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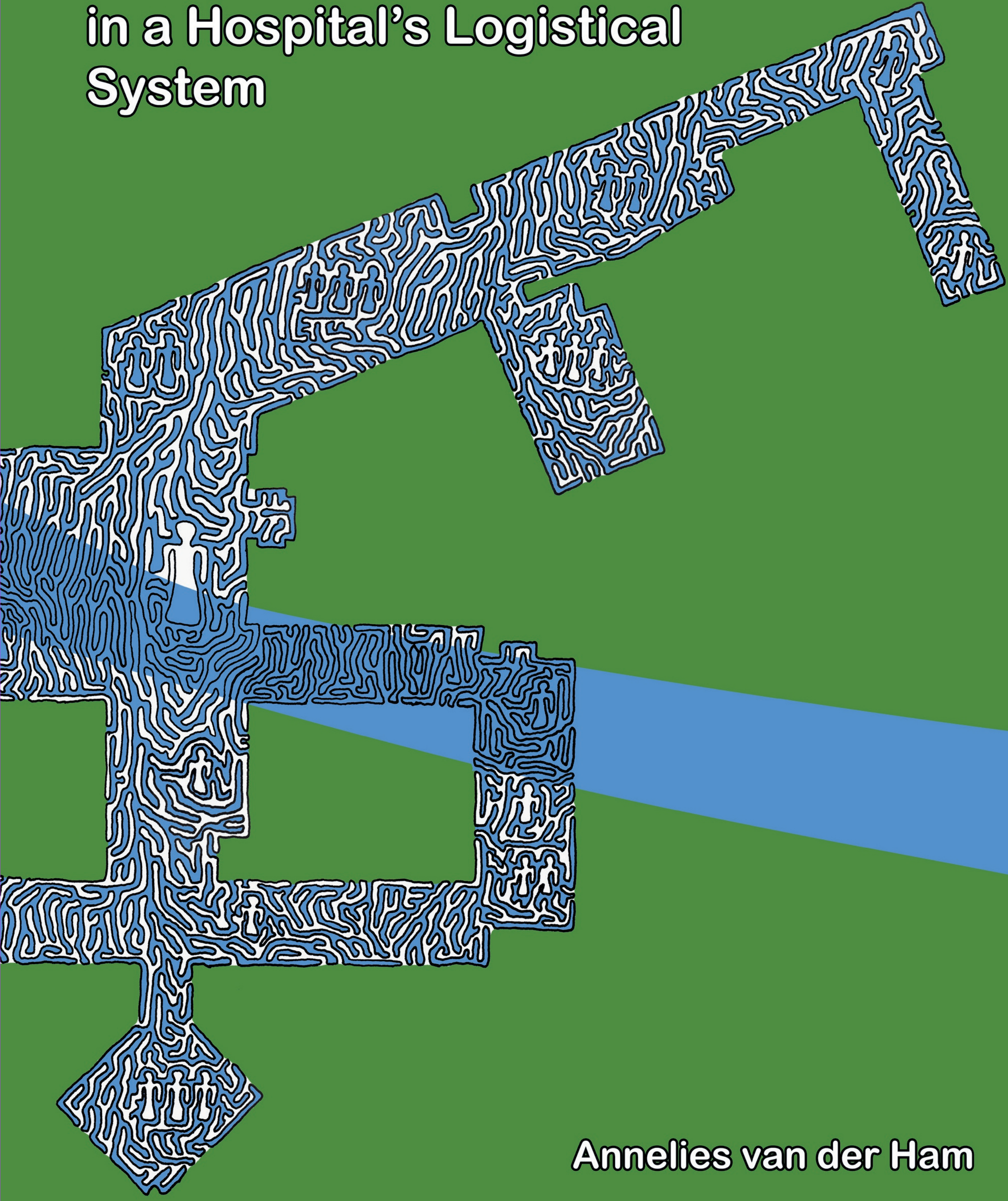

Annelies van der Ham

Integration and Differentiation in a Hospital's Logistical System

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Integration and Differentiation in a Hospital’s Logistical System

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Annelies van der Ham

Promotores
Prof. dr. G.G. van Merode
Prof. dr. D. Ruwaard

Copromotor
Dr. A.J.A van Raak

Beoordelingscommissie
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Dr. D. D. Westra

‘The flexibility and weakness of water make it stronger than strength’

François Jullien

CONTENTS

CHAPTER 1

GENERAL INTRODUCTION

GENERAL INTRODUCTION

"Next week, we will have four patients reporting hip fractures. They are not expecting to break their hip, but they will. We know, because we always have 4 cases at least, and sometimes 5, or even 10. We treat 300 hