swift patient flows. Most frameworks do discuss the agreed performance for hospital resources such as equipment, rooms or departments, but contrary to the ideas of Anthony (1965) and Bertrand *et al.* (1990) do not explicitly discuss the mutual coordination of these resources and the overall objectives set to guarantee patient flow performance. In order to understand whether this inequality can be found in other healthcare operations literature we zoom in further on the literature and investigate contributions the management of hospital resources and patient flows.

### *1.3.3 Planning & control: hospital resources*

The literature on planning & control of hospital resources can be divided into two main categories, patient scheduling and capacity management. The first category deals with fitting demand with the existing capacity efficiently by means of the scheduling of patients under various constraints and the second category deals with fitting capacity with demand by means of capacity allocation decisions.

Patient scheduling has been an important part of planning & control research in hospitals since the 1950's. The earliest contribution addressed the scheduling of patients in an outpatient clinic minimizing the waiting time for the patients and the idle time for the doctor (Bailey, 1952). Since then patient scheduling for outpatient clinics (Cayirli and Veral, 2003; Gupta and Denton, 2008), operating theatres (Cardoen *et al.*, 2010a) and diagnostic services (Green *et al.*, 2006) have been researched extensively. Although most care processes comprise of many stages, consist of recurring appointments and include multiple specialties, the dominant focus in clinical scheduling research is a single-stage system (Cardoen *et al.*, 2010a; White *et al.*, 2011).

Capacity management in healthcare involves decisions concerning the acquisition and allocation of three types of resources: work force, equipment and facilities (Smith-Daniels *et al.*, 1988). Capacity management research covers a wide range issues related to the adequateness of internal delivery systems in deploying scarce resources to meet the fluctuating demand for health-care services (Jack and Powers, 2009). The deployment of these resources involves the coordination of activities in an uncertain environment (White *et al.*, 2011). In general, operational capacity management studies focus on a specific step in a care process. For example, by means of a simulation study which predicts capacity needs Gupta *et al.* (2007) address the capacity management of resources involved in cardiac catheterization. They show that matching capacity too closely with demand will result in longer waiting times. Further, Sokal *et al.* (2006) show that reconfiguring OR capacity in order to allow parallel processing results in an increased throughput and decreased workload. In examining capacity management decisions and OR efficiency McGowan *et al.* (2007) mention that parameters of patient throughput must be identified and watched, however, they did not incorporate these measures in their study.

When further inspecting capacity management decisions in hospitals not the reduction of waiting times, but cost control and quality improvement seem the most important drivers. Li and Benton (2003) show that hospital capacity management decisions affect cost and quality performance. In their analysis of 463 healthcare operations contributions Jack and Powers (2009) show that contributions linking demand and/or capacity management to performance focus on three areas of performance: quality-of-care outcomes, efficiency, and financial performance. Capacity management in hospitals appears to disregards other performance objectives than cost and quality which makes reconciliation with patient flow very difficult.

Reviewing the literature on both patient scheduling and capacity management invokes the image that both categories are focused on maximizing the utilization of single hospital resources or a very small section of the total care process. Maximal utilization of a resource leads to maximum access times to this resource (Hopp and Spearman, 2001) and thus hinders flow performance. Conversely, a single-stage focus reduces complexity (Glouberman and Mintzberg, 2001a), but a single-stage focus also reduces practical representativeness. In mass production single-stage research can be justified through the law of bottlenecks, which states that "An operation's productivity is improved by eliminating or by better managing its bottlenecks" (Schmenner and Swink, 1998). Assuming the system has one bottleneck, improving a single stage improves the whole system. In hospitals, however, bottlenecks are constantly moving, due to the high routing variety of individual patients. Therefore, addressing a single-stage does not necessarily have to affect the system positively. Another argument for single stage approaches is posed by Rhyne and Jupp (1988), who assume that by managing the queue of the primary work center (i.e., the first major work center providing services), work required of the secondary work centers (e.g., ancillary departments) will tend to be properly balanced. This principle, well known in the workload control literature, is based on the idea that one can pick patients based on their resource use profile and form a pool of patients in order to accommodate the system's requirements. Adan and Vissers (2002) analytically show that a patient mix based admission planning works for a group of elective inpatients with low variability. However, little knowledge exists about a similar approach towards more complex and uncertain care processes. Poorly understood interdependencies between different hospital departments and healthcare professionals is a main concern in hospital management (Litvak and Long, 2000) and should be a main concern in academia.

### *1.3.4 Planning & control: patient flows*

From a clinical perspective, patient flow represents the progression of a patient's health status. From an operational perspective, patient flow is seen as the movement of patients through a set of locations in a health care facility (Côté, 2000). Improving patient flow is seen as of great importance in boosting hospital performance (Litvak, 2009; Villa *et al.*, 2009), since flow performance is an important aspect of organizational performance (Schmenner and Swink, 1998; Schmenner, 2001). We can distinguish two important streams in the literature discussing patient flows.

The first stream uses patient flow data as a means to provide an insight in hospital processes. Lane and Husemann (2008) for example demonstrate that a visual representation of stocks and flows to show the main patient flows could be used to illuminate the functioning of healthcare systems. Shaw and Marshall (2007) argue that by more accurately modeling the flow of patients through a hospital; medical resources could be managed more efficiently. Potisek *et al.* (2007)

see patient flow analysis as an effective technique to identify inefficiencies in patient visits. Once these inefficiencies are identified they can be improved through brief interventions.

These interventions are the main focus of the second stream of research which considers patient flow. In this stream improvement of patient flow is the main objective. Thompson *et al.* (2013) state that improvements in patient flow mainly stem from (1) a decrease in the amount of time a patient spends in given stages of the care process, (2) decreasing demand for urgent services, (3) decreasing the number of stages in the process, (4) performing stages in the care process parallel, and (5) decreasing the amount of time for a patient to move from one stage in the care process to the next. Côté (1999) shows that proper scheduling techniques can lead to higher resource utilization and increased patient flow. Similarly, if correctly configured, an open access system can lead to significant improvements in patient flow (Kopach *et al.*, 2007). Besides directly improving hospital operations Devaraj *et al.* (2013) find that information technology results in better diagnoses, scheduling, and coordination of patient care, which in turn result in an improved patient flow. A similar relationship between coordination and patient flow is found by Fredendall *et al.* (2009), who show that in hospitals a lack in relational coordination between departmental units causes operational failures, which in turn hinder the flow of patients.

Similar to scheduling and capacity management, most contributions addressing patient flow focus on a specific section of a care process, albeit often more than one resource. For example, Vissers (1998) focuses on inpatient facilities; O'Keefe (1985), Swisher *et al.* (2001), Akcali *et al.* (2006), and Chand *et al.* (2009) focus on the outpatient stage of a care process and Edward *et al.* (2008) investigate the pre-assessment stage. However, many patients start as outpatients, receive a pre-assessment and become inpatients. Little research has been done which considers these three stages. Roth and Van Dierdonck (1995) state that localized control of patient flows has led to significant sub-optimization of hospital resources. Similarly, optimization of local flows could harm performance in other dependent departments (Haraden and Resar, 2004). Therefore, as expected, in the literature on hospital resource management the interaction with resources from both previous and subsequent stages of the care are not taken into account.

Surprisingly, also in the literature addressing patient flows, often only parts of the care process are considered.

## 1.4 Research objectives

In summary; the brief literature review above shows several gaps in the healthcare operations literature. Because of the inherent complexity healthcare processes are often regarded as a set of independent process steps which results in a lack of focus on patient flows. This unit perspective hinders a sense of urgency in addressing sequential as well as parallel interdependencies within and between healthcare processes. As such, many things can be learned from supply chain approaches seen in the manufacturing literature. Currently health-care organizations are still lagging behind many other industries in realizing the benefits of adopting supply-chain management practices (Jack and Powers, 2009). However, the empirical studies in this thesis are conducted with the idea that both hospitals and patients can truly benefit from supply chain practices as they help increasing patient flow performance. Therefore, the overall goal of this thesis is: *to expand the knowledge on patient flow management by analyzing both causes and effects of supply chain practices in hospitals.*

Due to the predominant unit perspective in hospital operations management literature little knowledge exists on planning shared resources (i.e. resources which fulfill a hub function in hospitals, such as diagnostic equipment). However, previous research on supply chain integration (Van Donk and Van der Vaart, 2004; Van Donk and Van der Vaart, 2005) and observations on shared resources in hospitals by Vissers (1994) and Vissers *et al.* (2001) lead us to believe that shared resources are a major barrier for implementing supply chain practices in hospitals. Surprisingly, few studies are conducted to establish how hospitals deal with the abundance of shared resources in their processes. Even fewer address planning & control decisions regarding shared resources and the objectives involved in these decisions. Therefore, the first research objective in this study is:

1) *To understand the current practices and dominant objectives in the planning of shared resources in hospitals.*

In pursuing the first research objective, we assumed that supply chain management practices and especially supply chain integration will lead to better patient flow performance. This assumption stems from evidence linking supply chain integration to performance, which is found in the manufacturing setting (Leuschner *et al.*, 2013). However, little empirical evidence for this link exists for a healthcare environment. Therefore, the literature shows a gap in linking supply chain integration to patient flow performance. The conviction that the integration of planning & control functions of different hospital departments is key in improving patient flow, lead to the second research objective of this thesis:

2) *To map integrative planning & control practices in hospitals and to assess the effects of these practices on patient flow performance.*

In fulfilling the second research objective we aim to show that integration of planning & control leads to higher flow performance. However, we also note that the degree of integration in hospitals is very low. High differentiation (Glouberman and Mintzberg, 2001b) and autonomy (Smithson and Baker, 2007) do not contribute to integration and several other organizational and behavioral factors are noted as to influence integration in hospitals. Contrary to the manufacturing literature where operational factors play an important role in inhibiting or enabling integration (e.g. Stank *et al.*, 2001b; Pagell, 2004), little direct attention is given to these factors in a hospital context. This gave rise to the idea that general factors (such as organizational and behavioral) might provide too little insight in why hospitals lag behind in integrating their planning & control functions. This inspired the idea that such operational factors are important in explaining the fragmented planning seen in hospitals, we, therefore, defined our third and last research objective as:

3) *To uncover the operational factors which help and hinder the integration of planning & control in hospitals.*

To achieve these objectives three studies were conducted. Each study builds on empirical evidence gathered by means of a multi-case study methodology. Details on the individual methods are given in the separate chapters. In the following section the content of each of the studies is discussed briefly and the relationships between the chapters are explained.

## 1.5 Thesis outline

This thesis is structured as follows. Chapter 2 addresses how hospitals cope with shared resources and discusses the effects of these policies from a supply chain perspective. Commonly, hospitals use dedicated time slots (specific amounts of a resource's capacity dedicated to specific patient groups) to deal with multiple requests from different specialties for the capacity available in shared resources. Most contributions in this area discuss the use of dedicated time slots from a hospital resource control perspective, such as appointment scheduling for an MRI scanner (Green *et al.*, 2006), for a general practitioner (Klassen and Rohleder, 2004), or a CT scanner (Kolisch and Sickinger, 2008; Sickinger and Kolisch, 2009). However, these contributions fail to consider the effects from a broader perspective. The aim of chapter 2 is to provide insight into how the use of dedicated time slots affects other patient groups and adjacent process steps.

Chapter 3 assesses the relationship between integration of planning & control and patient flow performance. Hospital departments and specialties are highly differentiated (Glouberman and Mintzberg, 2001b) and autonomous (Smithson and Baker, 2007). It is well known that literature concerning integration argues that organizational entities within a firm should not act as functional silos, but as a unified whole (Barki and Pinsonneault, 2005). The aim of chapter 3 is to understand which integrative planning & control practices are used in hospitals and to assess their effects on patient flow. In chapter 3 it is argued that patient flow performance should be evaluated from the perspective of the entire internal supply chain.

The aim of chapter 4 is to explore the operational antecedents of integrating planning & control functions in hospitals. The majority of studies on integration in hospitals focuses on integration in general, rather than the integration of a specific aspect of the organization, such as planning & control. Consequently, reported antecedents are limited to general, organizational and behavioral factors such as organizational culture (Currie and Harvey, 2000), physician autonomy (Pearson *et al.*, 1995), top management support (Currie and Harvey, 2000) and politics (Vos *et al.*, 2009). Little to no attention has been given to operational antecedents of integration as found in a manufacturing context. In chapter 4 we investigate integrative practices in hospitals and the operational antecedents that either help or hinder integration of planning & control.

Chapter 5 consists of a general discussion of the main findings in the aforementioned studies and provides a guide for further research which should be undertaken to advance the knowledge on hospital operations management.

# CHAPTER 2

# 2 A critical assessment of the role of dedicated time slots in hospitals[1]

Shared resources form an important barrier to the integration of internal supply chains in hospitals. We argue that allocating shared resource capacity through dedicated time slots can overcome this barrier and enable more integrated care provision. Although frequently used, little is known about how hospitals use dedicated time slots. The purpose of this research has, therefore, been to assess the effectiveness of these dedicated time slots in enabling integrative planning practices within hospitals. The research is based on a multiple-case study carried out in a medium-sized hospital. We selected three cases within a radiology department, each displaying different usages of dedicated time slots. Three different effects of utilizing dedicated time slots have been identified: (1) using dedicated time slots with the objective of linking consecutive treatment steps clearly enables a process orientation, (2) using dedicated time slots with the objective to prioritize patients indirectly contributes to integration, but (3) using dedicated time slots with the objective of clustering patients counters integration and consequently flow. The theoretical contribution of this chapter lies in exploring the point where the management of patient flows and the planning of shared resources meet, a topic currently underexposed in the literature. We provide insights into managing a common trade-off in healthcare: resource utilization versus patient flow. From a managerial perspective, our findings can assist hospital administrators to reconcile market requirements and organizational objectives.

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[1] An earlier condensed version of this chapter was published as Drupsteen, J., Van der Vaart, J.T., and Wijngaard, J., 2009. Integral planning and control of shared resources in health care. Proceedings of the 16th annual EurOMA conference, Göteborg Sweden

## 2.1 Introduction

A key challenge for hospitals is how to balance patient flow and resource utilization. Highly utilizing resources such as operating rooms and diagnostic equipment easily leads to medical specialties competing for the scarce capacity of these shared resources. This competition complicates planning (Hoekstra and Romme, 1992) and jeopardizes patient flow. To disentangle the various care processes that come together at a shared resource, hospitals often choose to employ dedicated time slots. On the one hand, from a supply chain perspective one could argue that the use of dedicated capacity is beneficial in guaranteeing a smooth flow (Van der Vaart and Van Donk, 2004). On the other hand, queuing literature suggests that dedicating capacity and therefore, creating separate queues for a single capacity actually deteriorates performance (e.g. Gross *et al.*, 2008). In the line of this debate Joustra *et al.* (2010) argue that if two or more different service types (i.e. patient groups) are involved it remains to be questioned if capacities should be pooled. In this chapter, we address the planning of shared resources in hospitals by investigating the objectives of dedicated time slots used in allocating shared resource capacity.

From the mid-1980s onwards, a process orientation or internal integration perspective has gained popularity as a contributor to improving hospital performance. Initiatives such as service line management (MacStravic, 1986), clinical pathways (Bragato and Jacobs, 2003), process-oriented care (Vos *et al.*, 2009), and focused factories (Hyer *et al.*, 2009) are all examples of a process orientation discussed in the healthcare literature. All of these initiatives are based on the idea that care processes consist of several interdependent steps that should be managed as a whole (e.g. Vissers. However, none of these initiatives address the presence and use of shared resources, which potentially form an important barrier to their actual implementation.

Hospitals use dedicated time slots to deal with multiple requests from different specialties for the capacity available in shared resources. A dedicated time slot is defined as a specific amount of a resource's capacity dedicated to a specific group of patients. In defining dedicated time slots, a hospital allocates capacity to different groups of patients (e.g. Vissers *et al.*, 2001; Day *et al.*, 2010). These groups can be defined based on criteria such as duration, pathology, or urgency. As a result, each group of patients will have separate queues for the same resource. Most contributions in this area discuss the use of dedicated time slots from a resource perspective, such as appointment scheduling for an MRI scanner (Green *et al.*, 2006), for a general practitioner (Klassen and Rohleder, 2004), or a CT scanner (Kolisch and Sickinger, 2008; Sickinger and Kolisch, 2009). However, these contributions do not discuss the objectives of the time slots which are used. As a consequence, it is not easy to assess if the time slot studied in these contributions are implemented to enable integration of planning or implemented for others purposes. In other words, the current literature does not provide insight into how the allocation of shared resource capacity is effectuated and whether or not the use of time slots enables integration in hospitals. The aim of this study is to fill this gap by evaluating the use of dedicated time slots and to understand the current practices and dominant objectives in the planning of shared resources in hospitals. Our underlying perspective is based on the logic of swift, even flows (Schmenner and Swink, 1998). Thus, hospital productivity is associated with the swift and even flow of patients through care processes. In hospitals where care processes typically compete for the capacity of shared resources, the appropriate allocation of this capacity is crucial in ensuring swift and steady patient flows.

Given the lack of knowledge on the impact of the use of dedicated time slot in the planning of shared resources in hospitals, we adopt a case-based approach. Using three case studies, we examine the allocation of shared resource capacity in a medium sized, top-ranked hospital in the Netherlands. We investigate if and how subsequent and preceding process steps are included in the allocation of shared resource capacity. This requires a detailed analysis of the allocation decisions made and a thorough assessment of the effects of these decisions on patient flow.

Our theoretical contribution lies in addressing the intersection of the management of patient flows and the planning of shared resources meet, a topic currently underexplored in the literature. By uncovering how hospitals use dedicated time slots we provide insights into the most common trade-off in healthcare: resource utilization versus patient flow. From a managerial perspective, this can help hospital administrators reconcile market requirements with organizational objectives.

## 2.2 Theoretical background

In this section, we discuss several concepts related to hospital management. First, we discuss approaches in the healthcare literature that have a clear process orientation or based on an internal integration perspective. As most care processes and/or patient groups share important hospital resources, we discuss the role of shared resources in operations and the manner in which a hospital uses dedicated time slots to manage shared resources. Finally, we propose relationships between integrative planning practices, shared resources and the use of dedicated time slots through the theoretical lens of achieving a swift, even flow.

### *2.2.1 A process orientation in hospitals*

Traditionally, most general hospitals have adopted a functional organizational structure built around discipline-based specializations (Lega and DePietro, 2005). This functional organization leads to a view of hospital operations as a collection of individual resources or service centers (Roth and Van Dierdonck, 1995). The planning and control of each resource is then carried out locally and decoupled from the planning and control of other resources. Strikingly, most sequential steps are planned independently of one another, and only departmental performance is addressed (e.g. Cayirli *et al.*, 2006; Green *et al.*, 2006; Kolisch and Sickinger, 2008). Based on the contributions of Cayirli and Veral (2003) and Cardoen *et al.* (2010a), who review scheduling practices in hospitals, one can conclude that very few multistage situations are considered, either for inpatients or outpatients. Lega and DePietro (2005) question the functional approach adopted in hospitals and advocate a shift to greater integration and coordination of healthcare processes.

Such a shift could be accomplished through a process orientation or in other words internal integration. Internal integration comprises of the value-creating processes working together to provide the highest level of customer value (Pagell, 2004). Integration involves the management of a complete process in order to optimize the flow of goods, customers or patients (e.g. Stank *et al.*, 2001b; Vera and Kuntz, 2007; Vos *et al.*, 2009). In the healthcare literature, three related approaches with a process orientation can be identified: service line management, focused factories, and clinical pathways.

The service line approach originates in product line management, and was first introduced into healthcare in the 1980s (Milch, 1980; Nathanson, 1983; Ruffner, 1986). MacStravic, (1986) defines hospital service lines as specific programs or service categories. Hyer *et al.* (2009) add more detail and state that service lines entail organizing around an identifiable service, a segment of the market, or some combination of the two. Applying service line ideas in hospitals has yielded mixed outcomes. Service lines have been associated with improved health system performance, specifically when assessed in terms of quality of care (Greenberg *et al.*, 2003). However, Byrne *et al.* (2004) showed that service lines can have negative effects on several key indicators such as preventable hospitalization rate and discharge rate.

A second process oriented approach, focused factories, is very similar to service lines but differs in one important aspect in that a focused factory is considered to be an autonomous organizational unit. The main ideas behind focused factories stem from the seminal paper by Skinner (1974). He advocated focusing on a limited, concise, and manageable set of products, technologies, volumes, and/or markets. The basic manufacturing policies and supporting services should be structured in such a way that they focus on one explicit manufacturing task rather than on many inconsistent, conflicting, and implicit tasks. The most common form of a 'focused factory' found in healthcare is a specialty hospital focusing on, for example, coronary care (Herzlinger, 1997; Cram and Rosenthal, 2007), hernias (Heskett, 1983) or knee and hip replacements (Shactman, 2005). The main benefits of focused factories are seen as low risk-adjusted mortality scores, low complication rates, greater patient satisfaction, and lower unit costs (Hyer *et al.*, 2009).

The third process oriented approach, the clinical pathway, is a method for managing the care of a well-defined group of patients over a well-defined period of time (De Bleser *et al.*, 2006). This approach involves management plans that display patient goals and provide the corresponding ideal sequence and timing of staff actions to achieve these goals with optimum efficiency (Pearson *et al.*, 1995). In some cases, clinical pathways help to reduce the length of stay and variations in diagnostic and therapeutic prescriptions (Panella *et al.*, 2003) while also helping to reduce costs (Zehr *et al.*, 1998). However, in other situations, increased levels of documentation, dissonance between the managerial and clinical expectations, and limited scope for professional development are reported as downsides of the clinical pathway approach (Currie and Harvey, 2000).

In use, all three approaches tend to focus on a complete care process for a homogeneous group of patients. However, in practice, several homogeneous groups will make use of the same resources such as radiology, test laboratories, and the operating room (OR). In the next subsection, we discuss the impact of shared resources as a barrier to internal integration and discuss the way hospitals deal with these shared resources.

### *2.2.2 Shared resources and dedicated time slots*

If hospitals want to move towards a more integrated planning and control approach they need to consider shared resources (such as diagnostic equipment, operating rooms, and beds). As reported in the literature, the presence of shared resources is an important barrier to supply chain integration (Van Donk and Van der Vaart, 2005). Shared resources are not dedicated to a single homogeneous group of patients, and so their allocation to, or planning decisions concerning, one group of patients will have an effect on other patient groups.

In order to deal with shared resources, Vissers (1994) states that hospitals have to either set priority rules for patients who arrive at the same time, or allocate capacity in advance to specific users (i.e. to a patient group defined by specific criteria). In practice, dedicated time slots are commonly used in allocating the capacity of resources shared among different patient groups (e.g. Green *et al.*, 2006; Day *et al.*, 2010). Patient groups are created by classifying patients based on one or several criteria. These could be either process or patient characteristics. For scheduling patients, Walter (1973) advocated a distinction between inpatients and outpatients. His study found that this distinction resulted in a substantial reduction in the time that doctors were idle. Fetter *et al.* (1980) proposed grouping patients based on similarity of services, and these groups are today commonly known as diagnosis related groups (DRGs). In their assessment of patient classifications, Cayirli *et al.* (2008) provide several examples of other criteria that can be used to group, such as new versus returning patients, high versus low variability in service times, and by type of procedure. In addition, performance requirements can also play an important role in grouping criteria for dedicated time slots. For example, if resource utilization is the key performance indicator, focusing on internal supply chains will have a low priority and this will be reflected in the choice for specific dedicated time slots. Rather, batching patients based on pathology in order to reduce set-up times will be an attractive way of allocating time slots. However, this will create a 'lumpy' demand for the subsequent process step and can easily deteriorate flow performance. In contrast, if a hospital emphasizes flow performance for one or more patient groups, internal supply chains become more valuable (Vissers & Beech, 2005). Consequently, dedicated time slots will be defined differently depending on what indicator is emphasized.

### *2.2.3 Swift, even flow and hospital productivity*

The discussion on resource utilization versus patient service level relates closely to the question as to what is considered productivity in healthcare. Villa *et al.* (2009) suggest that poorly managed patient flows can result in low hospital productivity. Schmenner (2004) argues that productivity is only influenced by the swiftness and evenness of item flow in a system, and that other potential influences (such as automation, capital intensity, labor efficiency, machine utilization, and information technology) only influence productivity through their effects on the speed and/or variability of that flow. The theory essentially argues that the productivity of any process rises with the speed at which items flow through the process and falls with increases in the variability associated with either the demand for capacity or the supply of capacity (Schmenner and Swink, 1998; Schmenner, 2001).

Although the ideas linked to a swift, even flow were developed for manufacturing, they are also used in service operations (Schmenner, 2004) and have been applied as a measure of performance in healthcare (e.g. Shah *et al.*, 2008; Fredendall *et al.*, 2009; Drupsteen *et al.*, 2013). Two main measures are used: throughput time and variability. Throughput times are measured as the time an item spends in the system, and can be used to identify when flows become retarded or blocked. Variability is measured by the variance or standard deviation in the timing, the quantities demanded, or the time spent in various process steps (Schmenner and Swink, 1998).

### 2.2.4 Research model

The literature does not reveal how the allocation of shared resource capacity is effectuated and whether or not the use of time slots enables integration of planning in hospitals. Consequently, the central theme in the current study is to assess the use of dedicated time slots and identify their objectives and evaluate whether these objectives contribute to internal integration management.

Underlying the literature review is the idea that treating hospitals as a collection of interconnected internal supply chains, rather than as a collection of independent functional units, could improve hospital performance. However, many of a hospital's resources involve huge investments and, consequently, internal supply chains have to share these resources. As the sharing of hospital resources seems inevitable, one cannot ignore the role of shared resources when employing integrative practices. The model in Figure 2.1 depicts the conceptual relationships between the main concepts in this research. The main idea is that while integrative planning practices will inevitably be hindered by the existence of shared resources, allocating shared resource capacity using dedicated time slots could be a way to overcome this barrier (the question mark in Figure 2.1 refers to this specific issue) and so aid integration, which on its turn positively affects swift, even flow (Drupsteen *et al.*, 2013).

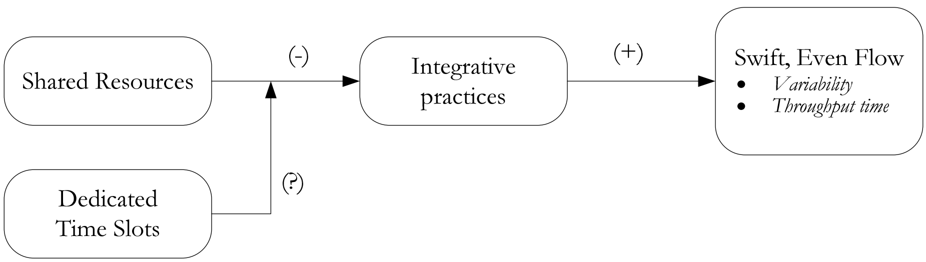


*Figure 2.1: Relationship between time slot allocation and performance based on the literature.*

## 2.3 Methodology

The aim of this study is to address the allocation of shared resource capacity and to assess the effects of dedicated time slots on the integration of planning in hospitals. The explorative nature of this research makes a case study methodology particularly appropriate (Yin, 2003). This research makes use of the main advantages of case study methodology as explained by Benbasat *et al.* (1987) in that: (1) we study the phenomenon in its natural setting, and actual practice is observed; (2) we try to answer the question of why, rather than just what and how, to gain a fuller understanding of the nature and complexity of the complete phenomenon; and (3) we conduct an exploratory investigation where the variables are still largely unknown and the phenomenon poorly understood. A multi-case approach is chosen in order to increase the external validity of the research (Voss *et al.*, 2002) and to provide a more comprehensive overview of capacity allocation decisions made in hospitals.

### *2.3.1 Case Selection*

The case study was conducted in a top-ranking, 280-bed, regional hospital in the Netherlands. We focused on diagnostic radiology as this has always been a function that is used by many specialties. Patients making use of diagnostic radiology services typically differ with respect to their pathology, their urgency, and the procedures and resources required. Consequently, almost all the diagnostic radiology resources are shared. As such, selecting diagnostic radiology resources is a logical choice when wanting to investigate the rationale behind the allocation of shared resource capacity, and analyzing the effects of these decisions on patient flow.

We selected three typical cases within the radiology department, each displaying a different choice with respect to the use of dedicated time slots. As such, the cases were selected for their diversity and their potential to contribute to the research objective (Stuart *et al.*, 2002). The first case addresses a situation in which the department decided not to use dedicated time slots. The second case demonstrates the use of dedicated time slots which are allocated to a few, broad patient groups. In the third situation, the shared resource capacity is distributed among many smaller patient groups.

The unit of analysis in each case is a single diagnostic imaging technique consisting of one or more work centers. In our definition, a work center includes the totality of employees and production infrastructure required to complete a quantity of work (Schönsleben, 2004). In other words, our unit of analysis includes fully-staffed equipment.

### 2.3.2 Data Collection and Analysis

Both qualitative and quantitative data were collected for each of the cases. In order to triangulate the data, multiple sources have been used (Yin, 2003). These sources comprise archival records, semi-structured interviews with the hospital's logistics manager, with radiology planners, with radiology technicians, and with the radiology manager. Further, direct observations in the form of a tour of the radiology department and attending a full shift at each work center provided additional insights into the inner workings of the radiology department. Process and performance data were gathered over a five-month period, resulting in detailed field notes and an extensive report on the current situation within the radiology department. The more qualitative data, regarding capacity allocation decisions, were gathered through interviews, which were held over a period of one month.

The data analysis in this study consisted of two elements: a within-case analysis and a cross-case analysis. Combining a within-case analysis with a cross-case analysis allows the unique patterns in each case to emerge before one generalizes patterns across cases (Eisenhardt, 1989).

The within-case analysis consisted of a detailed write-up of each of the cases in terms of the decisions the hospital makes concerning capacity allocation. In elaborating on these choices, we analyze determinants such as patient characteristics, process characteristics, and performance requirements of each of the work centers. Finally, we address the effects of these decisions on the swiftness and evenness of patient flow. Schmenner and Swink (1998) prescribe the use of throughput time as the measure for the speed of flow; but this is not further operationalized. In our within-case analysis, we used four measures commonly found in healthcare practice: (1) access time, that is the time between the call for an appointment and the first step in the total care process; (2) in-hospital waiting time, the interval between the time of the scheduled appointment and the actual interaction; (3) out-of-hospital waiting time, the time between the call for an appointment and the actual procedure within a care process; and (4) total throughput time, the total time involved in realizing a complete care process.

In the cross-case analysis, we aggregate the within-case findings into a typology of dedicated time slots. For each type of time slot we discuss the grouping criteria and the objective of the time slot. Further, by discussing whether each time slot serves local purposes (i.e. used for a single resource) or integrated purposes (i.e. used for multiple resources) we address the effects of using dedicated time slots on integrative planning practices.

## 2.4 Results

In this section we describe for each case the most important characteristics of the process and discuss the capacity allocation decisions and their individual effects in detail.

### *2.4.1 Case 1: X-ray*

The X-ray technique is one of the most frequently used diagnostic imaging techniques within the hospital. Annually, almost 40,000 patients from more than twenty different specialties are processed through the four X-ray work centers. On average, the weekly demand is 750 patients with a low coefficient of variation (CV = 0.13). Patient processing times are generally short and, although a large range of pathologies are processed, there is only moderate variation in processing times (outpatients: $\mu$ = 8 minutes, CV = 0.75; general practitioner (GP) patients: $\mu$ = 6 minutes, CV = 0.66). Further, as most patients follow similar procedures, set-up times are minimal.

In allocating the capacity of the four X-ray work centers, there is a basic division with two of the work centers servicing all outpatients and GP patients, one work center dedicated to emergency patients and inpatients, and one work center dedicated to Intensive Care Unit (ICU) and Coronary Care Unit (CCU) patients. Table 2.1 displays the patient groups that are distinguished, and the choices made in allocating the capacity. As depicted in the table, none of the four work centers use dedicated time slots.

*Table 2.1: X-ray capacity allocation decisions.*

| Work Center | Patient Group | Capacity allocation |
|---|---|---|
| 1+2 | Outpatients and patients referred by a general practitioner | single queue; walk-in system FCFS; no time slots |
| 3 | Inpatients and emergency patients | appointment system FCFA; unmarked time slots; walk-in system for emergency patients |
| 4 | CCU/ICU | appointment system FCFA/urgency; unmarked time slots |

In this study, we focus mainly on the performance of Work Centers 1 and 2 as Work Centers 3 and 4 are dedicated to relatively small patient groups requiring immediate and/or special attention. Work Centers 3 and 4 are permanently available, or on call, in order to service their patient groups as swiftly as possible.

With Work Centers 1 and 2, the hospital employs a single queue walk-in system with excess capacity. The patients are not homogeneous in terms of pathology, but in the sense that individual set-ups are not required and that there are no differences in urgency and processing times. As such, this group of patients can be divided between the two work centers without needing to use dedicated time slots for specific sub-groups. Patients are treated on a first come, first serve (FCFS) basis. Work Centers 1 and 2 have an average resource utilization of 80.8%. Figure 2.2 shows the average daily performance, over 50 Mondays, for the two resources combined. A similar pattern was seen on other working days. The graph displays the ratio between incoming workload and capacity and the variation in waiting time for a patient requiring use of the X-ray capacity throughout the day.

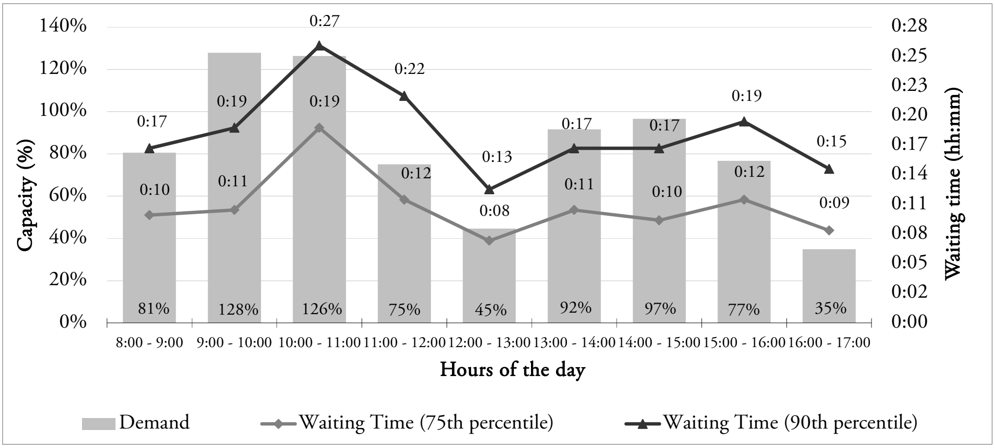


*Figure 2.2: In-hospital waiting times and ratio of incoming workload and capacity for X-ray Work Centers 1 and 2 (average of 50 Mondays).*

Neither the specialties nor GP consultations generate a balanced demand across the day. Having opted for a walk-in system, the resources cannot be buffered against the input variability, and a clear daily pattern can be distinguished (as shown in Figure 2.2). This leads to periods of over-demand and longer waiting times, and other periods with under-utilization and short waiting times during the day. The organization accepts a 20% overcapacity to ensure there is no out-of-hospital waiting time and only brief in-hospital waiting times for outpatients. The short processing times with only moderate variations and negligible setup times help to ensure an acceptable average in-hospital waiting time for outpatients.

The conclusion in terms of the relationship between time slot allocation and performance (Figure 2.1) is that, in this X-ray situation, dedicated time slots are not necessary to ensure a swift flow. Overcapacity is employed to reduce the possible negative effects of input variability. Although the X-ray work centers are shared among many different patient groups, the overcapacity and short processing times mean that the negative effects of sharing resources are minor. Viewed from an internal supply chain perspective, patients easily combine a visit to the X-ray facilities with preceding and/or subsequent steps because quick access to the X-ray work centers is effectively guaranteed.

### 2.4.1 Case 2: Magnetic Resonance Imaging

The radiology department has one MRI work center that annually processes approximately 4,000 patients drawn from at least twenty specialties. On average, the weekly demand is for 76 patients, again with a low variation (CV = 0.18). The MRI work center has relatively long processing times compared to the X-ray situation discussed above with moderate variation (outpatients: $\mu$ = 30 minutes, CV = 0.55; priority patients: $\mu$ = 29 minutes, CV = 0.47). All patients require preparation, and the work center requires a new set-up for each patient. Patient and machine set-ups are carried out simultaneously by two technicians and take about five minutes for all types of patient.

Given that the hospital has only one MRI work center available, physical dedication to specific patient groups, as in the X-ray case, is impossible. Two patient groups are distinguished: regular patients (outpatients) and priority patients (inpatients and urgent cases). Priority patients require access to the work center within periods varying from two weeks to less than 24 hours. Table 2.2 displays the patient groups that are distinguished and the choices that are made in the allocation of capacity at the work center.

*Table 2.2: MRI capacity allocation decisions.*

| Work Center | Patient Group | Capacity allocation |
|---|---|---|
| 1 | Outpatients | Appointment system FCFA;<br>14 thirty-minute time slots;<br>3 forty-minute time slots |
| | Inpatients and urgent patients | 4 dedicated time thirty-minute time slots reserved per day;<br>priority based on urgency code |

The daily capacity of the work center is divided into 14 thirty-minute time slots and 3 forty-minute time slots. This is based on the expected distribution of pathologies and their required processing times. If more thirty-minute time slots are required than are available, an unfilled forty-minute time slot will be used, 'wasting' some capacity. Each day, a further 4 thirty-minute time slots are dedicated to priority patients.

All regular patients requiring a visit to the MRI work center are scheduled on a first call, first appointment (FCFA) basis. Performance of the MRI work center is measured in terms of patient out-of-hospital waiting time. Figure 2.3 shows the average out-of-hospital waiting time, expressed in weekdays (as opposed to working days), for the two patient groups. The MRI work center achieves an average resource utilization of 92.8%. To avoid idle periods, all patients are requested to arrive fifteen minutes before the scheduled time. There is a clear difference between the average out-of-hospital waiting times for the two patient groups. Allocating disproportionate capacity to priority patients ensures their timely access to the work center. This overcapacity for priority patients is effectively at the expense of the regular patients.

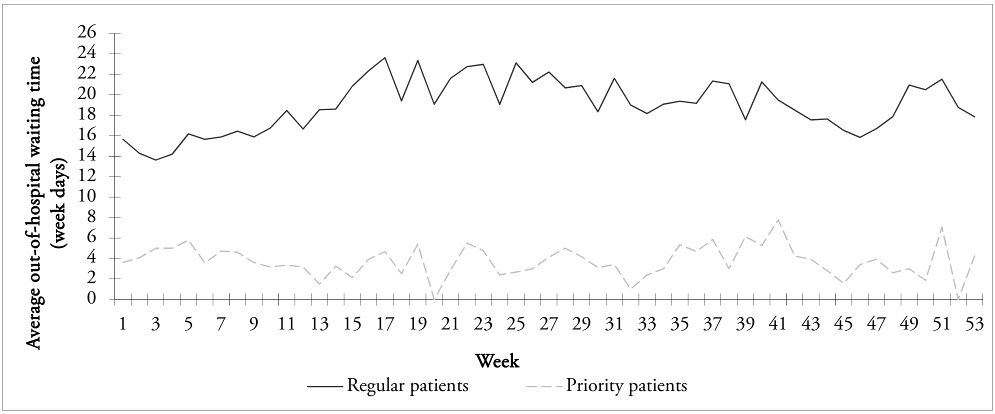


*Figure 2.3: Average out-of-hospital waiting time for the MRI work center.*

Considering the relationship between time slot allocation and performance (Figure 2.1) we observe that, in the MRI situation, dedicated time slots only facilitate a swift flow for the priority patients. For these patients, a similar situation to that with the emergency X-ray work center is created, one in which overcapacity guarantees rapid access to the resource. This makes combining a scan with preceding and subsequent steps more straightforward. However, regular patients may have to wait up to 24 days for an MRI scan, regardless of the use of aggregated time slots. Creating overcapacity for regular patients is much less attractive to the hospital due to their lower priority and the fact that the MRI equipment comes at a high cost. By limiting overcapacity to a small group of urgent patients (shielded overcapacity) the hospital can combine the aims of quick access for some patients and a high level of utilization.

### 2.4.1 Case 3: Ultrasound

Many of the hospital specialties have their own ultrasound (US) equipment, but several services are only offered within the radiology department. Annually, the two US work centers in the radiology department process approximately 8,000 patients. The average weekly load is 152 patients, again with a low variation in demand (CV = 0.15). Despite a wide range of pathologies requiring the US facilities, the work centers achieve moderate processing times with moderate variation (outpatients: $\mu$ = 14 minutes, CV = 0.50; priority patients: $\mu$ = 14 minutes, CV = 0.57; mammacare patients: $\mu$ = 12 minutes, CV = 0.58).

Unlike with the MRI work center, setting up plays an important role in the planning and control of the US work centers as different set-ups are required for the various groups of patients, in contrast to the standard set-up used in MRI scans. In principle, either US work center can be used for any patient visiting the radiology department, and patients are categorized into several different groups. Outpatients are subdivided into eight pathology-based groups. As with the MRI facility, inpatients and urgent patients are given a higher priority. Finally, a group of mammacare (breast cancer) patients is distinguished. Table 2.3 displays the types of patient groups that are distinguished and the choices that are made in allocating the capacity of the work centers.

For the outpatients, time slots are allocated based on pathology. Different prerequisites (such as empty stomach, full bladder or empty bladder) are defined for various groups of patients. These prerequisites not only determine the length of the allocated time slot, they also determine the time of day at which a time slot is planned. Each day, 4 thirty-minute time slots are dedicated to priority patients and, weekly, 12 twenty-minute time slots are reserved for mammacare patients.

All outpatients and mammacare appointments are planned in the same appointment system, primarily on an FCFA basis. Emergency patients and inpatients are planned in an ad-hoc manner based on urgency. A 'one-stop shopping' approach is adopted for mammacare patients, combining an outpatient clinic visit, a mammogram, and an ultrasound.

*Table 2.3: US capacity allocation decisions.*

| Work Center | Patient Group | Capacity allocation |
|---|---|---|
| 1 + 2 | Outpatients | appointment system FCFA; dedicated time slots for 8 different patient groups; approx. 20% of capacity unmarked time slots |
| | Inpatients and urgent patients | 4 dedicated time slots (of twenty minutes) per day; priority based on urgency |
| | Mammacare Patients | appointment system; 12 dedicated time slots per week (US is combined with outpatient clinic consult and mamma X-ray) |

The performance of the US work centers is measured in terms of patient out-of-hospital waiting times, and Figure 2.4 shows the averages for the three patient groups expressed in weekdays. One can see distinct patterns in their out-of-hospital waiting times for the three patient groups. Priority patients have the shortest out-of-hospital waiting time as allocating excessive capacity, not surprisingly, ensures quick access. Mammacare patients have a distinctly shorter out-of-hospital waiting time than other outpatients; although the fluctuating waiting times indicate that there is not sufficient overcapacity to buffer the variations in demand. The two US work centers achieve an average resource utilization rate of 92%.

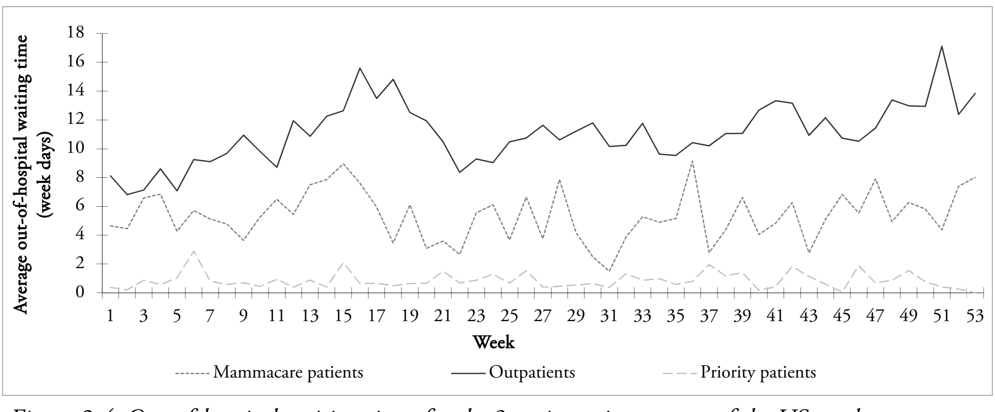


*Figure 2.4: Out-of-hospital waiting times for the 3 main patient groups of the US work centers.*

In considering the relationship between time slot allocation and performance, we observe that, in the US approach, the dedicated time slots affect patient performance in terms of whether a swift, even flow is achieved. As with the MRI work center, time slots are allocated for priority patients in order to create some overcapacity to guarantee quick access to the US resources. In contrast, the dedicated time slots created for eight other groups of outpatients do not create a swift, even flow. As explained above, these time slots are defined because different patient groups have different requirements in terms of prerequisites and the time of the day the examination should take place. Establishing these time slots is not intended to enable quick access to the work centers or to reduce variability in waiting time. Allocating time slots for mammacare patients does contribute to a swift flow by including some overcapacity and to a more even flow by connecting preceding and subsequent steps in the process. By combining these two mechanisms, the hospital is able to achieve a swift, even flow of mammacare patients. The use of time slots that are not dedicated to a specific patient group (unmarked time slots) for outpatients is interesting: these unmarked time slots provide flexibility and reduce the risk of dedicated time slots not being filled.

### *2.4.1 Cross-case analysis*

The three cases illustrate different approaches to managing shared resources. These vary from dedicating resources to specific patient groups, as displayed in the X-ray case, to the use of different forms of dedicated time slots, as seen in the MRI and US cases. In order to compare the choices made in the three cases, additional information was collected with respect to the hospital's objectives that laid behind the capacity allocation decisions and the mechanisms used to allocate capacity. In Table 2.4 the decisions, objectives, and mechanisms are summarized.

In assessing the use of dedicated time slots as enablers of integrative planning practices, we address the question why the Radiology Department defined dedicated time slots for a specific group of patients. In the within-case analyses, different objectives were identified. For instance dedicated time slots were defined to guarantee quick access or to reduce set-ups. From a process orientation, the span of the time slot is very important. Are the time slots defined to guarantee quick access to a single work center (using a narrow span) or to enable coordination of several steps in a care process (a wider span)?

A major finding in all three cases is that the objectives generally result in dedicated time slots with a short span (see Table 2.4). This reflects a situation in which most of the dedicated time slots are defined for local purposes and address a single step of the care process: patients are clustered, set-ups are reduced, or quick access is ensured. An integrated multistage approach was only applied in the mammacare program, enabling patients to flow quickly through consecutive stages of the care process.

Besides the differences in the objectives, the case study also illustrates the various mechanisms employed in using dedicated time slots. The first mechanism we observed was the use of dedicated overcapacity to enable urgent patients to gain rapid access to a resource. The second mechanism was the clustering of patients for local purposes. In the MRI work center, this mechanism is used to cluster outpatients in aggregated groups (of 30 or 40 minutes) in order to smooth planning. In the ultrasound situation, patient are clustered based on different prerequisites (such having an empty stomach, or having full or empty bladders). The third mechanism is in the form of combination appointments where dedicated time slots are used to enable integrated planning of consecutive steps in the care process, as seen with ultrasound appointments for mammacare patients.

*Table 2.4: Capacity allocation decisions concerning shared resources*

| Case | Capacity allocation decision | Grouping criteria | Objective | Span | Mechanism |
|---|---|---|---|---|---|
| **X-ray** | Dedicated emergency X-ray | Performance | Quick access | A single stage in a care process | Overcapacity |
| | Dedicated ICU/CCU X-ray | Performance, Process characteristics | Quick access , Provide adapted service | A single stage in a care process | Overcapacity, Modified work center |
| | Outpatient X-ray | None | | | None |
| **MRI** | Priority time slots | Performance | Quick access | A single stage in a care process | Shielded overcapacity |
| | 30 / 40 min time slots | Process characteristics | Improving planning accuracy by distinguishing two groups based on different processing times | A single stage in a care process | Allow specific time slots for specific processing times |
| **US** | Priority time slots | Performance | Quick access | A single stage in a care process | Shielded overcapacity |
| | Pathology based time slots | Patient characteristics | Accommodate patient prerequisites and reduce setups | A single stage in a care process | Allow specific time slots for specific patient prerequisites and setups |
| | Mammacare time slots | Performance, Process characteristics, Patient characteristics | Reduction of lead time for a vulnerable group of patients | Multiple stages in a care process | Shielded overcapacity Linking preceding and subsequent steps Patient prerequisites |
| | Overflow time slots | None | Allowing flexibility in a schedule full of dedicated time slots | A single stage in a care process | Unmarked time slot act as capacity buffer |

## 2.5 Discussion

The starting point for our research was the idea that sharing resources presents a barrier to effective integrative planning practices within hospitals. This was based on the work of Hoekstra and Romme (1992 and Van Donk and Van der Vaart (2005) who discuss the adverse effects of shared resources in a manufacturing environment. Unlike most contributions on internal integration in healthcare, we focused on the role of shared resources as a major barrier to moving forward from the widely seen functional independence.

Overall, the results from our case studies are in line with the ideas of Van der Vaart and Van Donk (2004) that shared resources form a barrier to integrative practices, but that by dedicating some parts of capacity and by coupling this capacity to capacity of other resources improves flow. In several instances we found that use of specific types of dedicated time slots can aid internal integration. Contrary to our assumptions that shared resources always form a barrier, under certain circumstances shared resources do not hinder integrative practices. That is, shared resources, provided they are associated with short, even processing times requiring minimal set-ups, can be deployed without becoming a barrier to internal integration. A further prerequisite for this is that either the variability in demand and processing times is low or there is sufficient overcapacity (which can be a viable option if operating costs are low) to act as buffer against these forms of variability. Certain shared resources, such as the X-ray work centers, satisfied these criteria and did not seem to require dedicated time slots to ease the flow from one resource to the next.

We found that the effects of using dedicated time slots to be threefold: (1) using dedicated time slots with the objective of linking consecutive treatment steps clearly enables a process orientation, (2) using dedicated time slots with the objective to prioritize patients indirectly contributes to integration, but (3) using dedicated time slots with the objective of clustering patients counters integration and consequently flow. Having set out to assess the use of dedicated time slots and identify their objectives and evaluate whether these objectives contribute to integrative practices, these three findings are worth further elaboration.

### *2.5.1 The effects of Dedicated Time Slots*

Although Vissers *et al.* (2001) note time-phased allocation of shared resources (i.e. the use of dedicated time slots) as an important production control function in hospitals, they provide little detail on their use and consequent effects. With respect to the question mark in the presented research model (Figure 2.1), the cross-case analysis has revealed that it is only in certain situations that dedicated time slots can contribute to internal integration. What became clear is that, in most cases, dedicated time slots do not contribute to, but rather hinder a process orientation. In other words, the effects of dedicated time slots vary depending on the type of dedicated time slot.

Dedicated time slots that do contribute to internal integration are those that help in coordinating several consecutive steps in a care process, so ensuring a swift patient flow. The use of this type of time slot reflects a move away from functional independence towards internal supply chains. In order to really benefit from these types of time slots, patients should be grouped based on routing commonality. This aligns with the ideas of Vissers *et al.* (2001), who also proposed grouping patients according to their resource use. However, when using routing commonality as a grouping criterion, the more steps/functions/departments that are included in an internal supply chain, the smaller the group will be that use a specific routing. This could result in a high coordination effort for many groups with few patients in each. An additional effect of this approach would be a lower fill rate of specific dedicated time slots as there is a lower likelihood of there being the ‘right’ patient for an allocated time slot. Therefore, before adopting a process orientation, hospitals need to investigate whether the lead-time benefits of creating long internal supply chains for narrow groups outweigh the coordination efforts and the risk of creating unused capacity. Further research is necessary to establish how patients should be classified and grouped from an internal integration perspective.

Using dedicated time slots for priority patients can indirectly contribute to internal integration. If a mechanism that allows patients to be prioritized (i.e. allowing quick access to a resource through, possibly shielded, overcapacity) is applied at consecutive resources, a priority internal supply chain is effectively created. A caveat against using this type of time slot, as noted by Silvester *et al.*

(2004), is that having such priority time slots worsens both the queue length and waiting times as time slots reserved for urgent patients may be left unfilled due to uncertainty, and might also be misused by non-urgent patients falsely being classified as urgent. Although Silvester *et al.* (2004) are against the use of priority time slots, they do not propose a clear alternative. We see an opportunity for further research to either find ways to overcome the negative effects of priority time slots, or to identify a better alternative.

The use of dedicated time slots for clustering purposes does not seem to benefit internal integration. In the situations we studied, the use of this type of time slot related only to functional independence, and the benefits of clustering were only local. Clustering patients has a similar effect on a system as batching: increasing the variability in the system (Hopp and Spearman, 2001). As such, one could argue that clustering patients without considering preceding or subsequent steps increases variability and, following Schmenner (2001), will negatively affect the swift, even flow of patients.

By understanding the effects of employing specific types of dedicated time slots, hospitals can decide how to address the trade-off between local objectives and supply chain objectives. This would contribute to balancing functional and market orientations, as called for by MacStravic (1986) and Vissers and Beech (2005). Given that there is a trade-off between adopting a process orientation and a local approach; hospitals need to carefully consider the use of specific time slots. In adapting the words of Hoekstra and Romme (1992), we would argue that, for each type of dedicated time slot defined, one has to determine whether its positive effects for a specific patient group outweighs the negative effects for all the other patient groups that use that resource.

## 2.6 Conclusions

This chapter has addressed the planning of shared resources in hospitals through investigating the objectives of dedicated time slots used in allocating shared resource capacity. The study was undertaken to address the influence of dedicated time slots on alleviating the negative effects of sharing resources.

This study shows that while dedicated time slots have the potential to enable process orientation, hospitals hardly use them for this integrative purpose. Rather, time slots are often defined to resolve local problems or to optimize the performance of a single unit or department without considering the effects on the overall performance of the internal supply chain. That is, while dedicated time slots have the potential to boost internal integration in hospitals, this potential is not fully realized.

Our theoretical contribution lies in exploring the intersection of managing patient flows and planning shared resources. We have focused on how hospitals try to balance the pressure to reduce costs through high utilization of shared resources and the pressure to improve patient flow performance. Each type of dedicated time slot contributes either to resource utilization or to patient flow. By uncovering the effects of dedicated time slots, we offer a comprehensive overview of how the use of these slots influences the trade-off between resource utilization and patient flow.

Our results can assist practitioners in choosing which types of dedicated time slots to use and, more importantly, which to avoid when pursuing a specific objective. By understanding the effects of specific time slot types on both resource utilization and patient flow, practitioners can make a deliberate and well thought out choice when deploying time slots. By using the appropriate types of dedicated time slots for a specific shared resource, a configuration can be created which will address the requirements of both patients and management.

As in all studies of this type, our work has several limitations. The first and most obvious is that we build our study on three cases originating in a single hospital. Although we believe that the dynamics surrounding the management of shared resources and internal supply chains will be largely similar in other hospitals, extending the research to other hospitals is desirable. The exploratory nature of this study does not enable a prescriptive model of how shared resources should be managed to be developed. Therefore, further research into more prescriptive multistage scheduling models that address shared resources would be beneficial for further developing process orientation in hospitals. In this study, we have addressed one specific barrier to internal integration in hospitals, and future research should take account of other possible barriers to more integrated care provision. A good starting point for this new research would be the factors that have been found to enable or inhibit the integration of manufacturing operations (Stank *et al.*, 2001b; Pagell, 2004). As with shared resources, these barriers have not been addressed in a hospital context. Understanding and overcoming existing barriers seems crucial for the further deployment of internal supply chains that deliver a swift and even flow of patients.

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# CHAPTER 3

# 3 Integrative practices in hospitals and their impact on patient flow[2]

The aim of this chapter is to investigate which integrative planning & control practices are used in hospitals and what their effects are on patient flow. The study is based on a three-hospital multi-case study carried out in the Netherlands. The main findings are based on over forty in-depth interviews and the analysis of detailed patient flow data. The analysis of the flow data is used to explore the effects of integrative practices on lead times and patient flow. Based on the various patient groups examined in the different hospitals, four integrative practices stand out: sharing waiting list information, sharing planning information, cross-departmental planning, and combining appointments. In line with earlier studies, the overall level of integration in hospitals was found to be low. However, patient flow performance is significantly better in those hospitals that employ more of the abovementioned integrative practices. This study provides clear support for the value of integration initiatives in healthcare operations. The performance of hospitals, in terms of patient flows, benefits from cooperation between the various members of an internal supply chain. Hospital administrators and medical professionals could learn from these results and attempt to abandon their silo mentality and start integrating for their patients′ and their own benefit. Despite the importance of integration in hospitals, little is known about the integrative practices hospitals actually employ. Most existing studies on patient flows are confined to a single stage in the care process. In this study, the effects of integration in the internal supply chain from the first visit to the end of treatment are examined.

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[2] An earlier version of this chapter was published as Drupsteen, J., Van der Vaart, J.T. and Van Donk, D.P., 2013. Integrative practices in hospitals and their effect on patient flow. International Journal of Operations & Production Management, forthcoming.

## 3.1 Introduction

Torn between reducing costs and improving service levels, healthcare service providers struggle to improve their internal supply chains. Improving patient flow and lead times might well be valued by patients but these improvements can lead to an increase in costs. The various departments involved in the different steps of a care process traditionally focus on their internal processes and costs. In general they are not naturally inclined to coordinate their activities with other departments involved in the same care process. Consequently, it is a challenge for hospital managers to determine which practices will increase patient flow without investing in expanded capacity. Integration has been an effective method in increasing flows in supply chain management. Therefore, the main aim of this study is to map integrative planning & control practices in hospitals and to assess the effects of these practices on patient flow performance.

In a review of healthcare operations management literature, White *et al.* (2011) show that the majority of studies on the planning & control of care processes concentrate on single-stage systems. Rhyne and Jupp (1988) had already recognized that proper planning should tie together key functions within a hospital. Haraden and Resar (2004) show that flow improvements within individual departments often exacerbate problems for other dependent departments. However, most departments in hospitals still operate independently (Lega and DePietro, 2005). Consequently, the different process steps patients undergo are not aligned, and this results in discontinuous patient flow. Improving the flow of patients is seen as crucial for increasing hospital productivity and increasing patient satisfaction (Litvak, 2009; Villa *et al.*, 2009).

It is well known from organizational studies that hospital departments/specialties are highly differentiated (Glouberman and Mintzberg, 2001b) and have a high degree of professional autonomy (Smithson and Baker, 2007). Integration is an important theoretical stance with respect to aligning different departments. Integration entails organizational entities within a firm not acting as functional silos, but as a unified whole (Barki and Pinsonneault, 2005). Several authors have found empirical evidence that integration leads to higher performance in a manufacturing context (e.g. Narasimhan and Das, 2001;

O'Leary-Kelly and Flores, 2002). More specifically, Droge *et al.* (2004) found positive effects of integration on several time-based measures, albeit only in specific parts of a supply chain. Despite the positive effects of integration in manufacturing, it remains unclear if the findings from such integration research can be translated to a healthcare setting (Thrasher *et al.*, 2010). So far, research has paid little attention to what practices might be effective in this specific context, and what the effect of such practices would be on patient flow performance.

The main thrust of this chapter is that patient flow performance should be evaluated from the perspective of the entire internal supply chain. On this basis, there are two important gaps in the literature which need to be addressed. First, most studies fail to address *entire* internal supply chains, while only an integrated approach seems able to address current management problems in healthcare. Second, little is known about *how* hospitals integrate their internal supply chains and what *effects* integrative practices have on flow performance.

In this chapter we address these two gaps and examine the effects of integration on patient flow performance in three hospitals. Specifically, we investigate within these hospitals the integrative practices with respect to *planning & control* and we assess the effects of these practices on flow performance. In a multiple case study, we investigate the integrative practices found in the orthopedic supply chain within the three hospitals. Within this orthopedic supply chain, we focus on three patient groups for which different integrative practices are employed. Our empirical findings provide compelling evidence that although integration is limited, the integrative practices that are implemented enable the hospitals to perform significantly better than hospitals that have not implemented these practices. The results provide health service providers with insights and tools on how to improve organizational performance without compromising patient service performance, and show the importance of overcoming the current silo mentality which still thrives in hospitals.

The chapter is structured as follows. First, in the theoretical background section, we present our conceptual model based on the literature reviewed on patient flow, internal supply chains in hospitals, and the concept of integration. This is followed by an explanation of the case study methods. In the results section, we discuss how the integration mechanisms we found affect patient flow performance. Following the subsequent discussion section where we interpret the results, we present our conclusions and the theoretical and managerial implications of this research.

## 3.2 Theoretical Background

### *3.2.1 Patient flow and Internal Supply Chains*

Improving patient flow is seen as of great importance in boosting hospital performance (Litvak, 2009; Villa *et al.*, 2009), since flow performance is an important aspect of organizational performance (Schmenner and Swink, 1998; Schmenner, 2001). In line with the definition of flow by Hopp and Spearman (2001), patient flow performance is defined as the speed at which patients are transferred from one step in the care process to the next. According to Schmenner and Swink (1998), improving flow performance can be achieved by overcoming three barriers: bottlenecks, non-value-added activities (e.g. unnecessary waiting or unnecessary process steps), and variability associated with the flow.

Removing one or more of these barriers in order to improve patient flow performance requires including all the relevant departments in a single investigation, rather than examining the contribution of each department individually. Haraden and Resar (2004) even suggest that an individual department that improves flow in its area alone could harm performance in other dependent departments. Nevertheless, most contributions on patient flow continue to focus on single stages of internal supply chains (Haraden and Resar, 2004). For instance, O'Keefe (1985), Swisher *et al.* (2001), Akcali *et al.*, (2006), and Chand *et al.* (2009) focus on outpatients; Edward *et al.* (2008) on the pre-assessment stage; Vissers (1998) on inpatients; and Santibáñez *et al.* (2009) on ambulatory services. We could only find two contributions that have focused on several consecutive steps in the care process, which are Fredendall *et al.* (2009) and White *et al.* (2011). However, even these contributions do not consider the patient's journey through the entire internal supply chain, and provide little insight into how to improve patient flow throughout a care process.

The lack of an internal supply chain perspective in hospitals can be explained by the fact that hospitals are traditionally considered to be a collection of individual resources or service centers (Roth and Van Dierdonck, 1995). Most general hospitals have adopted a functional organizational structure, built around discipline-based specializations (Lega and DePietro, 2005). These specializations are mostly based on anatomical divisions or medical technologies, and to a lesser extent based on segments of the population (e.g. age groups) or urgency (Montgomery, 1990). Given this strict functional division and the autonomy of departments, the planning & control of each department´s resources is carried out locally and decoupled from other departments.

Over the past three decades, several approaches have been proposed that adopt a process view on the delivery of care, rather than the classical functional perspective. These ideas include service lines (MacStravic, 1986; Berenson *et al.*, 2006), focused factories or specialty hospitals (Herzlinger, 1997; Cram and Rosenthal, 2007), and clinical pathways (Pearson *et al.*, 1995; De Bleser *et al.*, 2006). Such approaches reflect that considering hospitals as a set of internal processes, rather than as a set of departments, is gaining momentum in both academia and hospital management circles. In reviewing the healthcare operations literature we find an important paradox. On the one hand, the contributions that adopt a process or internal supply chain view do not focus on planning & control aspects whereas, on the other hand, if planning & control are considered then it is not usually from an internal supply chain perspective. For instance, in appointment scheduling, the dominant focus is on a single-server situation (e.g. Bailey, 1952; Cayirli and Veral, 2003; Green *et al.*, 2006; Cardoen *et al.*, 2010a). Again in studies on the scheduling of ancillary services such as laboratory services (Abdul Hamid *et al.*, 2010) or diagnostics services (Green *et al.*, 2006), the linkages with the other parts of the internal supply chain are not considered. Beyond the scheduling literature, we were able to find a few contributions that consider two-stage systems. Longo and Masella (2002), Beliën and Demeulemeester (2007), and McGowan *et al.* (2007), for example, link operating theatre capacity to ward capacity. Although these examples provide some insight into multi-stage systems, most contributions on capacity management or the management of patient flow do not go beyond two consecutive steps in a care process (White *et al.*, 2011), let alone discuss how to create a more integrated internal supply chain in hospitals.

### *3.2.2 Integration*

As little research has been conducted on integration within a healthcare context, we have to draw on other fields of research. The concept of integration is thoroughly ingrained in both organization theory (e.g. Lawrence and Lorsch, 1969) and operations management (e.g. Hayes and Wheelwright, 1984), and is also considered as an important concept in supply chain management (Flynn *et al.*, 2010). However, there is no generally accepted definition (Mendes Primo, 2010). Typically, integration is defined according to several multilevel constructs such as interaction, collaboration, and cooperation (Frohlich and Westbrook, 2001; Pagell, 2004; Flynn *et al.*, 2010; Braunscheidel *et al.*, 2010). We position our research around the central idea of integration: breaking down the functional barriers which appear both within and between firms (Zhao *et al.*, 2011).

Pagell (2004) supposes that integrative efforts move along a set course, from no integration to full integration, in discrete steps. These steps can be classified along several scales. When looking at the various classifications in the literature we can distinguish between the scope of integration, the span of integration, and the intensity of integration. The *scope* of integration addresses which aspects of the organization are integrated. Jaspers and van den Ende (2006) distinguish integration in the areas of coordination, tasks, ownership, and knowledge. Van Donk and Van der Vaart (2004) define five dimensions of supply chain integration: organization, physical flow, information flow, product development, and planning & control. Since our research is limited to planning & control, we do not need to elaborate on the various scopes of integration. The *span* of integration addresses which, and how many, organizational entities (e.g. departments, business units, organizations) are integrated. Stevens (1989) divides the span of integration into four incremental categories: no integration (baseline), functional integration, internal integration, and external integration. Frohlich and Westbrook (2001) have a similarly increasing scale of integration: inward facing, periphery facing, and outward facing. Compared to the span of integration, the *intensity* of integration focuses more on the nature of the integration. In defining the intensity of integration, Van der Vaart and Van Donk (2004) identify three stages: the transparency stage, in which supply chain members share relevant information on issue like inventories, demand, and promotions; the commitment and coordination stage, where supply chain members not only share relevant information but are also bound by quantity commitment clauses or similar; and finally the integrative planning stage, where the planning & control of at least part of a supply chain is effectively centralized. Integrative planning & control practices can therefore, differ in terms of the span and the intensity of integration, and thus vary in the way they influence patient flow performance.

### *3.2.3 Conceptual model*

In this study, we aim to contribute to the understanding of how the integration of planning & control affects patient flow performance. A positive effect of integration on patient flow performance is suggested by Fredendall *et al.* (2009), although they found little empirical evidence to link the two concepts. We argue that *if* the integration of planning & control contributes to patient flow performance it will do so by overcoming one or more of the barriers to flow proposed by Schmenner and Swink (1998). That is, integrating planning & control either reduces the variability associated with patient flow or helps in removing bottlenecks or non-value-added activities in a care process (see Figure 3.1).

Considering the three barriers to flow, it seems logical that integrating planning & control should reduce non-value-added activities by reducing the number of queues in a process by linking the capacities of the process steps and reducing the period between times of scheduling (i.e. a patient does not have to wait for a process step to be completed before being scheduled for the subsequent process step). A reduction in variability can be achieved through information sharing (Chen *et al.*, 2000; Chen and Lee, 2009) and capacity coordination (Frohlich and Westbrook, 2001). Whether integration can remove bottlenecks is less certain. We argue that temporary bottlenecks (such as those caused by peaks in demand) can be eliminated through a reduction in variability. However, a structural bottleneck can only be eliminated by increasing capacity or reducing the demand for the existing capacity. One way in which the integration of planning & control could contribute to a reduced demand for capacity is by establishing a patient acceptance policy (such as a pull system which uses information from all the steps in the care process to determine the workload in the system. Entry to the system would be refused when the workload is too high for any one of the steps).

This, however, could result in the undesirable scenario of refusing patients access to a care process.

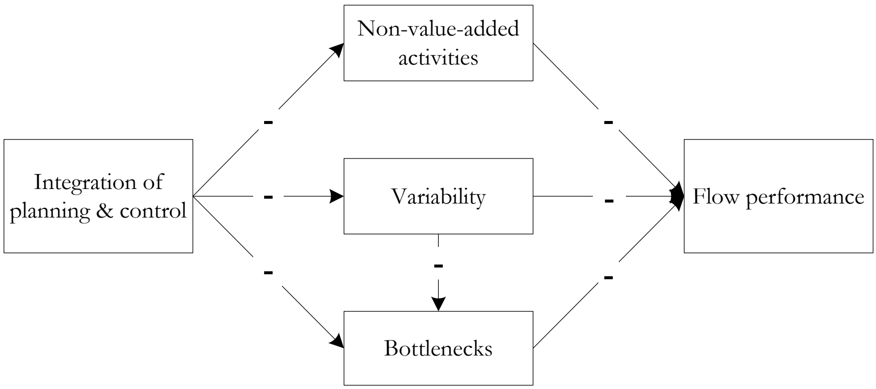



*Figure 3.1: Conceptual model*

Although a relationship between integration and patient flow performance seems logical, we know very little about which integrative practices are actually employed in hospitals and how they affect the barriers to patient flow performance. Based on the classifications of integration, we believe that hospitals can take various integrative routes to improve their patient flow performance. Given that hospitals generally show a low degree of integration (Bamford and Griffin, 2008), we would expect to find integrative practices with a relatively narrow span and of low intensity. Moreover, we would expect an increased span of integration and an increased intensity of integration to lead to improved patient flow performance.

## 3.3 Methodology

Given that little knowledge exists on how hospitals integrate their departments, and how such integrative practices influence patient flow, we have opted for an exploratory case study as suggested by Eisenhardt (1989) and Yin (2003) for such situations. The case study methodology is considered very useful when the research aims to answer "why" and "how" questions (Yin, 2003). Moreover, this methodology is underused in the field of operations management but is seen as able to contribute to enriching the field (Voss *et al.*, 2002). We chose a multiple case study approach as evidence gathered from such an approach is often more compelling than from a single case (Yin, 2003) Further, the use of multiple cases increases the external validity of the research (Voss *et al.*, 2002).

Based on Miles and Huberman (1994) we selected an extreme case and two typical cases. Hospital 1 can be seen as a best-in-class case, as it is regarded a top hospital, while Hospitals 2 and 3 are regarded typical cases. Following Stuart *et al.* (2002), we selected the three hospitals based on their diversity in employing integrative practices and thus their potential to contribute to the research objective. Two of the selected hospitals displayed a relatively high degree of integration (Hospitals 1 and 3), whereas the other hospital showed relatively limited integration. Besides the diversity in integrative practices between the hospitals, we also noted that each hospital employed different integrative practices for specific patient groups, which allows both theoretical and literal replication (Yin, 2003). Given that we did not expect to find high degrees of integration throughout the hospitals, we carefully selected three patient groups that are most appropriate for integration, ones that can be characterized by high volumes, low variety, and low routing variability. Moreover, we decided to choose patient groups that all used the services of the same departments in each hospital and so selected three orthopedic patient groups: Meniscus, Total Hip, and Total Knee. All these patient groups use the services of the Orthopedics, Radiology, and Anesthesiology Departments and of the Operating Theatre. The patients follow a similar, well-defined, care process in each of the case hospitals. With our unit of analysis being a patient group, we thus investigated a total of nine patient groups.

Capacity utilization is an important variable that affects patient flow performance (Hopp and Spearman, 2001). From a practical perspective, controlling capacity utilization in hospitals proves to be very difficult. Due to the influence of urgency, physician preferences, and patient preferences, it is difficult if not impossible to synchronize at the resource level among different hospitals. Therefore, we chose hospitals with similar high levels of capacity utilization. All three hospitals strive for and achieve high occupancy rates for their key resources (MRI and OR) and we considered them as comparable. However, if a difference in capacity utilization arises as a possible explanation for better flow performance, we will explicitly address this in our results.

Data were collected in the three hospitals between July 2010 and December 2010. The main data sources consist of quantitative patient flow data covering over 8500 patients treated during 2009 and 2010 plus 41 in-depth structured interviews. Data triangulation (Eisenhardt, 1989; Stuart *et al.*, 2002; Yin, 2003) was addressed by using multiple subjects, archival data, and observational data. Further, the study's results were presented to all the subjects in each of the hospitals and an earlier draft of this chapter was sent to all the subjects for comment. The subjects were invited to react both to the presented results as well as the written draft, and relevant comments and suggestions were incorporated in this revised chapter.

The quantitative data used consist of information from each hospital's information system. This system contains the dates of each activity performed by the hospital for each patient and is based on the Dutch DTC (Diagnosis Treatment Combination) system, which is comparable to the more widely known system of diagnosis-related groups (DRGs). However, unlike the DRG system, the DTC system is episode-based and each episode/activity performed within the hospital is registered, from the first outpatient clinic visit through to clinical discharge (Steinbusch *et al.*, 2007). Based on these data, we have reconstructed the complete care process and the time required to complete it for each orthopedic patient. We used qualitative data to determine the span and intensity of integration, and this information was obtained through interviews with hospital managers and department heads, and with physicians, nurses, and planners from each of the four departments involved. In total 41 interviews, with lengths between one hour and two and a half hours, were conducted.

The data analysis consisted of three parts. First, we mapped each of the internal supply chains. In mapping the orthopedics supply chain we took a process point of view, an approach generally not used in supply chain research (Oliva and Watson, 2011). This process view provided a "fine-grained qualitative data analysis" by creating visual maps (see Appendix 1) of the functions and processes (Langley, 1999) and provided a chain of evidence (Miles and Huberman, 1994), which was further supported by the qualitative data obtained from the interviews. Second, the qualitative data from the interviews were coded using existing classification schemes found in the integration literature. For the span of the integration, the definitions of Stevens (1989) were adapted; and for the intensity of integration we followed Van der Vaart and Van Donk (2004). This led to the classification presented in Table 3.1. The third and final step of our analysis consisted of assessing flow performance. We compare the flow times between several steps in the care processes for each unit of analysis. The focus is on those parts of the internal supply chain where we found integrative practices. The flow performance was assessed in two ways. First, we compared and visually displayed the cumulative percentages of the patient population that finished a specific part of the process within a specific lead time. Second, the flow performances at the different hospitals are statistically compared using the Mann-Whitney-U test for each step. This test was selected because the data did not pass the test of normality.

*Table 3.1: Span and intensity of integration (Stevens, 1989; Van der Vaart & Van Donk, 2004)*

| **Span** | **Description** |
|---|---|
| *Functional integration* | Integrative practices between two members (dyad) of an internal supply chain. |
| *Internal integration* | Integrative practices between more than two members of an internal supply chain. |
| **Intensity** | **Description** |
| *Transparency stage* | Members of the internal supply chain share information with other members of the supply chain relevant to the planning & control of patients. |
| *Commitment stage* | Rather than just sharing information, the internal supply chain members enter into commitments regarding capacity allocation, service level agreements, prioritization of patient groups, etc. |
| *Integrative planning stage* | The capacity of different departments is linked through combined patient planning, guided by a central objective. |

## 3.4 Results

The results section is structured according to the span of integration and distinguishes “no integration”, “functional integration”, and “internal integration”. This structure is based on the notion that organizations, in their integrative efforts, move along a set course in discrete steps from no integration to full integration (Pagell, 2004). Within each integration span, we distinguish three levels of intensity. As the "no integration" category has no intensity classifications, we effectively divide the integrative practices we found into six categories (see Table 3.2). For each of the integrative practices found, we elaborate on the flow performance effects associated with the part of the process in which the integrative practice occurs. First, in order to understand the empirical setting, we describe the orthopedics internal supply chain as observed in the three hospitals.

### *3.4.1 The orthopedics supply chain*

In general, the care process of an orthopedics patient consists of three stages: diagnosis, pre-assessment, and treatment. Within these stages, several process steps take place and most patients go through the following sequence of process steps (see also Figure 3.2). A patient's first orthopedic outpatient clinic consultation (OPC1) is preceded by an X-ray performed by Radiology. If additional diagnostics are required after the first consultation, the patient undergoes Magnetic Resonance Imaging (MRI), which is followed by a second orthopedic consultation (OPC2) to discuss the outcome of the MRI. Where a patient requires surgery, this diagnostic stage is followed by a pre-assessment stage in which the patient has to be evaluated as fit for surgery and is then prepared for the upcoming surgery. This involves attending an orthopedics nurse consultation (OC) and an anesthesiology consultation (AC). After the patient is declared fit for surgery, the patient will undergo the surgery (OR) attended by the orthopedic surgeon and an anesthetist. In each of the hospitals studied, the internal supply chain for orthopedic patients consisted of four main departments – Orthopedics, Radiology, Anesthesiology, and the Operating Theatre – all contributing their resources to one or more stages of the care process.

*Figure 3.2: Process steps for orthopedics patients*

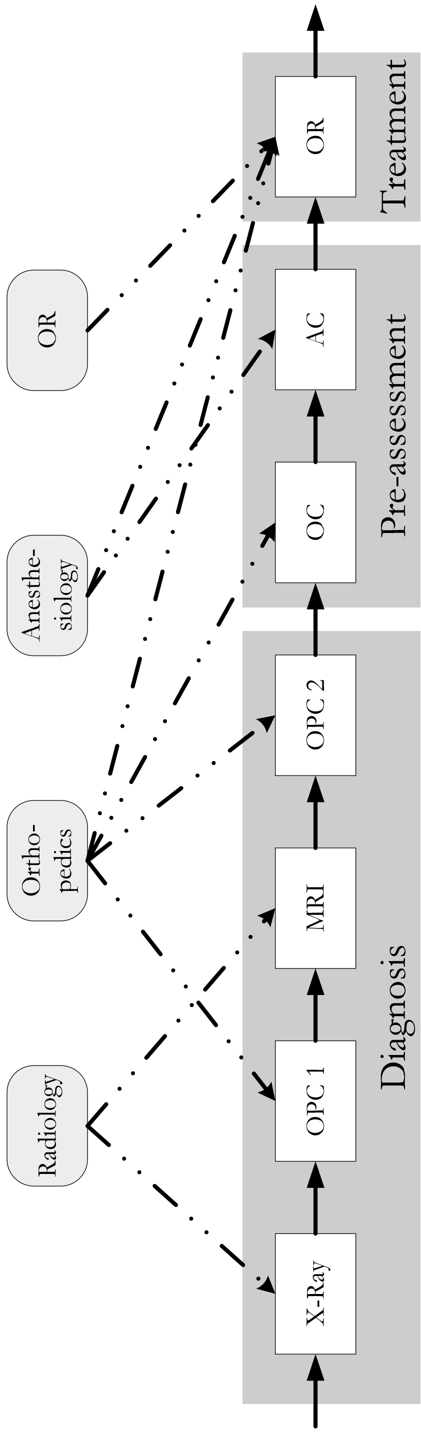


Figure 3.2 also shows the responsibilities of each of the supply chain members, represented by the dotted arrows, in the various stages of the orthopedics care process. The flow of patients is represented by the arrows between the process steps.

The remainder of this section is structured according to the span of integration, i.e. no integration, functional integration, or internal integration, and within each of these classes we discuss the intensity of the integration. In other words, we start by describing the negative effects observed on patient flow performance resulting from a lack of integration. Then we report on manifestations of functional integration and integrative planning, and their effects on patient flow performance.

### *3.4.2 The lack of integration and its effects on patient flow.*

From our interviews, we could conclude that a lack of integration in planning & control has a number of negative effects on patient flow. One of the most striking findings was the autonomy of Anesthesiology that we observed in all three hospitals. This autonomous planning hinders the balancing of capacity and the setting of effective priorities, and results in excessive throughput times. An orthopedic surgeon in Hospital 3 noted: *"Access time to the OR is only one week, but I have to wait four weeks for Anesthesiology to approve the patient for surgery."* Not only does this autonomous planning have negative effects on patient throughput time, it also negatively affects resource utilization, as expressed by an orthopedic surgeon from Hospital 1: *"I would really like a small buffer, of five to ten patients, who are already approved for surgery, that I could use to fill acute gaps in our OR schedule. However, I cannot arrange this with Anesthesiology."*

We observed several situations in which the lack of an exchange of logistical data negatively affected either the patient or the hospital administrators. An MRI technician at Hospital 1 noted that: *"The orthopedic surgeons 'promise' the patient a certain access time to the MRI, which we cannot deliver."* Misinforming patients about waiting times creates a discrepancy between a patient's expected waiting time and the actual wait. Cassidy-Smith *et al.* (2007) show that this type of expectancy misinformation negatively affects patient satisfaction. Besides the negative effects on patient satisfaction, the failure to exchange logistical information hinders management in taking effective action. The orthopedic unit manager of Hospital 2 stated: *"Real-time control information is completely lacking, sometimes I have to wait for three months before I get insight into the production we have realized."*

A positive observation is that the hospitals investigated do seem to be starting to recognize that a care process should not be planned and controlled in a stepwise manner if they want to fulfill the requirements of patients and live up to the standards set by the government. This has resulted in several examples of integration in the internal supply chain.

### *3.4.3 Functional integration and patient flow*

With functional integration we refer to integrative practices linking the planning & control functions of two departments. Table 3.2 provides a summary of all the integrative practices we observed within the hospitals. The table shows that compared to Hospitals 1 and 3, Hospital 2 seems to lag behind in terms of integration. It also shows that functional integration is the dominant form. In this section, we will discuss each of the functional integrations found in the three hospitals, in terms of the three stages of integration intensity (i.e. the transparency, commitment, and integrative planning stages).

The most evident manifestation of *transparency* in functional integration was in the sharing of MRI planning information between Orthopedics and Radiology. In Hospital 1, Radiology provides the planned date of a patient's MRI to Orthopedics, which gives Orthopedics the opportunity to plan a consultation to discuss the MRI outcome shortly after the planned MRI date. Orthopedics is then responsible for communicating both dates to the patient. In Hospital 3, Orthopedics is kept informed on MRI waiting times. As a result, Orthopedics can schedule a consultation to discuss the MRI outcome before the actual MRI is scheduled. In Hospital 2, such information was not exchanged between departments. Figure 3.3 shows the effects of information sharing between Radiology and Orthopedics on patient flow. The figure shows the cumulative percentages of the patient population with specific throughput times. The figure shows that, for Hospitals 1 and 3; over 50% of all patients completed the OPC1, MRI and OPC2 stages within 27 days, whereas for Hospital 2 the equivalent figure was 36 days. This indicates the positive effects of transparency on patient flow.

*Table 3.2: Integrative practices employed in the three case hospitals*

| | Functional Integration | | | Internal Integration | | |
|---|---|---|---|---|---|---|
| | Transparency | Commitment | Integrative planning | Transparency | Commitment | Integrative planning |
| Hospital 1 | Sharing of planning information (Radiology and Orthopedics)<br>Sharing of waiting list information (Anesthesiology and Orthopedics in order to schedule the OR) | Cross-departmental scheduling (Orthopedics and Anesthesiology)<br>Cross-departmental scheduling (Orthopedics and the OR) | Combined appointment (OC and AC)<br>Combined appointment (by means of overcapacity X-ray and OPC1) | Sharing of planning information (the OR schedule is leading) | | |
| Hospital 2 | | Cross-departmental scheduling (Orthopedics and Radiology) | | Sharing of planning information (Orthopedics, Radiology, Anesthesiology and OR) | | Combined appointment (OPC1, OC, AC and OR; for a small patient group) |
| Hospital 3 | Sharing of waiting list information (Radiology and Orthopedics)<br>Sharing of waiting list information (Anesthesiology and Orthopedics to schedule the OR) | Cross-departmental scheduling (Orthopedics and the OR; faulty scheduling results in capacity loss) | Combined appointment for (OC and AC) | | | |

Other evidence of the transparency stage being reached in functional integration is found between the OPC and OR process steps. In Hospital 2, the scheduling of patients for OR is done by the Admissions Office. In both Hospitals 1 and 3, Orthopedics is allowed to itself schedule patients for the OR, using a template provided by the OR. In both of these hospitals the subject responsible for scheduling patients for the OR stated that they did *"not wait for Anesthesiology to approve surgery before scheduling the operation"*[3]. This was not the case in Hospital 2. Hospitals 1 and 3 were able to schedule patients directly after the OPC (albeit including sufficient waiting time for the pre-assessment), whereas Hospital 2 would wait to schedule until approval had been given by Anesthesiology. When looking at the flow performance between the pre-assessment and the OR stages, it is clear that both Hospital 1 and Hospital 3 outperform Hospital 2 (Figure 3.4).

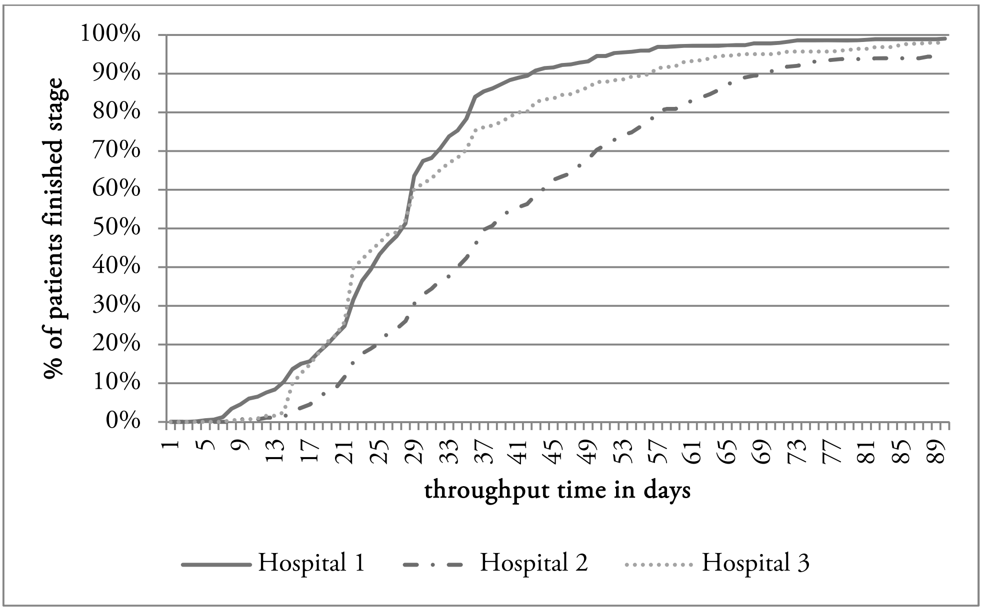



*Figure 3.3:Flow performance stage OPC1 – MRI – OPC2*

[3] Hospitals are obliged to pre-assess all patients before surgery; and this task was not neglected by any of the hospitals.

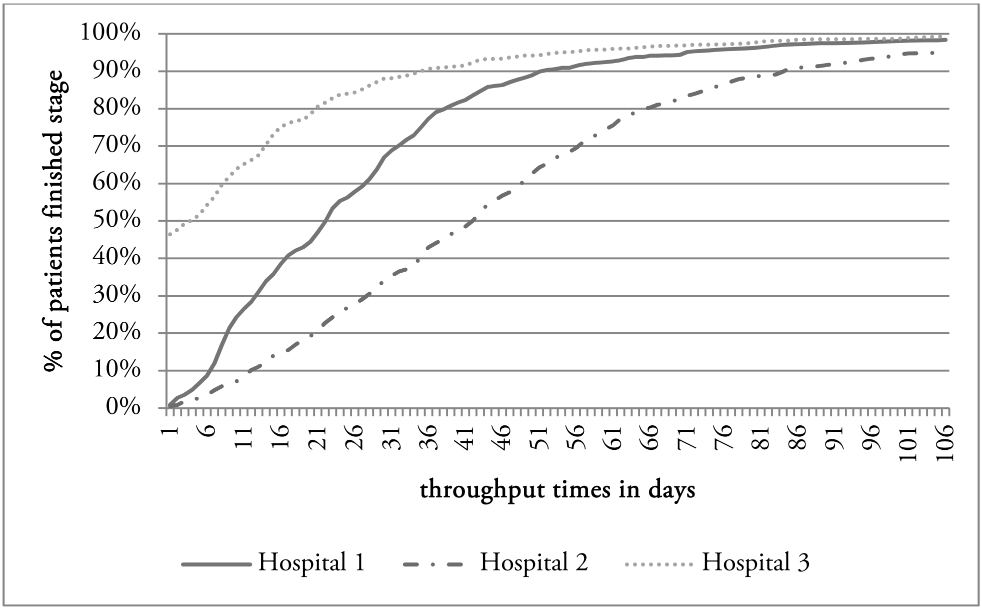



*Figure 3.4: Flow performance stage Pre-assessment – OR*

We found several practices which we judged as having achieved the *commitment stage*. The first such practice found was in the dyadic relationship between Orthopedics and Radiology. Hospitals 2 and 3 both use an appointment system to plan patients for an X-ray. However, in Hospital 2, Orthopedics can schedule patients themselves, whereas in Hospital 3 patients are scheduled by Radiology. The Orthopedics secretary from Hospital 3 stated that: *"in most cases, but not all, we are able to schedule X-rays just before the OPC visit"*. Looking at the flow performance of this stage (Figure 3.5), we see that Hospital 1 can guarantee same day access to the X-ray department for 99% of patients, whereas Hospitals 2 and 3 are able to guarantee same day access to the X-ray department for 92% and 81% respectively. This can be explained by the fact that Hospital 1 has a walk-in policy and guarantees a timely access to the X-ray service by means of an overcapacity. This allows Orthopedics to combine an X-ray with the orthopedics consultation (OPC1). The second such practice found was between the outpatient clinic visit and the pre-assessment (OC & AC). In Hospital 1, Orthopedics is allowed to schedule patients using a template provided by Anesthesiology. In Hospital 2, a dedicated department – the Admissions Office – schedules all patients for the pre-assessment stage. As such, Anesthesiology does not provide

Orthopedics with the possibility to schedule its own patients for pre-assessment appointments. In terms of the flow performance of this part of the process (Figure 3.6) we would expect Hospital 1 to outperform Hospital 2 since Hospital 1 has more information with which to prioritize patients. However, Hospital 2 outperforms both Hospitals 1 and 3. The explanation for Hospital 2 outperforming Hospital 3 can be found in a comment by an orthopedic surgeon of Hospital 3: *"Anesthesiology has a structural capacity shortage which needs to be resolved"*. Our interview data did not, however, explain why Hospital 2 outperformed Hospital 1 in this process step.

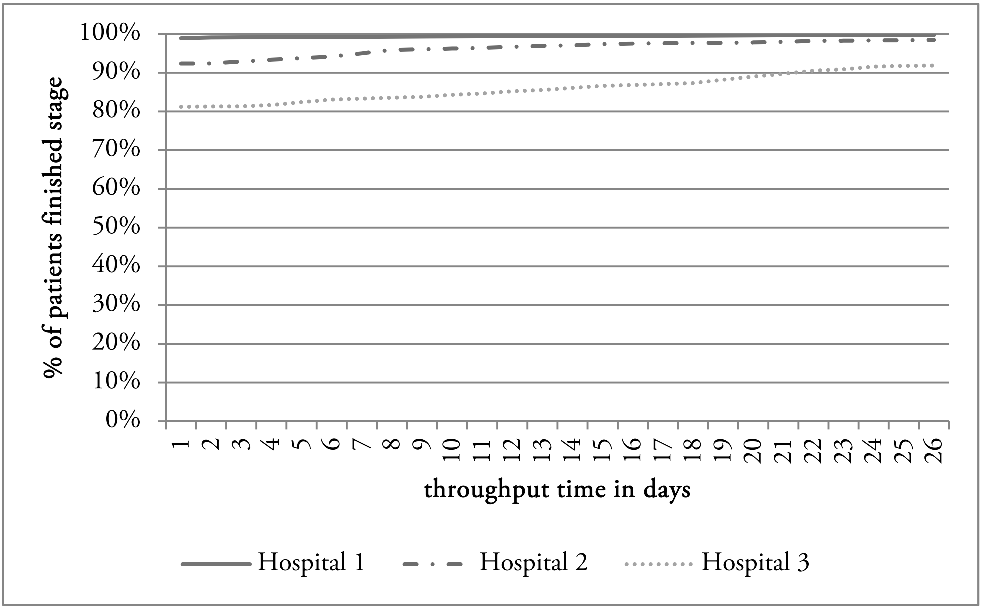



*Figure 3.5: Flow performance stage X-ray – OPC1*

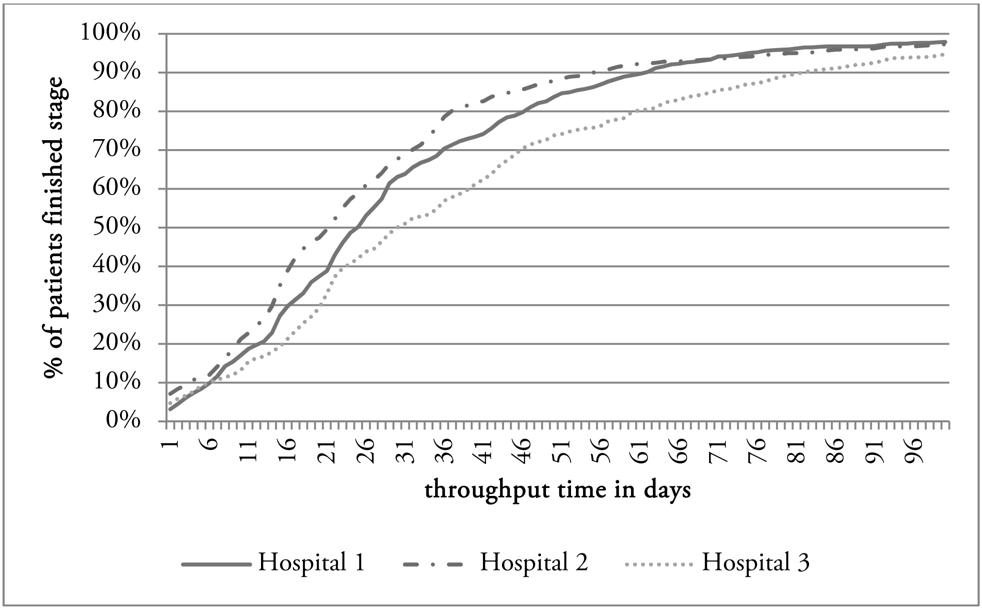



*Figure 3.6: Flow performance stage OPC – PRE*

An interesting observation related to the *integrative planning stage* in functional integration was made in the pre-assessment stages for both Total Knee and Total Hip patient groups. Hospitals 1 and 3 had both initiated a program in which the capacity of the orthopedics nurse consultation (OC) and the anesthesiologist consultation (AC) were coupled, with Anesthesiology specifically reserving capacity for these orthopedic patients. Hospital 2 has no such program. Figures 3.7 and 3.8 show the effects of such integrative planning between Orthopedics and Anesthesiology on patient flow. Again the figures show the cumulative percentages of the patient population with a specific throughput time. The figures show that over 80% of all Total Knee and Total Hip patients completed the pre-assessment stage within one day at Hospitals 1 and 3, whereas only approximately 50% of all Total Knee and Total Hip patients did so at Hospital 2.

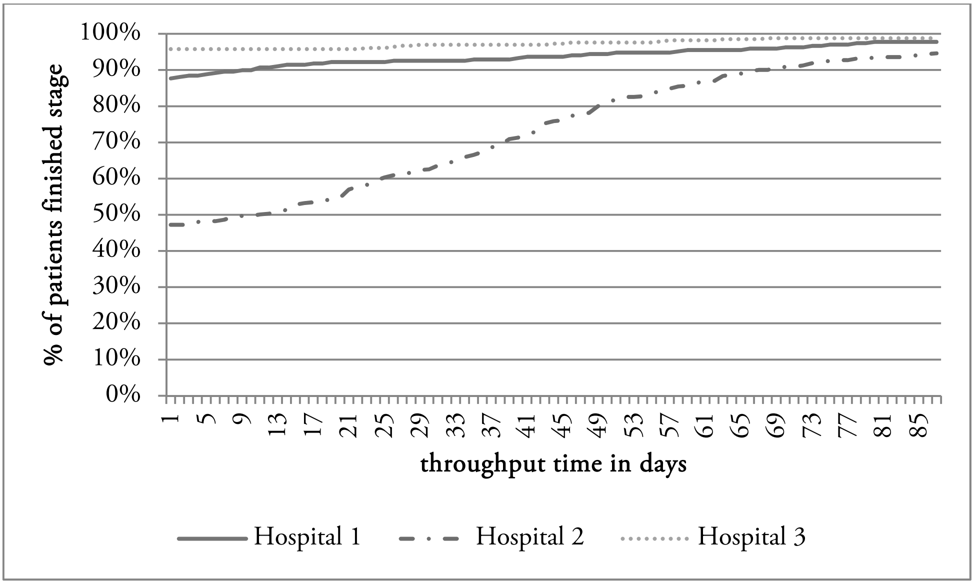



*Figure 3.7: Flow performance stage OC – AC (Total Hip)*

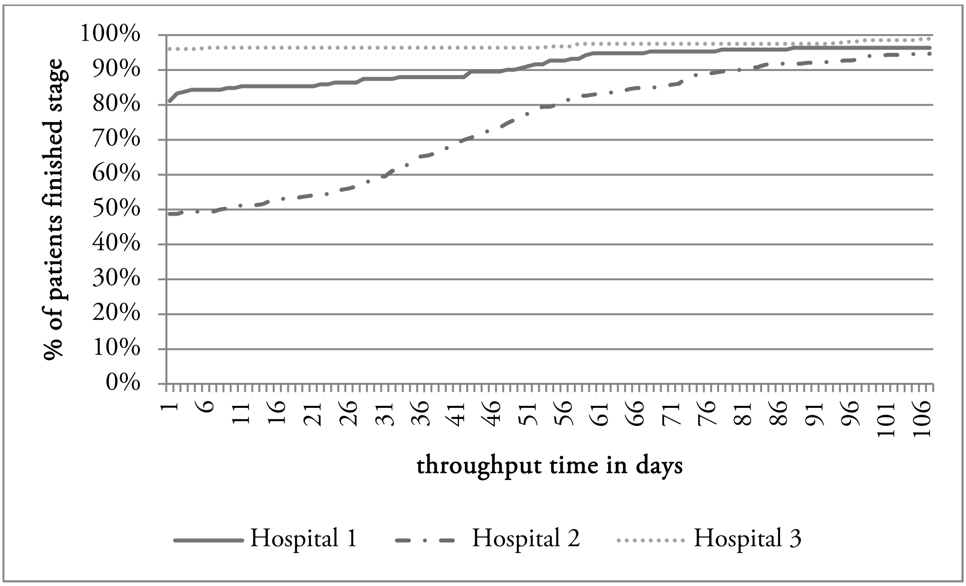



*Figure 3.8: Flow performance stage OC – AC (Total Knee)*

### *3.4.4 Internal integration and patient flow*

Internal integration occurs when integrative practices are seen between at least three members of the internal supply chain. We observed some, albeit limited, integrative practices that included more than two participating departments and these are summarized in the right half of Table 3.2. As with functional integration, internal integration can be refined into transparency, commitment, and integrative planning stages.

Orthopedics in Hospital 2 attempted to achieve the transparency stage by distributing planning information among all the supply chain members. However, the orthopedics planner commented: *"I very much doubt if anyone is using this information and I get no information in return"*. Next, we observed internal integration in Hospital 1 that could also be classified as being at the transparency stage. Throughout the departments of Hospital 1, relevant planning information is shared, although this is mainly communicated with the commonly heard phrase *"the operating theatre is leading"*. This results in each department being subject to the schedule of the OR. We were also able to observe integrative planning in Hospital 2, but only for a small part of the Meniscus patient group. Otherwise healthy patients with a specific type of insurance could apply for an integrated path which would ensure that both the diagnostics and the pre-assessment stages would be completed within one week provided an MRI was not required, or two weeks if an MRI was required. In the third week the patient would be treated in the OR. This swift path has been created by reserving capacity for these patients and by coupling the capacities of various departments through central planning.

*Table 3.3: Median flow time; Mann-Whitney-U test results*[1]

| | | Median flow time Hospital | | | Best performing Hospital | | |
|---|---|---|---|---|---|---|---|
| Patient Group | Process step | 1 | 2 | 3 | 1 vs. 2 | 1 vs. 3 | 2 vs. 3 |
| All patients | OPC1 - MRI - OPC2 | 27 | 37 | 27 | 1* | 1 | 3* |
| All patients | X-ray - OPC1 | 0 | 0 | 0 | 1* | 1* | 2* |
| All patients | OPC - Pre-assessment | 24 | 21 | 30 | 2* | 1* | 2* |
| All patients | Pre-assessment - Surgery | 22 | 41 | 3 | 1* | 3* | 3* |
| All patients | Total process | 68 | 77 | 56 | 1* | 3* | 3* |
| Total Knee | Pre-assessment | 0 | 7.5 | 0 | 1* | 3* | 3* |
| Total Hip | Pre-assessment | 0 | 10 | 0 | 1* | 3* | 3* |
| Total Knee | Total process | 78 | 93 | 65 | 1* | 3* | 3* |
| Total Hip | Total process | 82 | 85 | 51 | 1 | 3* | 3* |
| Meniscus | Total process | 65.5 | 58 | 64 | 2 | 1 | 2 |

* p< .05

[1] The Mann-Whitney-U test employed only allows for testing differences between two populations. In order to compare each hospital with the other two, the test had to be performed three times. The results of these tests are presented in the last three columns. For example, 1* in the column 1 vs. 2 means that Hospital 1 has a significantly better flow performance than Hospital 2 for that specific group and specific process step.

We did not observe the first two integrative practices (distributing planning information to all departments and having the OR leading) as having any effects on patient flow performance. However, the integrative planning efforts for the Meniscus patients in Hospital 2 did yield positive effects on patient flow performance. Table 3.3 shows that Hospital 2 is lagging behind both the other hospitals in terms of throughput for the Total Hip and Total Knee groups, which can be linked to the lack of integration in its processes. However, for the Meniscus group, there is no significant difference between the flow performances of the three hospitals. The increased performance of Hospital 2 in this area could be explained by the integrative practices practiced by this group as discussed earlier.

We would summarize our results as follows. Firstly, all the hospitals showed only limited integration, and this resulted in sub-optimal performance. The results did reveal several functional integration practices, such as having insight into other departments' waiting lists, sharing planning data, creating templates for other departments to fill in, and making combined appointments. A second important finding is that, overall, the effects of integrative practices are positive in terms of patient flow performance. The hospitals with the greatest functional integration showed higher patient flows than the hospital with little functional integration. We hardly saw any evidence of full internal integration in our case studies although the one manifestation we did observe yielded a significant positive effect on patient flow performance.

## 3.5 Interpretation of the results

The aim of this research has been to address two important questions related to patient flow performance: determining which specific integrative practices related to planning & control are employed by hospitals and determining the effects of these practices when considering a hospital's entire internal supply chain. The results clearly show that hospitals which employ more integrative practices achieve a better patient flow performance. While this result is in line with our expectations, we did find some unexpected patterns in how specific practices are employed and function in hospitals.

### *3.5.1 Removing barriers to patient flow: mechanisms for integration*

The results show that the three hospitals use a variety of integrative practices that can be summarized as four core mechanisms: *(1) Sharing of planning information*; information is shared about when a patient is scheduled for a preceding process step and this information is used by the planner of the subsequent process step to anticipate when the patient can be scheduled for this step. *(2) Sharing of waiting list information*; information is shared about the waiting time for scheduling a patient for a preceding process step and this information is used by the planner of the subsequent process step to anticipate when the patient can be scheduled for this step. *(3) Cross-departmental planning*; a department may schedule patients for a subsequent process step in a different department, allocating capacity of the department that will execute that step. *(4) Combined appointments*; multiple steps in the care process are arranged and executed on the same day. How these mechanisms relate to the barriers to flow as described by Schmenner and Swink

(1998), and how this affects our suppositions on the integration of planning & control in hospitals is discussed below.

The sharing of planning information and the sharing of waiting list information both reduce non-value-added activities in the care process. In both cases, the planner does not have to wait for a previous step in the care process to be completed before a patient can be scheduled for the next step. Since the planner of a subsequent step knows in advance when a patient is (or will probably be) scheduled for the preceding step, the planner can schedule the patient's subsequent step shortly after the preceding step. This results in less non-value-adding waiting time for the patient.

Cross-departmental planning has a double effect on flow performance. Firstly, it helps to reduce non-value-adding activities in a similar way as sharing information. Subsequent process steps can be planned closer together as the planner is aware of the planned date of the preceding process step (as this step occurs in the planner's own department). Again the patient has to wait less to be scheduled. More importantly, cross-departmental planning results in a reduction in variability. A planner is able to adapt the case-mix in such a way that different types of patients can be spread throughout the day, week or and/or month. As an example, if orthopedics can schedule patients for pre-assessment then it can spread hip patients (who consume a relatively large amount of OR capacity) evenly across the pre-assessment schedule, resulting in a more even input of hip patients for the OR.

Combined appointments reduce the number of visits a patient needs to make to the hospital. By combining the capacity of several process steps, the number of queues is reduced. A reduction of queues results in less non-value-added activities.

The identification of hospital-specific integration mechanisms and their effects on barriers to flow have led to a revised conceptual model (see Figure 3.9). In this model, two things should be noted: the absence of the term bottlenecks, and the fact that none of the integrative practices except cross-departmental planning contribute to a reduction in variability. Although we continue to believe that bottlenecks are an important barrier to patient flow, we omitted the term from the model because we could not find any theoretical or empirical base to justify a relationship between the integration of planning & control and the removal of bottlenecks. Turning to variability, we had expected to find several examples where information would be shared in order to reduce variability. However, none of the information-sharing practices we found addressed this aspect. It seems that hospitals opt for integrative practices that have a direct effect on patient flow performance. The effects of reducing non-value-added activities (e.g. reducing planning activities or removing queues) are rather intuitive and directly visible on the work floor, whereas the effects of reducing variability are far less intuitive. Jack and Powers (2004) showed that, on a strategic level, hospital try to cope with variability through flexibility strategies. Surprisingly, on a more operational level, we could find little empirical evidence of hospitals trying to reduce variability. Consequently, we would argue that achieving a broader insight into reducing variability in hospital operations is a valuable aim for future research.

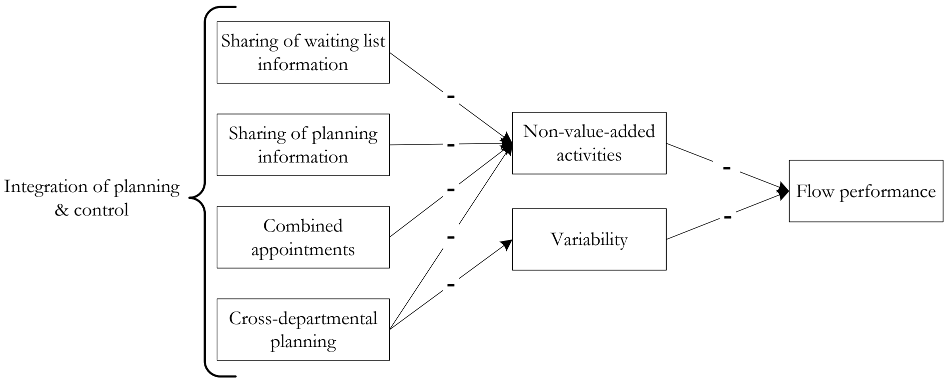



*Figure 3.9: Revised conceptual model*

## 3.6 Conclusions

This chapter has explored the integrative planning & control practices that are used in hospitals, and the effects of these practices on patient flow performance. Although the overall level of integration in the hospitals studied is limited, patient flow performance is significantly better in those that employ more integrative practices. This study contributes through offering a comprehensive view on the integration of planning & control in hospitals. From an internal supply chain perspective, we show that both dyadic initiatives and, although limited in practice, overall integration along an internal chain increase performance in terms of patient flow.

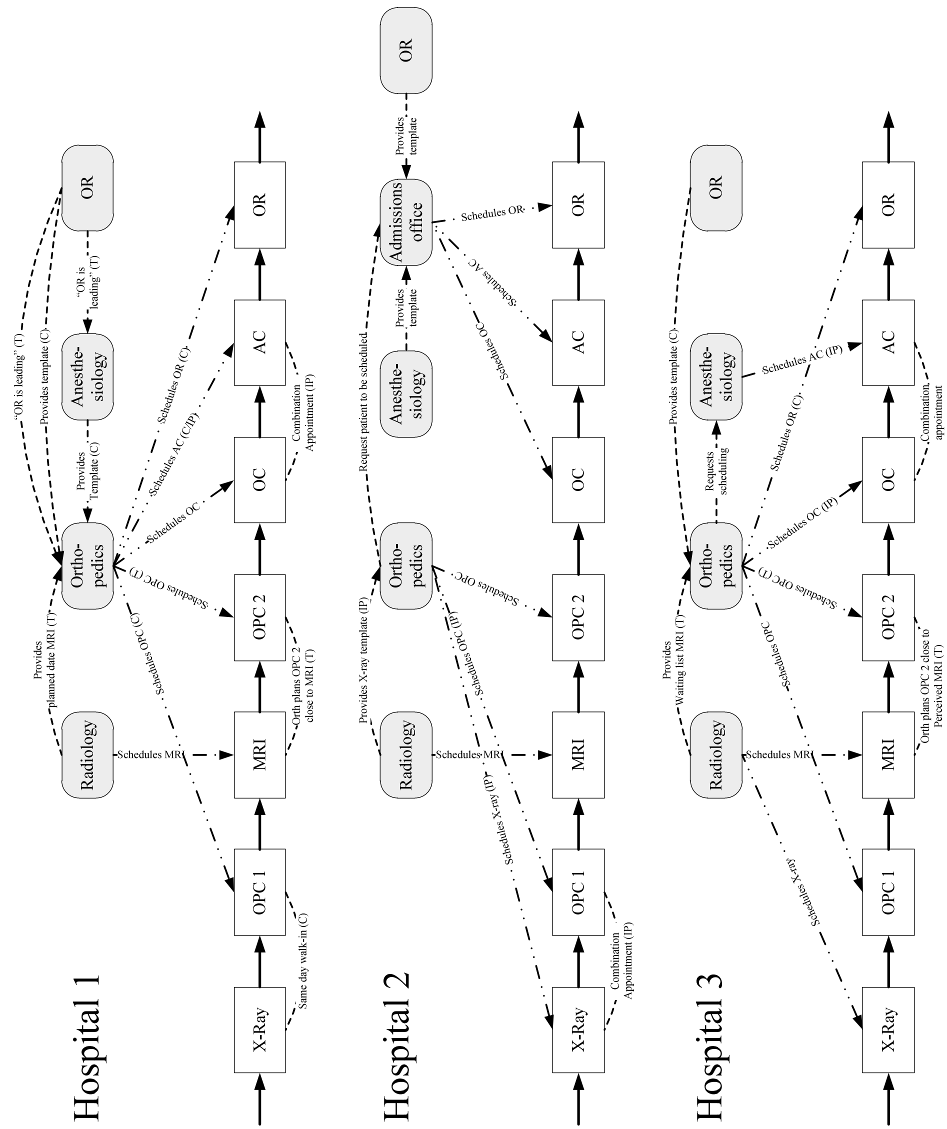
Four integrative mechanisms were identified: sharing waiting list information, sharing planning information, cross-departmental planning, and creating combined appointments. Each of these mechanisms helps by reducing either non-value-added activities or variability in patient flow. Further, we found that hospitals put little effort into reducing variability in their internal supply chains through information sharing.

This study has important implications for hospital administrators and for medical professionals, especially given that improving patient flow has become an important point on the political agenda. Improving flows benefits both hospitals and patients. A faster flow means that patients spend less time in the care process. As a result, a hospital gets reimbursed quicker by insurance companies (reimbursement takes place only after a patient has finished the care process) and less working capital is tied up in patients waiting for treatment. Since uncertainty concerning care processes is an important factor in patient dissatisfaction (Thompson *et al.*, 1996), more integrated planning which reduces uncertainty about patient schedules would boost patient satisfaction. We have shown that integration initiatives help to reduce non-value-added activities and variability. However, given the currently high capacity utilization levels, boosting patient flow performance is highly dependent on being able to reduce variability. Therefore, we would stress to hospital administrators that reducing variability though integration is one of the few options open to them in overcoming the challenges presented in the current healthcare environment.

A limitation of this study is that we focus on only one specialty, and that we did not consider the possible side effects of the observed integrative practices on other specialties. Given that orthopedic supply chains share several resources with other specialties, future research should adopt a broader perspective and include supply chains from different specialties that compete for capacity from the same resources. However, we agree with Vissers and Beech (2005) who warn that including too many hospital supply chains in a single study increases the complexity and makes it less likely that important insights will be discerned. Finally, we should note that the complex nature of hospitals and their care processes makes it difficult to control for all the relevant variables that might influence performance. In this study, we tried to minimize this by choosing straightforward care processes characterized by high volumes, low variety, and low routing variability. However, in future research, it would be valuable to assess the value of integration in internal supply chains with other characteristics such as a high routing variability.

This study focused on how performance is affected *if* integration occurs, and the low degree of integration we found in the hospitals suggests a major theme for further research: *how* can integration be achieved? Pagell (2004) argues that factors such as culture, structure, communication, physical layout, performance measurement, and cross-functional teams are major contributors to integration within manufacturing firms. The optimum degree of integration is also contingent on many business conditions (Van Donk and Van der Vaart, 2004; Das *et al.*, 2006). Further, as contextual factors significantly influence the use and performance of operations management practices (Sousa and Voss, 2008); a healthcare context might pose different, and currently underexposed, barriers and enablers to integration.

# Appendix I: Visual analysis of the orthopedic supply chains



# CHAPTER 4

# 4 Operational antecedents of integrated planning & control in hospitals[4]

The benefits of integrating planning & control functions are well known in manufacturing. However, in hospitals, planning & control is still dispersed over distinct functional departments. We believe that factors stemming from the primary process are key to explaining the fragmented planning seen in hospitals. Consequently, the aim of this study is to explore the operational antecedents to integrating planning & control functions in hospitals. The study is based on a three-hospital multi-case study carried out in the Netherlands. The main findings stem from over forty in-depth interviews with specialists, nurses, planners, and managers of four specialties that are all involved in the orthopedic internal supply chain. Five critical operational factors have been identified as major operational antecedents of integration in hospitals: performance management, information technology, process visibility, uncertainty/variability, and shared resources. This study shows a clear three-way split (initiating, inhibiting, or facilitating) in the role of these operational antecedents, and one that has yet to be clearly distinguished in the literature. This study shows the impact of various operational antecedents recognized in other contexts, and adds two major operational antecedents that are typical in a healthcare context. Contrary to other contributions, integration is addressed here on a detailed level providing a more comprehensive perspective of the inner workings of integration in hospitals. The five operational antecedents found in this study should be considered as essential supplementary factors to the more commonly discussed organizational and behavioral antecedents of integration.

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[4] A condensed version of this chapter was published as Drupsteen, J., Van der Vaart, J.T., and Van Donk, D.P., 2013. Operational antecedents to integration of planning & control in hospitals. Proceedings of the 20th annual EurOMA conference. Dublin, Ireland

## 4.1 Introduction

Both patients and care providers seem to accept waiting as an inevitable part of healthcare. Excessive waiting times are often attributed to a lack of coordination between departments, as in general, appointments are scheduled without considering subsequent steps in the care process that take place within other departments. Various researchers stress that integrating the planning & control functions in hospitals could help address this problem (Vissers and Beech, 2005; Aronsson *et al.*, 2011). While the benefits of an integrated planning & control function are recognized in manufacturing (e.g. Oliva and Watson, 2011), hospitals lag behind in integrating these functions (Cardoen *et al.*, 2010b). However, why hospitals lag behind is not clear.

The majority of studies on integration in hospitals focus on integration in general, rather than on the integration of a specific aspect of the organization, such as planning & control. Consequently, reported antecedents are limited to general organizational and behavioral factors such as organizational culture (Currie and Harvey, 2000), physician autonomy (Pearson *et al.*, 1995), top management support (Currie and Harvey, 2000), and politics (Vos *et al.*, 2009). Little or no attention has been given to those operational antecedents of integration found in a manufacturing context such as layout (Pagell, 2004), performance measurement (Stank *et al.*, 2001b), or shared resources (Van der Vaart and Van Donk, 2004). Given that only a few integrative practices have penetrated clinical operations (Glouberman and Mintzberg, 2001); one can wonder why such operational antecedents have yet to be addressed.

As such, the literature fails to provide insight into those operational factors that influence the integration of planning & control functions in hospitals. We address this gap by investigating integrative practices in hospitals and the operational antecedents that either help or hinder the integration of planning & control. The main thrust of this chapter is that a thorough understanding of the role and effects of these operational antecedents can enhance the integration of planning & control in hospitals. The main question in this study is: which operational antecedents either enable or inhibit the integration of planning &

control functions within hospitals? This question is explored in a multi-case study carried out in three hospitals in the Netherlands.

This study approaches the planning & control of hospital operations from a multistage perspective, rather than the more common single-stage perspective, and contributes to the literature in three ways. First, this study shows the impact of operational antecedents recognized in other contexts, and further adds two major operational antecedents typical of a healthcare context. Second, this study addresses integration on a detailed level providing a more comprehensive understanding of the inner workings of integration in hospitals. Finally, the operational antecedents found in this study are considered as essential additions to the general and organizational antecedents frequently discussed in the literature. The management contribution of this study lies in it addressing *how* integration can be achieved, rather than merely prescribing integration as a means to improve performance.

The chapter is structured as follows. First, the theoretical background section discusses integrating planning & control and then presents a conceptual model based on the reviewed literature on the antecedents of integration. This is followed by an explanation of the case study method used. Through within- and cross- case analyses, we establish the degree of integration for each of the cases studied and identify factors that helped in achieving this degree of integration or hindered further integration. This is followed by a discussion of the results, and concludes with the theoretical and managerial implications of this research.

## 4.2 Theoretical Background

Despite the concepts of both integration and of planning & control being used extensively, no generally accepted definitions exist in their original manufacturing context (e.g. Bertrand *et al.*, 1990; Pagell, 2004). This provides a challenge in using them in a different context such as healthcare. Therefore, in this section, both concepts are defined and placed in a healthcare setting. Further, previously uncovered antecedents of integration are discussed and linked to three stages of integration in order to build a conceptual model that will then guide this study.

### *4.2.1 Integration of planning & control in hospitals*

Planning & control consists of the process of reconciling supply with demand (Slack *et al.*, 2001). This study focuses on the operational level where the planning

& control function of healthcare processes is concerned with the day-to-day activities needed to facilitate patients (Vissers *et al.*, 2001). The most important planning activities on this level are patient scheduling, daily adjusting, and performance monitoring (Peltokorpi, 2011). On this level, cross-departmental coordination is necessary (Vissers *et al.*, 2001) because proper planning should tie key activities in hospitals together (Rhyne and Jupp, 1988). Remarkably, when it comes to planning & control in hospitals, the literature pays little attention to integrating these functions between departments. In fact, most studies only discuss planning issues on the operational level in hospitals, such as capacity management and appointment scheduling, and mainly focus on single-stage systems (White *et al.*, 2011).

As little theory-building has been carried out on integration in hospitals, we rely on research executed in a manufacturing context (e.g. Hayes and Wheelwright, 1984; Frohlich and Westbrook, 2001; Pagell, 2004; Zhao *et al.*, 2011). There is no generally accepted definition of integration (Mendes Primo, 2010), and therefore, we position our research around the central idea of integration: that distinct and interdependent organizational components should constitute a unified whole (Barki and Pinsonneault, 2005). In order to achieve this unified whole, organizations should employ activities and practices that allow functions within an organization to coordinate and cooperate with one another (Braunscheidel *et al.*, 2010).

It is assumed that integration takes place in distinct steps leading from no integration to complete integration (Pagell, 2004). In terms of activities in the planning & control function, Van der Vaart and Van Donk (2004) distinguish three stages of integration:

**Transparency stage**: entities (departments, organizations) only share relevant planning information.
**Commitment and coordination stage**: entities not only share relevant information, but also agree to some mutual commitments (e.g. capacity reservation).
**Integrative planning stage:** the planning & control of at least part of a supply chain is centralized.

In this study, we aim to acquire a comprehensive understanding of the operational antecedents that hinder hospital planners when attempting to reach one or more of these stages by taking more than one process step, department, or specialty into account whilst scheduling, performing daily adjustments, or monitoring performance.

### *4.2.2 Antecedents of integration*

Most studies on integration concentrate on the positive relationship between integration and organizational performance (e.g. Ellinger *et al.*, 2000; Frohlich and Westbrook, 2001; Narasimhan and Das, 2001; Stank *et al.*, 2001a; O'Leary-Kelly and Flores, 2002; Droge *et al.*, 2004; Gimenez and Ventura, 2005; Kim, 2009; Flynn *et al.*, 2010; Leuschner *et al.*, 2013). Less attention is given to those factors that help or hinder integration (Ho *et al.*, 2002). This section discusses such factors in both manufacturing and healthcare contexts.

In uncovering the logistic and supply chain competences of best-in-class companies, Stank *et al.* (2001b) identify eight important drivers of integration: internal support; proper measures; appropriate rewards; proper allocation processes; a long-term performance focus; consolidated product requirements; proper use of technology; and trust. Based on a study of eleven manufacturing companies, Pagell (2004) found that internal integration is directly or indirectly influenced by communication; by cross-functional teams and job rotation; and by performance measurement, plant layout, plant structure, and plant culture. Further, Pagell (2004) proposes that both the use of information technology and support from top management could help internal integration. In constructing a model for organizational integration, Barki and Pinsonneault (2005) consider six coordination mechanisms (standardization of planning, work, outputs, skills and norms, direct supervision, and mutual adjustment) that they believe enable integration. Further, they find that internal integration is severely hindered by specialization due to goal differences and to conflicts stemming from power and political considerations. Finally, Van der Vaart and Van Donk (2004) identify shared resources as an important barrier to the integration of planning & control.

To the best of our knowledge, no research has been conducted in a hospital context that primarily addresses the antecedents of integration. However, some of the work on integrative approaches in healthcare touches upon anteceding factors. A high patient volume (Pearson *et al.*, 1995; Nevers, 2002; Hyer *et al.*, 2009) is one of the main prerequisites for service line management and clinical pathways to be worthwhile. Physician involvement (Pearson *et al.*, 1995; Currie and Harvey, 2000; Nevers, 2002) is an important enabler for most integrative approaches, whereas physician autonomy is seen as a significant inhibitor (Pearson *et al.*, 1995; Vos *et al.*, 2009).

Four categories of antecedents can be identified. As stated earlier, a distinction has to be made between general (organizational & behavioral) antecedents, and operational antecedents. Further, a distinction can be made between antecedents specifically mentioned in a manufacturing context and antecedents in a healthcare context. When categorizing the antecedents discussed in the previous paragraphs, it becomes apparent that little attention has so far been given to operational antecedents in hospitals (the lower right quadrant in Figure 4.1). Given that a patient's care process is the main link between hospital departments, we suspect that a lack of understanding about antecedents that stem directly from this care process could be a reason why integrated planning & control functions are not yet realized in hospitals.

| | | Manufacturing | | | | Healthcare | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Stank *et al.* (2001) | Pagell (2004) | Van der Vaart and Van Donk (2004) | Barki and Pinsonneault (2005) | Pearson *et al.* (1995) | Currie and Harvey (2000) | Nevers (2002) | Vera and Kuntz (2007) | Vos *et al.* (2009) |
| **Organzational & Behavioral** | Communication | | x | | | | | | | |
| | Goal Consensus | | | | x | x | x | x | | x |
| | Job rotation & Cross functional teams | | x | | | | | | | |
| | Organizational culture | | x | | | | | | | |
| | Organizational structure | | x | | | | | | x | |
| | Politics | x | | | x | | | | | x |
| | Specialization | | | | x | | | | | |
| | Support | | x | | | x | x | x | | |
| **Operational** | Shared resources | | | x | | | | | | |
| | Performance management | x | x | | | | | x | | |
| | Volume | | | | | x | | | | |
| | Standardization | x | | | x | x | | | | |
| | Use of Information Technology | x | x | | | | | | | |
| | Facility layout | | x | | | | | | | |

Focal area of this study

*Figure 4.1: A classification of factors influencing integration found in the literature*

### *4.2.3 Connecting operational antecedents to the stages of integration*

The literature provides some guidance when it comes to operational antecedents of integration. Although these antecedents, as well as the integration stages, have little foundation in the healthcare context, we would expect them to be applicable there, but we do not exclude there being other factors that act as antecedents. Based on the literature, we constructed a conceptual model (see Figure 4.2) as the starting point for our empirical exploration. Each of the presumed relationships in Figure 4.2 will be justified below.

Integration requires incorporating and communicating the performance requirements of other links in the chain (Stank *et al.*, 2001b). However, in most hospitals, performance management is fragmented with individual departments focusing on their own targets. Often, the main objective of a hospital department is optimal capacity utilization (Vissers and Beech, 2005). As such, it seems that current hospital performance management largely discourages the final two integration stages as these both require departments to relinquish responsibility for their own capacity utilization.

Shared resources form a barrier to both the commitment and coordination stage and the integrated planning stage. In the transparency stage of integration, internal rules for efficient use of resources can be employed whereas, in the latter two stages, efficient use of capacity becomes determined by external parties (Van der Vaart and Van Donk, 2004).

Volume is widely seen as a prerequisite for effective integration. Especially for 'focused factories' in hospitals, a sufficient volume is required to enable efficient processes (Hyer *et al.*, 2009). Similarly, it is only possible to create critical pathways for high-volume, low-variety patient groups, such as patients needing a total hip replacement. Having high-volume patient groups which are predictable in their routing (i.e. highly standardized treatment) simplifies capacity allocation as there are always patients to fill the capacity, and the next step in their routing is easily predictable. As such, volume and associated standardization would seem to enable the last two stages, whereas low-volume and high variety patient groups will hinder their use.

The uncertainty surrounding many patient groups requires flawless information integration to enable efficient and timely decision-making (Shih *et al.*, 2009) but this might be difficult to achieve given the limitations of enterprise resource planning (ERP) systems in general (Deep *et al.*, 2008). In manufacturing, information technology such as ERP systems is considered an enabler of integration (Narasimhan and Kim, 2001; Stank *et al.*, 2001b). Similarly, Van Merode *et al.* (2004) state that "integrated hospitals need a central planning & control system to plan patients' processes and the required capacity". Most contemporary hospital information systems do allow information exchange and capacity allocation (Haas and Kuhn, 2012) and, therefore, it appears that hospitals have the information technology needed to enable all three stages of integration.

Pagell (2004) reasons that layouts that allow managers from different functional areas to communicate informally will increase integration in manufacturing plants. Accepting this rationale, the facility layout becomes a potential enabler of the transparency stage. However, hospitals are generally laid out in a highly functional manner (Butler *et al.*, 1992), thus allowing little informal information sharing. The literature provides little insight into how a hospital's layout might influence the two other integration stages.

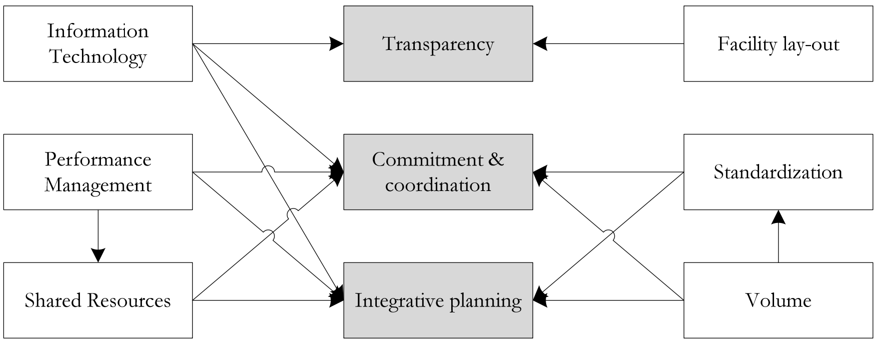


*Figure 4.2: Operational antecedents of the integration of planning & control in hospitals based on literature*

## 4.3 Methodology

As argued in the previous sections, how integration can be achieved, and what operational antecedents help or hinder the integration of planning & control functions, in hospitals is under-researched. As our study focuses on operational antecedents that are derived from a non-healthcare setting, and thus have little foundation in the healthcare setting, we believe that a case study approach is the most appropriate for our endeavor. A case study method is also particularly suitable when studying phenomena in complex contexts (Stuart *et al.*, 2002). A multi-case study approach was chosen as this tends to produce more compelling evidence than single cases (Yin, 2003). Further, the use of multiple cases increases the external validity of the research (Voss *et al.*, 2002).

### *4.3.1 Research setting*

As with most hospitals in the Netherlands, the three case-study hospitals are privately owned not-for-profit foundations. They offer a full range of services (outpatient clinic, inpatient clinic, emergency room (ER), intensive care unit (ICU), etc.) and include all medical specialties. Medical specialists can be employed by a hospital but, as is more common in the Netherlands, medical specialists in the three case hospitals are self-employed and organized as a specialist partnership. These specialist partnerships work in the hospital and depend on the hospital's resources, but they are not employed by the hospital. Despite their independent status, these specialist partnerships do have contractual obligations to the hospital and representatives of specialist partnerships often report directly to the hospital's board.

A hospital department covers both the outpatient and inpatient services for a specific specialty. Although technically, the medical specialists are an autonomous organizational entity, they are considered part of the department. Often, departments have nurses who are dedicated either to the clinic (inpatients) or to outpatient services. Wards are often shared with several other specialty departments. The ER and ICU are considered as autonomous departments. The same is true for supporting specialties such as Anesthesiology and Radiology. In the Dutch healthcare system, diagnostics are categorized as secondary care. This means that patients require a doctor's referral to obtain an X-ray or a magnetic resonance image (MRI). Unlike in many countries, there are hardly any dedicated or free-standing outpatient clinics providing diagnostic services.

Approximately 80% of hospitals' income flows through health insurance companies that are funded by all citizens through income tax and mandatory health insurance (VvAA, 2010). Health insurance for regular medical treatment is obligatory. The system is operated by private health insurance companies that are obliged to accept all residents within their area of activity. Long-term treatments (such as for chronic illnesses) are covered by a state-controlled mandatory insurance. The Dutch health authority sets an annual limit on healthcare costs and, within this limit, insurance companies and healthcare providers can maneuver their production agreements. To some extent, these production agreements shape the volume and case-mix of care provided to patients in each hospital.

### *4.3.2 Case selection*

This study is conducted within three general hospitals and data on each of the hospitals is provided in Table 4.1. Based on Miles and Huberman (1994) we selected an extreme case and two typical cases. Hospital 1 can be seen as a best-in-class case, as it has been one of the top hospitals in the Netherlands, Hospitals 2 and 3 are regarded typical cases. All three hospitals are viewed as performing well both financially and in terms of care quality, as can be derived from publicly available sources. We deliberately excluded university hospitals from our sample as they often function as teaching hospitals and daily practices could be distorted to accommodate teaching obligations.

*Table 4.1: Case hospital characteristics*

| Hospital | Type | Beds* | FTE employees* | Specialties | Patients treated per year* | Interview subjects | |
|---|---|---|---|---|---|---|---|
| Hospital 1 | Regional | 280 | 850 | 31 | 100,000 | Orthopedics | 5 |
| | | | | | | Radiology | 3 |
| | | | | | | Anesthesiology | 2 |
| | | | | | | OR | 2 |
| Hospital 2 | Regional | 580 | 1950 | 29 | 200,000 | Orthopedics | 5 |
| | | | | | | Radiology | 3 |
| | | | | | | Anesthesiology | 2 |
| | | | | | | OR | 3 |
| Hospital 3 | Regional | 620 | 2500 | 34 | 210,000 | Orthopedics | 4 |
| | | | | | | Radiology | 7 |
| | | | | | | Anesthesiology | 3 |
| | | | | | | OR | 2 |

* Approximate

The unit of analysis within this study is the orthopedics supply chain. We selected our cases based on theoretical criteria rather than statistical criteria (Eisenhardt, 1989; Yin, 2003). We expected that an internal supply chain with a relatively high patient volume and both low variety and low uncertainty would be most likely to have adopted integrative practices. On this basis, the orthopedics supply chain was selected because of its stable nature. Each of the orthopedic supply chains studied consists of four key departments that all execute activities linked to the patient's care process. These departments are Orthopedics, Radiology, Anesthesiology, and the Operating Room (OR).

### *4.3.3 Data Sources*

Our study is built on four separate sources of data: structured interviews with subjects from each department in the orthopedic supply chain; archival data such as annual reports; quantitative data from the hospital information system; and observational data. Data were collected between July 2010 and December 2010, with several visits to each of the hospitals. By triangulating multiple data sources, a stronger foundation is created for the findings (Benbasat *et al.*, 1987; Eisenhardt, 1989; Yin, 2003). Each of the data sources is now discussed briefly.

The intention of the interviews was to understand the role of each of the subjects in the internal supply chain and to document their perspectives on factors that helped to achieve the current level of integration, or hindered further integration, of planning & control functions in their internal supply chain. All the interviews followed an interview protocol (Appendix 1) consisting of 29 questions concerning integration in general, the relationships between each of the departments, the flow of information, the planning & control of patients, and the measurement of performance. The interview protocol was based on several existing questionnaires and constructs concerning internal integration (Lawrence and Hottenstein, 1995; Ahmad and Schroeder, 2001; Prahinski and Benton, 2004; Pagell, 2004; Benton and Maloni, 2005) and adapted to fit the healthcare setting. In total, 41 subjects were interviewed. The interviews lasted between forty-five minutes and two hours, with the average duration approximately one hour. In each department, we interviewed at least one person responsible for the planning (i.e. planner or secretary), at least one person responsible for daily management (i.e. manager or head nurse), and at least one person responsible for executing patient-related activities (i.e. physician, technician, or nurse) in order to ensure a multifaceted view on integration. Several subjects performed roles in several functional departments and so could respond on more than one of the responsibilities we were interested in. Table 4.1 displays the number of subjects interviewed in each hospital. Several documents were used to corroborate the data gathered from our interviews. We used the contents of annual reports, planning sheets, and performance agreements. During the hospital visits, interactions and communications among different functional departments were observed, and this observational data used to strengthen the information gathered from the interviews, documents, and information system.

In order to reconstruct the orthopedic internal supply chain, we used quantitative data from the hospital information system made up of case-mix data based on the Dutch DBC (Diagnosis Treatment Combination) system. Unlike diagnosis-related groups (DRGs), the DBC system is episode based, registering each episode / activity performed within the hospital from first outpatient clinic visit to clinical discharge (Steinbusch *et al.*, 2007).

### *4.3.4 Data Analysis*

Both within-case and cross-case analyses of the data were employed. The within-case analysis was used to establish the degree of integration present at each hospital by classifying the observed integrative practices in terms of the three consecutive integration stages (Van der Vaart and Van Donk, 2004). This classification was based on the subjects' descriptions of current planning & control activities as performed by their department. Questions 3, 4, 5, 18, and 20 (see Appendix 1) of our interview protocol provided information enabling this classification. We used visual maps (Langley, 1999) of the integrative practices to gain a clear impression of which integrative practices were employed in each of the hospitals. The visual maps were checked by several subjects in feedback sessions, and any suggestions for alterations were incorporated in the final visual maps.

The second part of our investigation, the cross-case analysis, complements the insights from the within-case analysis by determining which operational antecedents lead to a specific stage of integration, and which hinder further integration. In establishing antecedents that helped or hindered the current degree of integration, we mainly relied on answers to questions 6, 7, 8, 9, 19, and 21 of our interview protocol. All the interviews were audio recorded and were transcribed into an explanatory effects matrix since this helps to trace back emerging trends of causality (Miles and Huberman, 1994). Further, an explanatory effects matrix provides a clear overview of which antecedents are most frequently mentioned as important. Based on this frequency, we identify the most important antecedents for further discussion.

## 4.4 Integrative practices: a within-case analysis

First, we evaluate the integrative practices used in each case. The analysis focuses on assessing the degree of integration at each hospital by classifying the observed integrative practices based on the stages defined by Van der Vaart and Van Donk, (2004).

### *4.4.1 Case hospital 1*

Hospital 1 is a relatively small hospital with a catchment area containing approximately 110,000 potential patients. The hospital has three divisions: surgical care, medical care (including diagnostic and supporting specialties), and facilities. The orthopedics department comes under surgical care. The four orthopedic surgeons treat approximately 7200 (surgical and non-invasive) patients per year.

In this hospital's orthopedic supply chain, we found seven integrative practices. Three of these can be characterized as a form of transparency, two are forms of commitment and coordination, and two are manifestations of integrated planning. Integration in Hospital 1 is mainly dyadic (as can be seen in Table 4.2), and there is no planning & control function that monitors the complete internal supply chain.

### *4.4.2 Case hospital 2*

Hospital 2 is a medium-sized hospital providing care to a large regional area. The hospital has 31 responsibility centers that are mainly based on a specialization. Orthopedics, Radiology, and Anesthesiology constitute separate responsibility centers. The OR, the fourth functional department in the chain, is part of the Perioperative Care responsibility center. All activities, whether considered pre-, per-, or post- surgery are merged in this center. Six orthopedic surgeons work within the orthopedics department and they treat approximately 8500 (surgical and non-invasive) patients annually.

Three integrative practices were found in Hospital 2, each representing a different stage of integration (as can be seen in Table 4.3). Two of the three integrative practices span more than two departments. Information sharing in Hospital 2 seems somewhat of a one-way affair: Orthopedics provides information, but doubts if others use it and they receive little information in return. Cross-departmental planning was found in one instance where appointments were combined throughout the care process for a group of specific meniscus patients.

### *4.4.3 Case hospital 3*

Hospital 3 is the largest of the three hospitals. Care in Hospital 3 is organized in twelve centers. Each center focuses on a specific category of patient. The centers are chaired by a center manager and a mandated specialist. A center combines both the inpatient and the outpatient clinics. Orthopedics and the Operating Room are located within one center whereas Anesthesiology and Radiology are separate centers. In total, six orthopedic surgeons work within the orthopedics center. Annually approximately 9600 (surgical and non-invasive) patients pass through the orthopedic supply chain.

Five integrative practices could be distinguished in Hospital 3, all of which were dyadic (as shown in Table 4.4). Two practices consist of information sharing, one of cross-departmental planning, and two involve combining appointments.

When considering the degree of integration in the three hospitals, we can see clear evidence of all three stages being applied. The transparency stage is apparent in the sharing of planning information between departments and the sharing of waiting list information between departments. Cross-departmental scheduling is the sole manifestation of the commitment & coordination stage, and evidence of the integrative planning stage can only be found in combined appointments. Which factors lead to the current degree of integration, and which factors have hindered further integration will be discussed in the next section.

*Table 4.2: Degree of integration in Hospital 1*

| Integrating Practice | Type | Stage (Van der Vaart & Van Donk, 2004) | Informant's Quote | Informant - Department |
|---|---|---|---|---|
| Planned MRI date is shared with Orthopedics so that an appointment to discuss the results can be planned near to the planned MRI date | Sharing of information | Transparency | We send the letter with the planned MRI data to orthopedics, and they add a latter appointment to discuss the results to this letter [before it is sent to the patient]. | Technician Radiology |
| Pre-assessment waiting list time is shared with Orthopedics | Sharing of information | Transparency | Officially we do not plan an OR appointment for a patient without a pre-assessment; however this often takes too long and therefore we do. In doing so, we take the pre-assessment waiting list into account. | Planner Orthopedics |
| The leading role of the OR master plan is communicated throughout the supply chain | Sharing of information | Transparency | It's designed in such a way that everyone is "forced" to make it happen, everyone has to participate, it's a team effort. | Planner OR Planning |
| | | | The OR is situated in the center of the network … this is the spot where the money is made …and that is why we communicate that the OR is leading. | Manager OR Planning |
| | | | The pre-assessment template is fully based on the OR master plan. | Planner Anesthesiology |
| Orthopedics schedules pre-assessment appointments | Cross departmental scheduling | Commitment & Coordination | By sequencing the pre-assessments for the orthopedic patients in a specific way, the OR case-mix ready can be influenced. | Logistics Manager |
| Orthopedics schedules OR appointments | Cross departmental scheduling | Commitment & Coordination | The OR releases the template for a specific month, and Orthopedics can then enter their patients. | Planner Orthopedics |
| Orthopedic and Anesthesiologic parts of the pre-assessment are combined | Combining appointments | Integrative Planning | We've combined the Orthopedic and Anesthesiologic parts of the pre-assessment so that patients only have to visit the hospital once for two appointments. | Nurse practitioner Orthopedics |
| Patients can walk in for an X-ray just before their appointment with Orthopedics | Combining appointments | Integrative Planning | We tell the patients to visit the X-ray department 30 minutes before their appointment with Orthopedics | Secretary Orthopedics |

*Table 4.3: Degree of Integration in Hospital 2*

| Integrative Practice | Type | Stage (Van der Vaart & Van Donk, 2004) | Informant's Quote | Informant - Department |
|---|---|---|---|---|
| Orthopedics shares the main planning information with dependent departments | Sharing information | Transparency | I share important planning information with the other departments; however, I very much doubt if anyone is using this information and I get no information in return. | Planner Orthopedics |
| Orthopedics schedules a patient's X-ray appointment so that it is just before their appointment with Orthopedics | Cross departmental scheduling | Commitment & Coordination | We can schedule all our required x-rays ourselves … If we couldn't plan ourselves, it would be much more difficult for us, we would be to much dependent on the scheduling of Radiology … This saves time and the patients like it. | Secretary Orthopedics |
| For a small distinct group, a three-week lead-time guarantee is provided | Combined appointments | Integrative Planning | We have some preferred care paths where we have made a performance commitment to an insurance company. In this path, several appointments are combined and the patient has to be operated upon within three weeks. | Surgeon Orthopedics |

*Table 4.4: Degree of integration in Hospital 3*

| Integrative Practice | Type | Stage (Van der Vaart & Van Donk, 2004) | Informant's Quote | Informant - Department |
|---|---|---|---|---|
| MRI waiting list information is shared so Orthopedics can anticipate on this in planning the appointment to discuss the results | Sharing information | Transparency | We request an MRI and simultaneously we schedule an appointment to discuss the results. This appointment is scheduled 3 - 4 weeks from now, depending on the waiting list for the MRI. | Planner Orthopedics |
| Pre-assessment planned date is shared with Orthopedics | Sharing information | Transparency | We find out when the patient is scheduled for the pre-assessment and we schedule an OR appointment in the next open slot. | Planner Orthopedics |
| Orthopedics schedules OR appointments | Cross-departmental scheduling | Commitment & Coordination | Orthopedics schedules the OR activities. | Planner Preassessment |
| | | | OR provides a template every six weeks for the OR to schedule in appointments. | Manager OR Planning |
| Orthopedics schedules pre-assessment appointments | Combining appointments | Integrative Planning | Orthopedics schedules the actual pre-assessment … we've reserved slots for Orthopedics. | Planner Preassessment |
| Orthopedic and Anesthesiologic parts of the pre-assessment are combined | Combining appointments | Integrative Planning | To convenience patients, we enable them to come only once to the hospital … it used to be up to six times. | Nurse Orthopedics |

## 4.5 Antecedents of integration: a cross-case analysis

When making a cross-case comparison, a pattern of antecedents emerges which helps to explain the current degree of integration in hospitals. As expected, our findings do not fully match the initial conceptualization presented in Figure 4.2. An analysis of the interview data revealed that some of the antecedents mentioned in the literature were not seen as important by the subjects, whereas other antecedents that were deemed as important had not emerged from our literature review. After assessing the explanatory effects matrix, five critical operational factors were identified as major operational antecedents of integration in hospitals: performance management, information technology, process visibility, uncertainty/variability, and shared resources.

### *4.5.1 Performance management*

All three hospitals show a compartmentalized approach to performance management. Each department is responsible for its own performance and gives little consideration to the performance of other departments, or indeed of the hospital as a whole. This is reflected in terms such as 'internally focused' and 'silo-mentality' used by our subjects in discussing how the compartmentalized approach to performance management hinders integration:

> *Hospital Manager (1):* The hospital is divided in pillars, and each pillar is responsible for its own results. Departments should focus on total performance rather than local.
> *Manager Orthopedics (2):* I've noticed that we're internally focused.
> *Unit manager Preassessment (2):* The silo-mentality is maintained because we're responsible for our own part of the process and not for the total process.
> *Team manager Radiology (3):* You try to run your own department as efficiently as possible and finding the link with other departments has never been stimulated.
> *Unit manager Orthopedics (2):* Only being responsible for a part of the process hinders integration.

A symptom of the compartmentalized approach to performance management is the absence of performance measurement based on lead-times. None of the hospitals monitored the lead-times from beginning to end of a care process, and subjects in both Hospitals 1 and 2 acknowledged that performance management lacks common goals, feedback loops, and proper measures concerning patient lead-time performance:

> *Manager Radiology (1):* If you are unaware of a lead-time requirement, you cannot manage lead-time performance.

*Manager OR (1):* There's no intentional control of lead times.
*Manager Anesthesiology (3):* I don't receive feedback in the form of lead-time-related performance information.
*Manager Radiology (1):* We do not monitor a patient's entire care process.
*Manager Orthopedics (2):* We do have a norm (for lead times), but we lack proper measurement or measures.
*Team manager Radiology (2):* We do not monitor the whole care process of a patient.
*Unit manager Preassessment (2):* We do not monitor the whole care process of a patient.

In all three hospitals, subjects stressed the fragmented approach to performance management. It was suggested that an orchestrator, to monitor and manage a patient's progress throughout the care process, would be greatly beneficial in implementing lead-time-driven performance management. Orthopedics, as the gateway specialty, is suggested as appropriate for this orchestrating role as it is the main link between the patient and the hospital:

*Planner Orthopedics (2):* If orthopedics could plan its own patients for the other departments, we could have much more patient-friendly planning.
*Anesthesiologist (1):* What we miss is a coordinator for the entire perioperative process.
*Manager Anesthesiology (3):* As long as no one is responsible for care paths, their performance will not be monitored.

The interview data reveal that the main driver for implementing integrative practices is improved performance. The improvements that hospitals are seeking relate to either a reduction in patient waiting time or a need to comply with the lead-time requirements imposed by insurers or the government:

*Nurse Practitioner (1):* We've combined the orthopedic and anesthesiology parts of the preassessment so that patients only have to visit the hospital once for two appointments.
*Orthopedic surgeon (2):* We've some preferred care paths where we have made a performance commitment to an insurance company. In this path, several appointments are combined and the patient has to be operated upon within three weeks.
*Nurse (3):* Patients only come once to the hospital … it used to be up to six times.

Given the local focus in performance management, most departments have a disincentive to share information or to relinquish control over part of their capacity (and therefore, lower their self-performance control) to other departments.

### *4.5.2 Information Technology*

Most integrative practices highlighted in the within-case analyses rely on the functionalities available in the hospital information system. All three integration stages seem to be facilitated by the hospital information system. The hospital information system helps in accessing planning information and waiting list information from other departments, it provides access to the planning templates of other departments, and it helps in scheduling combined appointments on a single day with as little time as possible between the appointments:

> *Hospital manager (1):* The information system is a facilitating factor in the cooperation between the different departments.
> *Secretary Radiology (1):* This is the ideal situation, everything is digital and all information is in the system.
> *Manager Radiology (2):* The information system helps to plan time slots for patients in multiple departments.
> *Team manager Radiology (2):* Data exchange between the Radiology System and the Hospital Information System works well.
> *Planner Preassessment (3):* In the event of combined appointments, the system shows us all the scheduled appointments.

Hospital 3 subjects were negative about the contribution of their information technology to integration: an outdated planning system allows little digital interaction between departments in several stages of the internal supply chain. Most informants involved in these stages recognized the limitations that their system imposed on integration. A second complication is that even though orthopedics is technically able to access radiology's planning, the complex coding of procedures and the non-graphical interface make integrative efforts difficult:

> *Orthopedic surgeon (3):* We don't have an automated waiting list, most lists are manually generated.
> *Technologist (3):* We've got a very rigid planning system; a new system should create much greater transparency.
> *Team manager Radiology (3):* Others cannot plan within our system due to the complex coding of requests in our system.
> *Team manager OR (3):* We lack an adequate system. … We should use IT much more to generate automated care paths; this would make a tremendous difference.

Our data suggest that the role of the hospital information system is critical for integrative practices to be effective in each stage of integration. The absence of a supportive hospital information system clearly hinders hospitals in shifting from functioning as isolated silos toward integrated processes.

### *4.5.3 Process visibility*

Due to the functional division of work in hospitals, process steps are often spatially separated because they are performed within different departments. Moreover, most process steps in hospitals inherently take place behind closed doors. Therefore, contrary to many manufacturing processes, there is no visual flow of patients, and the actual process is difficult to deduce from all the separate process steps. Our data reveal that process visibility is very low in all three hospitals. This is characterized by the subjects' lack of knowledge of the overall process and of the contributions each department makes to this overall process:

*Technologist (1):* There is a lack of understanding, not everyone is aware of others' procedures.
*Unit manager Preassessment (2):* Each (actor) contributes to their part (of the process) and is unfamiliar with the contributions of others.
*Unit manager Orthopedics (3):* Currently, the process is unclear for most of the people involved.

This lack of clarity about the process is recognized as problematic by most informants. In all three hospitals, informants stated a desire to increase process visibility in order to gain better understanding of the process:

*Planner OR (1):* It would be nice to discuss with other departments why things work the way they do in our department.
*Orthopedic surgeon (2):* We should all explain our processes and elaborate on why they work the way they do.
*Planner Preassessment (3):* I think it is of major importance that we know what's going on in other departments.

Low process visibility is accompanied by limited knowledge regarding the consequences of one's own department's decisions on the planning & control processes of other departments. Lack of awareness, rather than unwillingness to share relevant planning information, seems a barrier to achieving the transparency stage of integration. One simply does not know which information is relevant and/or available:

*Manager Radiology (1):* I would like to sit down with everyone to discuss the patients' routings and to identify bottlenecks in the process.
*Planner OR (2):* One has very little knowledge and insight into the inner workings of other departments, especially concerning the criteria they use in their planning.

Our study shows that this low process visibility is a severe barrier to internal integration. With the narrow view of all departments, there is little motivation or possibility to take other departments' processes into account. Sources of delay and/or of variability that stem from a specific department are obscured from other departments.

### *4.5.4 Uncertainty / Variability*

The uncertainty found in the three case hospitals mainly relates to the routing of patients. Only after diagnosis can the care process for a patient be determined. Consequently, the steps up until the diagnosis are decoupled from the steps after it. Informants stated that this type of uncertainty is a barrier to cross-departmental planning and especially to combining appointments:

> *Secretary Radiology (1):* At the beginning of a care process, we cannot by default plan a pre-assessment for every patient as we do not know whether they're going to need one.
> *Manager Orthopedics (2):* Uncertainty is a barrier to integration; the way a care path continues depends completely on the diagnosis part of the care process.
> *Planner Orthopedics (3):* Care paths vary and we don't have figures on how.
> *Anesthesiologist (3):* The course of a care process is not very predictable.

Similar to routing uncertainty, informants also see demand variability (originating from either internal or external demands) as a barrier to both cross-departmental planning and combined appointments:

> *Manager OR (1):* You cannot control your input. One day, four patients need surgery, the next day fourteen. It's impossible to design a one-stop shop for this.
> *Technologist (3):* One day, ten out of thirty patients require an x-ray, the next day every patient.

Although routing uncertainty and demand variability are relatively low in the orthopedics department, our data still suggest that they both form barriers to adopting the final two integration stages as it is very difficult to commit capacity. There is no evidence that these aspects form a barrier to achieving the transparency stage.

### *4.5.5 Shared resources*

The orthopedics supply chain shares several resources (including diagnostic equipment in the radiology department, the anesthesiologists, and the OR) with other supply chains or other groups of patients. For departments requesting such resources, a set amount of allocated capacity would enable them to integrate planning & control. However, for the supplying department, capacity allocation decisions can become complex, especially when high resource utilization is required:

> *Manager Radiology (2):* One has to consider which paths cross in our (radiology) planning. Allowing dedicated time slots in the MRI planning for specific specialties would create very rigid planning.

> *Manager Orthopedics (3):* Shared resources often form a bottleneck. X-ray, for example, crosses each silo. With those kinds of departments, we have to make different agreements than we do with the silos.
> *Secretary Radiology (3):* With well-defined care paths, we (Radiology) would be put on the spot. We would have to adapt to all those paths' requirements, which will be a difficult planning puzzle.

Hospital 2 has experience of using the 'focused factory' concept for specific types of orthopedic procedure. Focused factories do not share resources:

> *Orthopedic surgeon (2):* Preferably, one wants to work with dedicated personnel but we have to share facilitating departments with many others. A focused factory might be the solution.
> *Manager Orthopedics (2):* A dedicated pre-assessment for orthopedics is preferable. … We have a separate clinic in which we only work with dedicated resources, this makes planning a lot more efficient.

Shared resources, especially in an environment which emphasizes local performance, hinder integrative practices which involve relinquishing control over capacity (and thus control over performance) to other departments. As a consequence, shared resources hinder both the commitment and coordination stage and the integrative planning stage.

## 4.6 Discussion

Overall, our findings are consistent with the presupposed relationships based on the disparate literature. However, we also came across some notable and/or unexpected outcomes. First, the antecedents found in this study differ from the ones depicted in the initial model. Second, we found a three-way split in the roles of operational antecedents, an aspect that is not clearly distinguished in the literature. We illustrate each category in this split by discussing the recurring antecedents. The outcomes of our empirical investigation have given rise to some alterations to the original model (Figure 4.2) and result in the following model of operational antecedents (see Figure 4.3).

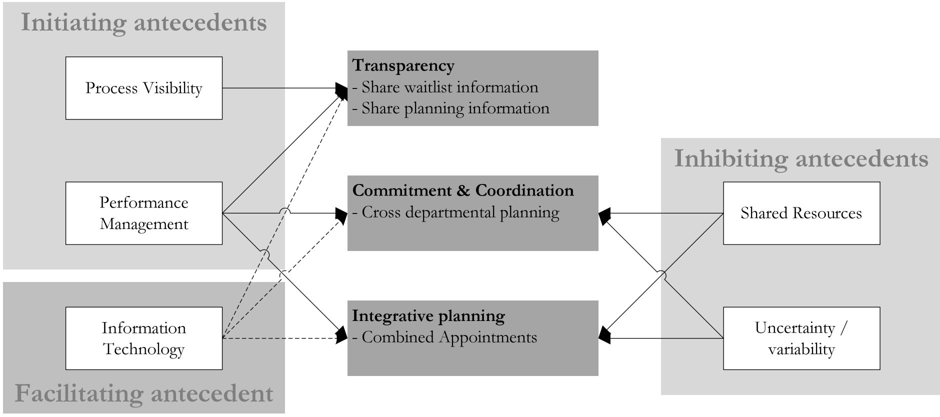


*Figure 4.3: Revised model of antecedents of the integration of planning & control functions in hospitals*

### 4.6.1 Operational antecedents of integration in hospitals

The cross-case analysis revealed some antecedents of integration that had not previously been reported in the literature. Conversely, some of the antecedents depicted in the initial model did not appear to play a role in the three hospitals used in the multiple case study.

First, the *volume* construct was not mentioned by any our subjects. This can be explained by the fact that those earlier studies that did report volume as an antecedent seemed to be focusing on situations where a separate service line was created for a specific group of patients. As such, volume is not so much a prerequisite for integration but a necessary condition for the viability of physically isolated resources.

The second construct that has been excluded from the revised model is *standardization*. Standardization can be considered as a specific way to counter uncertainty and variability. However, in hospitals, there are many strategies to cope with *uncertainty and variability* (Jack and Powers, 2004) and, therefore, we chose to include the cause (*uncertainty and variability*) in our model, rather than a specific solution (*standardization*). Despite the orthopedic chains assessed in this study displaying relatively low degrees of uncertainty compared with other hospital chains, the routing of patients is not always known in advance. All three hospitals indicated that routing uncertainty was one of the reasons why not all the departments involved were integrated: one simply does not know in advance which departments to include. Allocating capacity under conditions of uncertainty and variability is undesirable as low resource utilization might result. Both cross-departmental planning and combined appointments would require executing departments to allocate capacity to requesting departments.

The third and last construct excluded from the revised model is *layout*. None of the subjects mentioned the functional layout as particularly problematic. A lack of *process visibility* might explain why subjects did not mention functional layout as an antecedent of integrated planning & control. Therefore, instead of layout, process visibility is included in our model.

Process visibility seems to play a major role in the integration of planning & control in hospitals. Many informants from all three hospitals indicated that the lack of process visibility was a major issue for them. Buchanan (1998) noted that it was not common for hospital staff involved in a process step to communicate relevant information to staff involved in preceding or subsequent process steps. Our study suggests that low process visibility results in staff being unaware of what planning information would or could be relevant for staff or departments involved in other process steps. The same is true for information available in other departments that would be relevant for their own planning. Barratt and Oke (2007) suggest that information-sharing leads to visibility rather than the other way around. These two facets result in a vicious cycle where not sharing information results in low visibility, which results in not sharing information. Proper process mapping might be a first step in breaking this vicious cycle. Such mappings would provide insight into the relationships between the different functions involved, and in the different steps, and could be used to manage the coordination and cooperation of those performing tasks (Staccini *et al.*, 2005). Understanding at least the basic processes of adjacent departments in the care process would help staff to appreciate the information required for planning the flow of patients between departments.

### *4.6.2 Operational antecedents: a three-way split*

The literature is cautious about attributing specific roles to specific antecedents and there is no clear logic classifying the roles of antecedents in integration. From our empirical findings, we found a clear three-way split in the role of operational antecedents.

First, we were able to distinguish ***initiating*** antecedents, ones that should be encouraged in practice. Process visibility is a clear initiating factor since with no understanding of the processes and steps involved there is no trigger for integration. Another initiating antecedent is integral performance management, As in manufacturing, a shift from local performance management to integral performance management (Stank *et al.*, 2001b) would provide opportunities and incentives for integration. The integrative practices employed in the case hospitals mainly stemmed from an emphasis on overall lead-time performance. An emphasis on the performance of the entire process results in hospitals acknowledging the importance of integration. While integral performance management is promoted by the literature, most hospitals still employ departmental performance management, hindering all stages of integration. These findings reflect the traditional emphasis in hospitals on resource utilization (Vissers and Beech, 2005). Although some studies take other performance measures, such as length of stay (e.g. Hashimoto *et al.*, 2000; McDermott and Stock, 2007; Devaraj *et al.*, 2013) and waiting times (Siciliani and Hurst, 2005; Willcox *et al.*, 2007; White *et al.*, 2011), into consideration, it seems that in both academic circles and in practice few measures exist that can monitor a care process from first contact to discharge.

Second, a category of antecedents that clearly ***inhibit*** integration is distinguished. Often these antecedents are inherent to the care process and need to be addressed in order to achieve integration. As discussed above, uncertainty and variability hinder integration to a large extent. The same is true for the wide usage of shared resources in hospitals. As in manufacturing contexts, shared resources were found to be a major barrier to cross-departmental planning and combining appointments. In practice, dedicated time slots are used to allocate shared resource capacity (e.g. Green *et al.*, 2006; Day *et al.*, 2010) in an attempt to balance resource utilization with the required service level. From a resource utilization perspective, this reluctance of departments to allocate capacity to a specific user is understandable. The emphasis on resource utilization in hospitals makes it difficult for the supplier of shared resource capacity to achieve their own performance requirements while at the same time providing an agreed level of service to the various users of the shared resource.

Finally, we distinguish a third category of antecedents that ***facilitate*** integration. Since most integrative practices are dependent on IT but not triggered by it, IT seems better viewed as facilitating rather than as initiating or inhibiting. The use of IT in hospitals does result in the better coordination of patient flows (Devaraj *et al.*, 2013), and an increased emphasis on IT is critical to improving process integration (Narayanan *et al.*, 2011). However, simply automating existing processes is unlikely to optimize the benefits of IT (Devaraj *et al.*, 2013). Van Merode *et al.* (2004) emphasize the importance of an information system to integrated hospitals, and our data show that the functionalities generally available in a hospital information system are crucial for executing integrative practices in all three categories. Research suggests that IT on its own does not advance integration in industry (Pagell, 2004), and our data suggest this is also the case in hospitals.

## 4.7 Conclusions

This study has explored the operational antecedents of integrating planning & control functions in hospitals. Three theoretical contributions stemmed from analyzing current integrative practices and their operational antecedents.

First, in this study, the planning & control of hospital operations was approached from a multistage perspective, rather than the single-stage perspective commonly seen in the literature. Building on the ideas of Pagell (2004), Van der Vaart and Van Donk (2004), Barki and Pinsonneault (2005), and Braunscheidel *et al.* (2010), this study has used the concept of supply chain integration as a theoretical lens and shows that existing knowledge on integration can be transformed to a healthcare context. In addition to demonstrating the relevance of operational antecedents previously revealed in other contexts, this study adds two major operational antecedents (uncertainty/variability and process visibility) uncovered within a healthcare context.

Second, this study contributes to the literature by offering a more detailed perspective on integration in hospitals. In contrast with earlier contributions, the effects of antecedents on the different stages of integration, rather than on integration as a whole, are assessed. By adopting this level of detail, this study offers a novel and more comprehensive perspective on integrating planning & control activities in hospitals.

Third, unlike in earlier contributions, operational rather than organizational antecedents were explored. This study has demonstrated that antecedents stemming from the primary process can explain why hospitals lag behind other organizations in integrating their planning & control functions. Naturally, organizational and behavioral antecedents, such as top management commitment, organizational culture, and communications, remain of importance. Nevertheless, the five antecedents found in this study (performance management, information technology, process visibility, uncertainty/variability, and shared resources) have to be considered as essential additions to these more general antecedents.

The management contribution of this chapter lies in addressing the issue of *how* integration can be achieved, rather than just prescribing integration as a means to improve performance. The antecedents discussed in this study could help explain the success or potential failure of process-based approaches such as focused factories and service lines (e.g. Pearson *et al.*, 1995; Hyer *et al.*, 2009; Vos *et al.*, 2009). It can help practitioners understand which antecedents are initiating, and so to be embraced, which are inhibiting and to be avoided, and which are facilitating and to be employed in order to actually benefit from the promises of integration.

As all studies, this study has its limitations. The first limitation acknowledged is that the study is performed within the Dutch healthcare sector and, as contextual factors significantly influence the use and performance of operations management practices (Sousa and Voss, 2008), a different healthcare system might well generate a different pattern of antecedents. We have tried to minimize the impact of country context on the outcomes of this study by focusing on those antecedents that stem from the primary process. Nevertheless, we believe that the healthcare system will influence integrative practices and that the system's influence should therefore, be investigated.

In this study, we deliberately chose to investigate an internal supply chain with a lower care complexity than most. The questions remain whether, in more complex care processes, the impacts of the antecedents remain similar and whether other antecedents would emerge from a study of more complex care processes. Extending this study to more complex care processes would provide a more comprehensive insight into the role of antecedents that influence the integration of planning & control in a range of care processes in hospitals.

By addressing the multiple steps in a care process, this study goes further than most published contributions on planning & control in hospitals. However, the internal supply chain discussed in this chapter is a part of an internal supply network, which, in turn, is part of an external supply network. Vissers and Beech (2005) discuss the inherent complexity of addressing such networks. As Lillrank *et al.* (2011) before us, we wonder whether healthcare supply networks can be approached in the same way as supply chains. Further research on both internal supply networks and external supply networks is essential for furthering efficient future healthcare systems.

# Appendix II: Interview Protocol

*Introduction*

1. Could you summarize the responsibilities of your function

*Cooperation*

2. Could you explain what the concept of cooperation means to you?
3. Could you describe the degree of cooperation between your department and the three other departments? (Orthopedics, Radiology, Anesthesiology, and OR) Please use terms such as good / bad / not existent etc.
4. Could you describe the content of any cooperation between your department and the three other departments?
5. Can you give any more examples of cooperation between the four departments?
6. Which items would you consider when trying to investigate cooperation between hospital departments?
7. What actions do you think could be undertaken to increase cooperation between the four departments?
8. Is the current form of cooperation geared towards solving problems or geared towards preventing problems?
9. What mechanisms / programs / initiatives are undertaken by the hospital to promote cooperation among departments?
10. Which factors hinder cooperation between the four departments?

*Organization*

11. How do your decisions influence other departments?
12. How do decisions made by other departments influence your work?
13. Are you aware of any cross-functional teams/meetings involving the four departments that are:
    a. focused on the medical aspect of care?
    b. focused on the logistics aspect of care?
14. Could you give a few examples of the issues dealt with in these teams / meetings?
15. If you have a formal meeting with someone from another department, what is that person's function?

*Flow of information*

16. What information is exchanged between departments?
    a. What information do you require from other departments?
    b. What information do other departments require from you?
17. How does the current information system influence the exchange of information between departments?

*Planning & control*

18. Is the care process of a patient seen as a collection of individually managed steps, or as an integrated process?
19. How does this show?
20. Could you explain the patient planning for the process steps in which you are involved?
21. Could you explain the extent to which the complete care process of a patient is controlled?
22. When do you intervene in a care process (e.g. when a patient is active in the system for far too long)

*Performance*

23. Could you explain the performance goals set for your function?
24. How do medical goals relate to organizational goals?
25. Could you explain the performance goals set for your department?
26. Could you indicate how much of your time is spent on extra-departmental activities?
27. What is your opinion of the performance of your department?
28. How does your department perform in terms of the performance goals set by the hospital?
29. What is your opinion of the performance of the other three departments?

# CHAPTER 5

# 5 General discussion

By approaching hospitals as a set of autonomous resources, which can be planned independently, much of the inherent complexity of hospitals disappears. This approach is favorable if a hospital is interested in the efficiency of resources only and not so much in patient flow performance. However, establishing a balance between patient flow performance and resource efficiency gains importance every day. Therefore, the interaction between all the resources contributing to a patient's care process should be considered. In this thesis we set out to: *expand the knowledge of patient flow management by analyzing both causes and effects of supply chain practices in hospitals.* This chapter discusses the main findings of the three studies reported in this thesis and elaborates on the theoretical and managerial implications of this thesis. Further, the limitations of this thesis are discussed and further research to fill in the gaps left by these limitations is suggested. Finally, based on the results of the studies in this thesis we identify additional opportunities for further research.

## 5.1 Main findings

The literature review in Chapter 1 reveals several shortcomings in healthcare operations literature. First, healthcare processes are often regarded as a set of independent process steps, which results in poor patient flow performance. Second, there does not seem to be a sense of urgency in addressing sequential as well as parallel interdependencies within and between healthcare processes. Third, as opposed to manufacturing, little research is conducted on the possible benefits of supply chain practices in healthcare processes.

### *5.1.1 Shared resources: a unit perspective*

We found that due to the predominant unit perspective in healthcare operations literature little knowledge exist on how to plan shared resources which are so abundantly present in hospitals. Therefore, in Chapter 2 we conducted a study to *understand the current practices and dominant objectives in the planning of shared resources in hospitals.*. In this chapter we address the tension between supply and demand in hospitals by exploring the role of shared resources in hospitals. More specifically, the chapter assesses the influence of dedicated time slots on alleviating the negative effects of sharing resources. This study shows that while dedicated time slots have the potential to enable process orientation, hospitals hardly use them for this integrative purpose. Rather, time slots are often defined to resolve local problems or to optimize the performance of a single unit or department without considering the effects on the overall performance of the internal supply chain. That is, while dedicated time slots have the potential to enable internal integration in hospitals, this potential is not fully realized.

### *5.1.2 Integrative practices and patient flow*

In chapter 2 we mainly focus on the role of one specific resource in the internal supply chain. In furthering our understanding, in Chapter 3 we broaden the unit of analysis and address an internal supply chain. Believing that integrating planning & control functions of different hospital departments is paramount to improving patient flow we started to *map integrative planning & control practices in hospitals and to assess the effects of these practices on patient flow performance.* Chapter 3 confirms that the overall level of integration of planning & control in hospitals is rather limited. However, the results in this chapter also show that patient flow performance is significantly better in the hospitals that employ more integrative practices. Two types of integration are distinguished; dyadic initiatives and, although limited in practice, overall integration along the chain. Both dyadic and overall integration comprise of four integrative mechanisms: (1) sharing waiting list information, (2) sharing planning information, (3) cross-departmental planning, and (4) creating combined appointments. Each of these mechanisms helps by reducing either non-value-added activities or decreasing variability in patient flow. By decreasing the negative influence of these two factors, integrative planning & control mechanisms increase patient flow performance.

### *5.1.3 Antecedents of integration*

As noted earlier the degree of integration in hospital planning & control is rather low, whilst the effects of integration on patient flow performance are positive. Disparate literature provides some guidance in explaining this phenomenon by addressing factors such as politics, organizational culture and physician autonomy. Further, the manufacturing literature stresses the important role of factors stemming from the primary process (e.g. lay out, performance measurement and shared resources). However, few of such operational antecedents are explicitly studied in hospitals. As we are convinced that these operational antecedents are important in explaining why we see such a fragmented planning in hospitals; in Chapter 4 we planned to *uncover the operational factors which help and hinder the integration of planning & control in hospitals*. Current integrative planning & control practices and their antecedents were studied in Chapter 4 and five operational antecedents which help or hinder integration in hospitals are discussed. Further, we found that these antecedents play a different role. (1) Process Visibility and (2) Integral Performance Management are found to initiate integration. (3) Variability/Uncertainty and (4) Shared Resources turn out to inhibit integration and (5) Information Technology appears to facilitate integration. This study reveals that some antecedents and their relationships with integration are consistent with the relationships found in the disparate literature. However, several operational antecedents and their relationships with integration found in this study appear to be new and/or specific for a hospital context.

Both the findings from our literature study as well as from our empirical studies suggest that adopting a planning & control approach which addresses more than one process step benefits patients and hospitals. This holds for shared resources in hospitals, which function as intersections between different internal supply chains, as well as studying internal supply chains themselves. Further, we found that to enhance the integration of planning & control in hospitals it is essential to address its operational antecedents.

## 5.2 Theoretical implications

Many previous contributions concerning healthcare operations adopt a unit perspective (Cardoen *et al.*, 2010a; White *et al.*, 2011). This thesis moves away from this unit perspective in two ways. First, by assessing the objectives of planning & control decisions concerning shared resources and whether these objectives also incorporate a patient flow perspective (Chapter 2). Second, by considering the antecedents of supply chain practices and their effect on patient flow performance (Chapters 3 and 4). Besides the implications of the individual studies, which are more elaborately discussed in respective chapters, this thesis has five main theoretical implications.

First, by focusing on the flow of patients we abandoned the predominant unit perspective prevalent both in hospital practice and healthcare operations literature. Most studies addressing flow do not address *entire* internal supply chains (e.g. O'Keefe, 1985; Vissers, 1998; Swisher *et al.*, 2001; Akcali *et al.*, 2006; Edward *et al.*, 2008; Chand *et al.*, 2009). By exploring which integrative practices are adopted in order to conceive a chain perspective we help overcoming the barriers to patient flow posed by Fredendall *et al.* (2009).

Second, as discussed in the first implication, planning & control issues are not often considered from a chain perspective. Similarly, the contributions that do elaborate on a chain perspective do not consider the planning & control of these chains. Literature on process oriented practices such as service lines (e.g. MacStravic, 1986; Berenson *et al.*, 2006) and clinical pathways (e.g. Pearson *et al.*, 1995; De Bleser *et al.*, 2006) thoroughly describe the focal process steps and prescribe that the involved resources should be organized in a multidisciplinary way. However, they fail to elaborate on the planning & control aspect of these process steps and resources, omitting the actual process of reconciling supply with demand. By focusing on the planning & control aspect this thesis complements existing knowledge about process based care.

Third, this research adds a vital building block to a new hospital planning & control system. As Bertrand *et al.* (1990) suggest a planning framework should incorporate production unit control and goods flow control. Most healthcare operations literature focuses on the former part and neglects the mutual coordination of production units and the overall production control objectives set to guarantee patient flow performance. This thesis complements the ideas of Bertrand *et al.* (1990) by showing how production units in hospitals (i.e. departments and process steps) could be integrated in order to encourage patient flow. Further, this thesis shows the importance of measuring flow performance along an internal supply chain.

Fourth, the results of this thesis extend the existing knowledge on internal integration and expands the model of internal integration suggested by Pagell (2004) in three different ways. (1) By not just defining integration but through distinguishing clear stages of integration we provide a detailed understanding of the relationships between integration and its antecedents. Contrary to other contributions we not just discuss effect of each antecedent on integration as whole, but on each of the integrative stages. (2) By focusing on operational antecedents and moving away from general antecedents such as organizational structure, organizational culture, and top management commitment we could focus on concrete day-to-day antecedents. This led us to add, for example, process visibility to the model, which is considered an important factor in gaining a sustainable competitive advantage (Barratt and Oke, 2007). (3) Contrary to the studies of Pagell (2004) and Fredendall *et al.* (2009) we empirically show the effect of integration on performance rather than inferring it from the literature.

Fifth, by drawing on the supply chain management literature and the theory of swift even flow, we advanced the knowledge about both bodies of literature in a healthcare context. Although the theory of swift even flow is considered as an important theory in operations management, very few studies in healthcare except Fredendall *et al.* (2009), and Devaraj *et al.* (2013) considered it as a theoretical lens. Similarly, as discussed above, few studies considered supply chain theory in order to analyze healthcare processes. The final implication of this thesis is showing the important effect of supply chain management principles on swift, even flow in a hospital context (see figure 5.1). The theory of swift even flow argues that the productivity of any process rises with the speed at which items flow through the process and falls with increases in the variability associated with either the demand for capacity or the supply of capacity (Schmenner and Swink, 1998; Schmenner, 2001). Whereas supply chain management is concerned with an aligned and possibly integrated network of processes from end customer to source and design of product and service (Storey *et al.*, 2006).

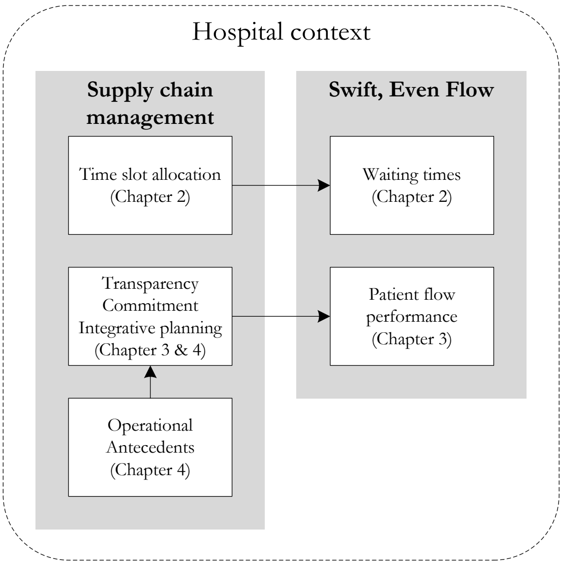


*Figure 5.1: The relationship between supply chain management and swift, even flow in a hospital context*

In this thesis we show that supply chain management principles applied within a hospital context positively influences a swift and even flow. This is done by addressing hospital supply chain management practices, such as time slot allocation (Chapter 2), information sharing, cross departmental planning and combined appointments (Chapter 3) and linking these practices to waiting times and flow performance. Besides focusing on the relationships between the two theories in a hospital context we also elaborate the content of each of the theories by thoroughly defining, analyzing and categorizing both supply chain management practices (Chapters 2, 3, and 4) and by operationalizing swift, even flow (Chapters 2 and 3).

## 5.3 Managerial implications

The findings in this thesis indicate that if departments in hospitals cooperate on planning & control, flow performance will improve. Our results show that considering resources involved in complex care processes as if they were isolated lowers hospital productivity. This thesis helps explaining and understanding decisions made in hospitals and assessing the effects of those decisions on patient waiting time and hospital productivity. The knowledge gained from this thesis can be used to evaluate current hospital planning & control practices and, more importantly steer hospitals towards achieving a more integrated delivery of care. This helps hospitals in balancing costs with patient flow performance

This thesis helps managers to assess their current allocation practices regarding shared resources by describing the most common types of time slots and discussing their objectives in the light of internal integration Chapter 2). These results can assist managers in choosing which types of dedicated time slots to use and, more importantly, which to avoid when pursuing either a high resource utilization or a more swift and even flow. Given that improving patient flow has become an important point on the political agenda several practical implications concerning flow performance have to be noted. Adopting the four integrative practices discussed in Chapters 3 and 4 can help hospital managers to reduce non-value-adding activities and variability, which will result in improved patient flow performance. Such improved performance benefits patients (as expected) and the hospital will be reimbursed quicker (reimbursement takes place after a care process is completed) by insurance companies which means that less working capital is tied up in patients waiting for treatment.

Our results show that even a limited degree of integration leads to improvements in patient flow performance. However, we did not explore the limits of integration. Integrating process steps just for the sake of integration, as seems to be the case nowadays with the uncurbed implementation of focused factories (Pieters *et al.*, 2010) or the implementation of ERP systems which are not compatible with the care process (Lluch, 2011), is not recommended. Therefore, managers should focus on those process steps which benefit the most. By clearly assessing which information (e.g. demand patterns for preceding and subsequent process steps, capacity utilization information and sequence dependent planning information) is worthwhile to share between departments and process steps information overkill can be avoided. Further, managers should clearly indicate within which processes and for which process steps cross departmental planning and combination appointments are relevant. For example, process steps with a clear sequence dependence (e.g. executing an MRI and discussing the results with the patient) are more eligible for these two integrative practices than process steps without (e.g. diagnosis and preassessment). Determining the desired trade-off between extensive forms of integration and flexibility is key.

This chapter helps practitioners understand which antecedents are initiating (integral performance management and process visibility), and so to be embraced, which are inhibiting (shared resources and variability/uncertainty), and to be avoided, and which are facilitating (information technology) and to be employed in order to actually benefit from the promises made for integration. Increasing process visibility and constructing integral performance measurements will be an important task for the contemporary hospital manager. By focusing on these two antecedents first, the requirement for countering variability, managing shared resources and sensibly deploying IT solutions will be much more focused. Proper process mapping will be the first step in gaining process visibility. Each department should map their care processes by describing the relationships between the different departments and different process steps. They should then use this map to manage the coordination and cooperation of actors performing tasks in the specific care process (Staccini *et al.*, 2005). Understanding at least the basic processes of and the dynamics between adjacent departments in the care process would already help staff to comprehend the motivations and requirements for planning the flow of patients between departments.

Although length of stay (LOS) (e.g. Hashimoto *et al.*, 2000; McDermott and Stock, 2007; KC and Terwiesch, 2011) and waiting times (Siciliani and Hurst, 2005; Willcox *et al.*, 2007; White *et al.*, 2011) are commonly used as performance measure in the literature and practice, few measures exist that monitor a care process from a patient's first appointment all the way through to its discharge.

Managers should, therefore, focus on creating length of care performance objectives, measuring the total duration of a care process. Adopting these objectives for elective care processes will provide a balance with the currently predominant resource utilization objectives. This will not only benefit the patient and the hospital but also other stakeholders such as insurance companies and the government.

One of the major difficulties in this study was getting data from which we could reconstruct patient care processes and assess patient flow performance. We noted that hospital managers face similar challenges. Although hospitals do collect a myriad of data, obtaining the right logistical information regarding the patient's progress remains a struggle. Commonly hospital productivity is measured according to length of stay (e.g. Hashimoto *et al.*, 2000; McDermott and Stock, 2007; KC and Terwiesch, 2011). However, such hospital length of stay data is insufficient for studying patient flow because data representing the path and associated lengths of stay along that path for each patient is required (Isken and Rajagopalan, 2002). From the inception of diagnosis related groups (DRGs), authors argue to use DRG data which is recorded by hospitals as input for a planning system (Rhyne and Jupp, 1988; Roth and Van Dierdonck, 1995). However, DRGs are rather heterogeneous groups when it comes to resource use (Roth and Van Dierdonck, 1995). Vissers *et al.* (2001) note that DRGs are useful to market and finance hospitals, but not for managing day to day hospital operations. With the implementation of diagnosis treatment combinations (DTCs) in the Dutch healthcare system the main drawbacks of the use of DRG's are nullified. For this thesis we developed an Excel tool which can read DTC data and convert it to patient flow data. The care process of each patient, related patients, major patient groups and more aggregated groups can be easily analyzed. An important managerial implication of this thesis, therefore, is showing that DTC data can be used as the basis for planning & control decisions in hospitals. Thus, the rich data currently available through the DTC reimbursement system should be used as management information for aligning the different departments in a care process. Two caveats have to be noted. First, contrary to financial purposes, when using this data for logistical purposes managers should clearly stress that the sequence of which the episodes are registered is of utmost importance. Second, the level of detail incorporated in DTC data (such as the exact times of an episode or whether or not the episode was re-planned) might be insufficient for detailed adjustments in the planning process.

In line with the implication above Vos *et al.* (2010) showed that case-mix reimbursement within hospitals' budgeting processes positively influences the adoption of process based care. However, this thesis shows this system on its own does not guarantee improved flow performance. As described in Chapter 1 (figure 1.1) both the Dutch government and the insurance companies are major stakeholders in financing the Dutch healthcare system. Representatives of the various national health branches agreed on target standards and maximum waiting times for non-acute care (TiLD, 2013). However, these targets are rather coarse and provide little guidance in the maximum duration of elective care processes. The results of this thesis show that performance management mainly focuses on resource utilization because there are still little incentives for hospitals to pursue high patient flow performance. Such incentives could also come from other stakeholders such as the major insurance companies, who currently agree with hospitals on annual quantities and not on flow performance. In Chapter 3 we show that stimuli from insurance companies regarding throughput time results in higher patient flow performance. Therefore, in order to effectively incorporate process oriented care for elective care processes insurance companies as well as the government should make agreements on flow performance with hospitals. By rewarding hospitals which honor the flow performance agreements and show low costs insurance companies and the government stimulates economically viable process oriented care.

## 5.4 Limitations and further research

In this section we focus on further research which originates from this thesis. First, we discuss the limitations of this thesis, which offer opportunities for further research. Second, we elaborate on further research resulting from the findings in this thesis.

### *5.4.1 Limitations*

This study was performed within the context of the Dutch healthcare system which is considered among the best in the world (WHO, 2000; OECD, 2011). However, comparing healthcare systems across countries is difficult (Wendt, 2009; Reibling, 2010) and assessing the effects of the healthcare system on the topics studied are beyond the scope of this thesis. Contextual factors are believed to significantly influence the use and performance of operations management practices (Sousa and Voss, 2008). Therefore, the results from this thesis cannot be one on one copied to other healthcare contexts without assessing the differences of these contexts with the Dutch healthcare context. Although we believe a different healthcare system does not inherently result in different processes, we do believe it influences the way processes are managed. As financial incentives are an important method to shift management priorities, further research should focus on hospitals in different financing systems in order to assess whether a different incentive structure will influence required performance objectives and the degree of integration.

In this thesis we tried to get an as detailed picture as possible of hospitals operations. Chapters 3 and 4 are based different aspects of the same cases. The richness of the information (both qualitative and quantitative) which was gathered in these cases allowed us to investigate the phenomenon of integration into more depth than expected beforehand. Chapter 3 has mainly built on the quantitative data supported by the qualitative data whereas Chapter 4 has mainly built on the qualitative data supported by the quantitative data. Where other studies condensed a hospital's performance into one 'average length of stay' figure (e.g. KC and Terwiesch, 2011), we tried to expose the inner workings of a hospital. In order to do so we deliberately chose a small sample size allowing us to gather rich data, which can be defended for theory building purposes (Eisenhardt, 1989; Yin, 2003), but which might be seen as a limitation of this thesis. We constructed several theoretical models which help explaining the empirical phenomena we observed. These theoretical models suggest a positive relationship between supply chain management and swift, even flow. In order to further explore and test this relationship it is important to undertake a large sample size study. Such a study helps verifying the relationships we found in our individual studies and the overall relationship between supply chain management and swift, even flow in hospitals. Similarly, verifying this relationship outside the hospital context will provide valuable to the whole operations and supply chain management community.

In this study, we deliberately chose to investigate internal supply chains with a low care complexity. However, a more complex care processes (e.g. a longer chain, more than one specialty involved in a process step, higher routing uncertainty, or higher demand variability) could yield additional or different relationships. We therefore, suggest theoretical replication (Yin, 2003) of the studies performed in Chapters 3 and 4 by focusing on, for example, the specialty of internal medicine or emergency patients. Based on our findings and experiences in hospitals we expect that such a replication study could yield different integrative practices (e.g. combined appointments are not feasible for emergency patients, but strict response agreements or service level agreements with other specialties are) and a different emphasis on performance (setting realistic performance objectives for patients with very unpredictable care processes will be very difficult).

Similarly, in this thesis we address multiple steps in a care process, which goes further than most published contributions on planning & control in hospitals. However, the internal supply chains studied are part of an internal supply network. In accordance with Lillrank *et al.* (2011) we are unsure whether healthcare supply networks can be approached in the same way as supply chains. We expect that the increased number of interdependencies and conflicting requirements could negatively influence integrative practices such as combined appointments since such commitments might harm the objective of other actors in the network. As a contrast to the decomposition approach (large problems can be broken down into smaller ones, analyzed, and solved by rational deduction) of for example Bertrand *et al.* (1990) and Glouberman and Mintzberg (2001b) is the complexity theory approach to healthcare which suggests to "abandon linear models, accept unpredictability, respect (and utilize) autonomy and creativity, and respond flexibly to emerging patterns and opportunities" (Plsek and Greenhalgh, 2001). A great opportunity for further research is extending the studies conducted in this thesis to an internal supply network and to broaden this with a discussion about the decomposition approach versus complexity theory. As empirical research on complexity theory in supply chain management in general is still in its infancy (Mena *et al.*, 2013) such further research will not only benefit the hospital community but also the broader supply chain management community.

### *5.4.2 Further research*

The findings in this thesis form the basis of several opportunities for further research. Based on the theoretical and managerial implications of this thesis we elaborate on three topics which provide challenging ways for further research.

Due to the limited implementation of integrative practices we only found positive effects when employed. However, we expect the positive effects resulting from integration to show an optimum depending on the extent of integration. In the managerial implications we discussed finding a balance between integration of process steps and desired planning flexibility. In successfully adopting the integrative practices discussed in this thesis the question: "to which extent does integration help and to which extent does it hinder performance" should be further explored. Further research into the extent and content of information shared by different actors in a care process should be undertaken. Also, the extensive use of combined appointments and cross departmental planning should be further scrutinized. Further research in this topic should help an understanding of whether the use of integrative practices is a good solution for performance issues or whether hospitals should eventually chose a different organization form such as a focused factory.

We noted that measuring and using operations management related performance data either for resource utilization purposes or for patient flow purposes is still very limited in hospitals. Creating methods for using DTC data (such as noted in the managerial implications) for planning & control purposes show to be very beneficial to hospitals. However, the literature provides little guidance in creating performance metrics for hospitals. Healthcare operations literature lacks a set of basic performance objectives such as developed for manufacturing companies (e.g. Treacy and Wiersema, 1993; Slack *et al.*, 2001) and consequently a set of key performance indicators (KPIs), which can be used to establish and compare logistical performance of hospitals. Further, current time based performance measures such as the commonly used 'length of stay' do not accurately represent the patient's care process. Therefore, further research into developing a set of universal performance objectives and related KPI's which are representative for a patient's care process is urgently needed.

A main issue raised by the hospital during most our visits was the subject of variability. Hospitals seem to feel ill equipped coping with variability and uncertainty. Therefore, more research should be conducted into how to reduce variability in hospitals. It is common belief that the source of variability in healthcare is found in the demand for care. Jack and Powers (2004) provide several ways to deal with demand uncertainty in healthcare processes. However, several authors attribute the supply of care as source of variability in hospitals (Litvak and Long, 2000; McManus *et al.*, 2003). Similarly, Van der Vaart and Bakker (2013) show the negative effects of variability in specialist capacity on patient flow performance. However, currently, little research is conducted in reducing variability stemming from this supply side of care. Especially in organizations in which process visibility is low, the sources of variability in the organizations could be clearly pointed out and addressed. Therefore, further research into reducing variability stemming from current management practices in hospitals seems promising for helping hospitals performing better.

## 5.5 Concluding remarks

In this thesis we closely studied planning & control in hospitals. We found that the planning of different process steps in a care process is often done in isolation. Similar to specialties in hospitals, each department is responsible for their own planning & control and there is little consideration for adjacent departments or process steps. However, we did find several integrative practices which clearly contributed to an increased patient flow performance. In order to increase integration, we explored the factors which help or hinder integration in hospitals. Therefore, stressing the importance of integration, establishing the effects of integration and uncovering the antecedents of integration this thesis can be used as a guide to improve cooperation between the different departments in hospitals. Such cooperation would benefit both patients and hospitals.

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# English Summary

This thesis contributes to the literature on the crossroads of healthcare management and operations management by expanding the knowledge base on patient flow management in hospitals. This thesis addresses the reconciliation of the supply of care with the demand for care from a supply chain perspective and focuses on the planning & control of patients in a care process. In a care process patients flow from one resource to the next, which do not necessarily belong to the same department. This thesis is motivated by the notion that the management of these resources is often done irrespective of a patient's care process, resulting in unnecessary and excessive waiting times. This thesis contributes to improving patient flow, which is regarded crucial for increasing hospital productivity and increasing patient satisfaction (Litvak, 2009; Villa *et al.*, 2009). The overall goal of this thesis is: *to expand the knowledge on patient flow management by analyzing both causes and effects of supply chain practices in hospitals.* Based on the gaps found in the literature three empirical studies were conducted. Each study builds on empirical evidence gathered by means of a multi-case study methodology.

## A brief review of the literature

Improving flow should be a joint effort of all departments involved in a patient's care process. It is argued that flow improvements of a part of a care process could harm performance in other dependent departments (Haraden and Resar, 2004). However, traditionally, most general hospitals have adopted a functional organizational structure built around discipline-based specializations (Lega and DePietro, 2005). This functional organization leads to a view of hospital operations as a collection of individual resources or service centers (Roth and Van Dierdonck, 1995). The planning and control of each resource is then carried out locally and decoupled from the planning and control of other resources. Strikingly, most sequential steps are planned independently of one another, and only departmental performance is addressed (e.g. Cayirli *et al.*, 2006; Green *et al.*, 2006; Kolisch and Sickinger, 2008).

In a review of healthcare operations management literature, White *et al.* (2011) show that the majority of studies on the planning & control of care

processes concentrate on single-stage systems. Examples are found in O'Keefe (1985), Vissers (1998), Swisher *et al.* (2001), Akcali *et al.* (2006), Edward *et al.* (2008), Chand *et al.* (2009), and Santibáñez *et al.* (2009). Various researchers stress that integrating the planning & control functions in hospitals could help address this problem (Vissers and Beech, 2005; Aronsson *et al.*, 2011).

Despite the positive effects of integration in manufacturing, it remains unclear if the findings from such integration research can be translated to a healthcare setting (Thrasher *et al.*, 2010). So far, research has paid little attention to what practices might be effective in this specific context, and what the effect of such practices would be on patient flow performance.

While the benefits of an integrated planning & control function are recognized in manufacturing (e.g. Oliva and Watson, 2011), hospitals lag behind in integrating these functions (Cardoen *et al.*, 2010b). An explanation for this can partly be found in general, organizational barriers such as organizational culture (Currie and Harvey, 2000), physician autonomy (Pearson *et al.*, 1995), top management support (Currie and Harvey, 2000), and politics (Vos *et al.*, 2009). Conversely, important operational barriers such as layout (Pagell, 2004), performance measurement (Stank *et al.*, 2001b), and shared resources (Van der Vaart and Van Donk, 2004), which can be found throughout the manufacturing literature are not considered within the healthcare operations literature.

In summary, the brief literature review above shows that when it comes to integration of planning & control in hospitals still many knowledge gaps need to be filled.

## Empirical studies

In order to gain a better understanding of planning & control in hospitals and its effect on patient flow we undertook three empirical studies to: (1) analyze the practices employed to plan shared resources, (2) assess whether efforts to integrate planning & control functions help to improve flow, and (3) address the reasons why these efforts are not as widely adopted as one would expect and wish.

### *A critical assessment of the role of dedicated time slots in hospitals*

Shared resources form an important barrier to the integration of internal supply chains in hospitals. We argue that allocating shared resource capacity through dedicated time slots can overcome this barrier and enable more integrated care provision. Although frequently used, little is known about how hospitals use dedicated time slots. The purpose of this research has, therefore, been to assess the effectiveness of these dedicated time slots in enabling integrative planning practices within hospitals. The research is based on a multiple-case study carried out in a medium-sized hospital. We selected three cases within a radiology department, each displaying different usages of dedicated time slots. Three different effects of utilizing dedicated time slots have been identified: (1) using dedicated time slots with the objective of linking consecutive treatment steps clearly enables a process orientation, (2) using dedicated time slots with the objective to prioritize patients indirectly contributes to integration, but (3) using dedicated time slots with the objective of clustering patients counters integration and consequently flow. The theoretical contribution of this chapter lies in exploring the point where the management of patient flows and the planning of shared resources meet, a topic currently underexposed in the literature. We provide insights into managing a common trade-off in healthcare: resource utilization versus patient flow. From a managerial perspective, our findings can assist hospital administrators to reconcile market requirements and organizational objectives.

*Integrative practices in hospitals and their impact on patient flow*

The aim of this chapter is to investigate which integrative planning & control practices are used in hospitals and what their effects are on patient flow. Despite the importance of integration in hospitals, little is known about the integrative practices hospitals actually employ. Most existing studies on patient flows are confined to a single stage in the care process. In this study, the effects of integration in the internal supply chain from the first visit to the end of treatment are examined. The study is based on a three-hospital multi-case study carried out in the Netherlands. The analysis of patient flow data and interview data is used to explore the effects of integrative practices on lead times and patient flow. Based on the various patient groups examined in the different hospitals, four integrative practices stand out: sharing waiting list information, sharing planning information, cross-departmental planning, and combining appointments. In line with earlier studies, the overall level of integration in hospitals was found to be low. However, patient flow performance is significantly better in those hospitals that employ more of the abovementioned integrative practices. This study provides clear support for the value of integration initiatives in healthcare operations. The performance of hospitals, in terms of patient flows, benefits from cooperation between the various members of an internal supply chain. Hospital administrators and medical professionals could learn from these results and attempt to abandon their silo mentality and start integrating for their patients′ and their own benefit.

*Operational antecedents of integrated planning & control in hospitals*

The benefits of integrating planning & control functions are well known in manufacturing. However, in hospitals, planning & control is still dispersed over distinct functional departments. We believe that factors stemming from the primary process are key to explaining the fragmented planning seen in hospitals. Consequently, the aim of this study is to explore the operational antecedents to integrating planning & control functions in hospitals. The study is based on a three-hospital multi-case study carried out in the Netherlands. The main findings stem from over forty in-depth interviews with specialists, nurses, planners, and managers of four specialties that are all involved in the orthopedic internal supply chain. Five critical operational factors have been identified as major operational antecedents of integration in hospitals: performance management, information technology, process visibility, uncertainty/variability, and shared resources. This study shows a clear three-way split (initiating, inhibiting, or facilitating) in the role of these operational antecedents. This study shows the impact of various operational antecedents recognized in other contexts, and adds two major operational antecedents that are typical in a healthcare context. Contrary to other contributions, integration is addressed here on a detailed level providing a more comprehensive perspective of the inner workings of integration in hospitals. The five operational antecedents found in this study should be considered as essential supplementary factors to the more commonly discussed organizational and behavioral antecedents of integration.

## Conclusion

We set out to expand the knowledge on patient flow management by analyzing both causes and effects of supply chain practices in hospitals. By closely studying planning & control in hospitals we found that the planning of different process steps in a care process is often done in isolation. This thesis uncovered that when it comes to shared resources in hospitals, to a very limited extent dedicated time slots are used for integrative purposes. However, we did find several integrative practices which clearly connected different departments. The adoption of these integrative practices, albeit in a limited way, clearly shows significant improvements in patient flows. By uncovering the factors which help or hinder integration in hospitals, this thesis contributes by offering means to increase the degree of integration in hospitals. This thesis helps managers to understand the influence they can have on the balance between resource utilization and patient flow performance, by using specific types of time slots. Further, it shows to managers, planners and physicians that in order to increase patient flow performance practitioners they need to acknowledge the importance of cooperation when it comes to planning & control. Finally, we show managers areas of immediate attention and provide insight in which factors should be addressed in order to achieve integration.

This thesis is just the starting point of research on the relationship between integration and patient flows in hospitals. It opened up a whole new array of further research of which the most important are further exploration of the limits of integration i.e. "when does integration stop to be a benefit and becomes a burden?" and further exploration of a set of universal performance objectives and related Key performance indicators (KPIs) which are representative for a patient's care process. Finally, the reduction of variability caused by the hospital itself should become a central topic of academic research and managerial focus.

# Samenvatting

Het goed aansturen van zorgprocessen is van essentieel belang in de moderne gezondheidszorg. Dit proefschrift richt zich op het uitbreiden van het kennisbestand omtrent patiëntenstromen en logistieke besluitvorming in ziekenhuizen en draagt bij aan de literatuur op het raakvlak van zorgmanagement en operations management. In dit proefschrift richten we ons op de afstemming tussen het aanbod van zorg en de vraag naar zorg vanuit een supply chain perspectief en focussen ons de planning en beheersing van patiënten in een zorgproces. In een zorgproces stromen patiënten door van de ene capaciteit naar de andere, welke niet noodzakelijkerwijs tot dezelfde afdeling behoren. De motivatie achter dit proefschrift ligt in het feit dat de aansturing van deze betrokken capaciteiten vaak wordt uitgevoerd ongeacht het zorgproces van een patiënt. Dit resulteert in onnodige en excessieve wachttijden.

Dit proefschrift draagt bij aan het verbeteren van de doorstroming van patiënten en daarmee aan de productiviteit van een ziekenhuis (Litvak, 2009; Villa et al., 2009). De doelstelling in dit proefschrift is: uitbreiding van de kennis over de aansturing van patiëntenstromen door middel van het analyseren van zowel de oorzaken als de gevolgen van integratie in ziekenhuizen. Gemotiveerd door hiaten in de literatuur zijn er drie empirische studies ondernomen. Ieder van deze studies is gebaseerd op een multi-case studie methodologie.

## Een kort overzicht van de literatuur

Het verbeteren van de doorstroom van patiënten zou een gezamenlijk doel moeten zijn van alle afdelingen betrokken in een zorgproces. Haraden en Resar (2004) beargumenteren dat wanneer verbeteringen in doorstroom van een gedeelte van een zorgproces worden doorgevoerd, de prestaties van andere, afhankelijke afdelingen geschaad kunnen worden. Echter, van oorsprong hebben de meeste ziekenhuizen een functionele organisatorische structuur gebaseerd op specialisaties (Lega en DePietro, 2005). Deze functionele organisatie zorgt juist voor een benadering van het primaire proces van een ziekenhuis als een verzameling van individuele capaciteiten of verantwoordelijkheidsgebieden (Roth en Van Dierdonck, 1995). De planning en beheersing van elke capaciteit wordt vervolgens lokaal uitgevoerd en is zodoende ontkoppeld van andere capaciteiten. Opvallend is dat de meeste opeenvolgende stappen in een zorg proces daarom apart van elkaar worden ingepland en dat uitsluitend prestaties van individuele afdelingen wordt gemeten (bijv. Cayirli et al., 2006; Green et al., 2006; Kolisch en Sickinger, 2008).

In een overzicht van de literatuur laten White et al. (2011) zien dat de meerderheid van de studies over planning en beheersing van zorgprocessen zich beperken tot systemen met maar één processtap. Voorbeelden zijn te vinden in O'Keefe (1985), Vissers (1998), Swisher et al. (2001), Akcali et al. (2006), Edward et al. (2008), Chand et al. (2009), en Santibáñez et al. (2009). Verscheidene onderzoekers benadrukken dat integratie van de plannings- en beheersingsfuncties in ziekenhuizen dit probleem zou kunnen helpen oplossen (Vissers en Beech, 2005; Aronsson et al., 2011). Ondanks de positieve effecten van integratie zoals gezien in de productie-industrie, blijft het onduidelijk of deze bevindingen kunnen worden vertaald naar de zorg (Thrasher et al., 2010). Tot nu toe is er weinig aandacht besteed aan welke toepassingen wellicht effectief kunnen zijn in de zorgcontext en aan de effecten van deze toepassingen op de doorstroom van patiënten.

Daar waar de voordelen van integrale plannings- en beheersingsfuncties worden herkend in de productie-industrie (e.g. Oliva en Watson, 2011), lopen ziekenhuizen achter in het integreren van deze functies (Cardoen et al., 2010b). Aan de ene kant kan een verklaring hiervoor worden gevonden in algemene en organisatorische barrières die zich voordoen in de zorg, bijvoorbeeld: organisatiecultuur (Currie en Harvey, 2000), autonomie van de arts (Pearson et al., 1995), toewijding van hoger management (Currie en Harvey, 2000) en politiek (Vos et al., 2009). Aan de andere kant worden belangrijke operationele factoren zoals lay-out (Pagell, 2004), prestatiemetingen (Stank et al., 2001b) en gedeelde capaciteiten (Van der Vaart en Van Donk, 2004), welke ruimschoots aan bod komen in productieliteratuur, niet meegenomen in de zorgmanagement literatuur.

Samenvattend; het bovenstaande literatuuronderzoek laat zien dat er zich in de literatuur diverse kennishiaten bevinden wanneer het gaat om de integratie van planning en beheersing in ziekenhuizen.

## De drie empirische studies

Om planning en beheersing in ziekenhuizen en haar effecten op patiëntenstromen beter te begrijpen hebben we drie empirische studies ondernomen om 1) te analyseren hoe ziekenhuizen omgaan met gedeelde capaciteiten 2) te bepalen of pogingen om plannings- en beheersingsfuncties te integreren de doorstroom van patiënten helpen verbeteren, en 3)er achter te komen waarom deze toepassingen niet zo wijdverbreid zijn als men zou verwachten.

*De rol van gereserveerde plekken in ziekenhuizen*

Gedeelde capaciteiten (zoals een MRI, OK of Röntgen apparaat) zijn belangrijke obstakels in de integratie van interne supply chains in ziekenhuizen. In dit onderzoek beredeneren we dat deze obstakels weggenomen kunnen worden, door het expliciet toewijzen van delen van deze capaciteit aan specifieke patiëntengroepen door middel van gereserveerde plekken. Hoewel, het reserveren van plekken vaak wordt gebruikt door ziekenhuizen, weten we niet precies op welke manier en voor welke patiëntengroepen ziekenhuizen plekken op gedeelde capaciteiten reserveren. Het doel van dit onderzoek is daarom het bepalen of en hoe het reserveren van plekken bijdraagt aan een meer geïntegreerde planning binnen ziekenhuizen. Hiervoor bestuderen we drie typische gedeelde capaciteiten binnen een radiologie afdeling, die elk op een andere manier omgaan met het reserveren van capaciteit. Deze studie laat drie verschillende effecten van het gebruik van gereserveerde plekken zien: 1) het gebruik van gereserveerde plekken met als doel het verbinden van opeenvolgende stappen in het zorgproces draagt direct bij aan integratie, 2) het gebruik van gereserveerde plekken met als doel patiënten te prioriteren draagt indirect bij aan integratie, maar 3) het gebruik van gereserveerde plekken met als doel patiënten te clusteren (batching) werkt integratie en dientengevolge doorstroom tegen. De theoretische bijdrage van dit hoofdstuk is het verkennen en uitdiepen van het raakvlak van het aansturen van patiëntenstromen en het aansturen van gedeelde capaciteiten; een onderwerp dat momenteel onderbelicht is in de literatuur. We verschaffen inzicht in het balanceren van één van de belangrijkste trade-offs in de zorglogistiek: benutting van capaciteit versus de doorstroom van patiënten. Vanuit een praktisch perspectief kunnen de resultaten van deze studie ziekenhuismanagers helpen om de behoeften van de markt en de behoeften van de organisatie op elkaar af te stemmen.

*Integratie en de doorstroom van patiënten*

De doelstelling van dit hoofdstuk is te onderzoeken welke vormen van integratie van planning en beheersing ziekenhuizen toepassen en welke effecten deze toepassingen hebben op de doorstroom van patiënten. Ondanks het belang van integratie in ziekenhuizen is er weinig bekend in hoeverre ziekenhuizen integratie daadwerkelijk toepassen. De meeste bestaande studies over patiëntenstromen zijn beperkt tot een enkele fase/stap in het zorgproces. In deze studie worden de effecten van integratie in de interne supply chain vanaf het eerste bezoek tot het eind van de behandeling onderzocht. Deze studie is gebaseerd op een multi-case studie binnen drie ziekenhuizen in Nederland. Interviewdata en verrichtingsdata zijn gebruikt om de effecten van integratie op de doorlooptijd van patiënten te onderzoeken. Vier toepassingen van integratie kunnen worden onderscheiden: 1) het delen van wachtlijst informatie, 2) het delen van planningsinformatie, openstellen van agenda's voor andere afdelingen en combinatieafspraken. Net als in eerdere studies is de mate van integratie in ziekenhuizen laag. Echter, de doorstroom van patiënten is significant beter in de ziekenhuizen die meer integratie toepassen. Dit onderzoek bevestigt daarom de waarde van het integreren van de plannings- en beheersingsfuncties in ziekenhuizen. Dit onderzoek laat zien dat de samenwerking tussen de verschillende leden van een interne supply chain op het gebied van planning en beheersing leidt tot betere ziekenhuisprestaties in termen van patiëntendoorstroom. De resultaten van dit onderzoek geven zowel managers als specialisten een reden om hun huidige tunnelvisie met betrekking tot planning en beheersing op te geven. We laten zien dat integratie van planning en beheersing voordelen oplevert voor zowel het ziekenhuis als de patiënt.

*Operationele factoren van invloed op integratie in ziekenhuizen*

De voordelen van geïntegreerde plannings- en beheersingsfuncties zijn bekend binnen de productie-industrie. In ziekenhuizen daarentegen is planning en beheersing nog steeds verdeeld over de afzonderlijke functionele afdelingen. In deze studie onderzoeken we of en hoe factoren gerelateerd aan het primaire proces van een ziekenhuis een verklaring kunnen geven waarom planning en beheersing in ziekenhuizen zo gefragmenteerd is. Dientengevolge is het doel van dit onderzoek de operationele factoren die van invloed zijn op de integratie van planning en beheersing in ziekenhuizen te verkennen. Dit onderzoek is gebaseerd op een multi-case studie van drie ziekenhuizen in Nederland. De belangrijkste bevindingen zijn gebaseerd op meer dan veertig diepte interviews met specialisten, verpleegkundigen, planners en managers van vier afdelingen die betrokken zijn bij de orthopedische interne supply chain. In dit onderzoek stuitten we op vijf kritische operationele factoren de van invloed zijn op integratie in ziekenhuizen: prestatiemanagement, informatie technologie, proces-zichtbaarheid, onzekerheid / variabiliteit en gedeelde capaciteiten. De resultaten laten een duidelijke driedeling zien (initiërend, verhinderend, of ondersteunend) in de rol van deze operationele factoren. We laten zien dat operationele factoren die van invloed zijn in andere contexten ook gelden in een ziekenhuiscontext en voegen aan deze lijst twee factoren toe die specifiek voor ziekenhuizen lijken te gelden. In tegenstelling tot andere studies, wordt integratie hier bekeken op een meer gedetailleerd niveau. Dit leidt tot een dieper begrip van het concept integratie zelf. De vijf operationele factoren die gevonden zijn in dit onderzoek moeten worden beschouwd als essentiële aanvulling op de bekende algemene organisatorische factoren van invloed op integratie.

## Conclusie

Door zowel de oorzaken als de gevolgen van toepassingen van integratie in ziekenhuizen te onderzoeken draagt dit proefschrift bij aan het uitbreiden van kennis over zorglogistiek. Uit een gedetailleerde analyse van de plannings- en beheersingsfuncties in ziekenhuizen blijkt dat de planning en beheersing van verschillende processtappen in een zorgproces vaak door iedere afdeling onafhankelijk van elkaar wordt gedaan. Dit onderzoek laat zien dat wanneer het gaat over gedeelde capaciteiten in ziekenhuizen slechts een paar gereserveerde plekken worden gebruikt voor integratie doeleinden. We hebben echter ook verscheidende andere toepassingen van integratie gevonden die duidelijk verschillende afdelingen met elkaar verbinden. Hoewel ze in geringe mate voorkomen, zorgen deze toepassingen voor significante verbeteringen in de doorstroom van patiënten. Door te onderzoeken welke factoren van belang zijn voor integratie draagt dit proefschrift bij aan het verhogen van de mate van integratie. Dit proefschrift helpt managers te begrijpen welke invloed ze kunnen uitoefenen op de trade-off tussen capaciteitsbenutting en de doorstroom van patiënten, door gebruik te maken van specifieke typen gereserveerde plekken. Daarnaast laat het managers, planners en artsen zien dat, wanneer het gaat om planning en beheersing, ze het belang van samenwerking moeten inzien, willen ze de doorstroom van patiënten verbeteren en daarmee wachttijden verkorten. Als laatste wijzen we managers op welke factoren ze zich zouden moeten richten, willen ze integratie bevorderen.

Dit onderzoek is slechts het begin van verder onderzoek naar de relatie tussen integratie en de doorstroom van patiënten in ziekenhuizen. Dit proefschrift biedt een hele nieuwe reeks van mogelijkheden tot verder onderzoek, waarvan de meest belangrijke het verder onderzoeken van de limieten van integratie is; oftewel, wanneer houdt integratie op een voordeel te zijn en wordt het een last? Ook onderzoek naar een set van universele prestatiedoelstellingen en gerelateerde prestatie indicatoren die representatief zijn voor een zorgproces is belangrijk, omdat prestatiedoelstellingen en –indicatoren afgeleid van de productie-industrie onvoldoende geschikt zijn. Als laatste zou de vermindering van variabiliteit veroorzaakt door het ziekenhuis zelf een belangrijkrijk onderwerp van wetenschappelijk onderzoek en managementfocus moeten zijn.

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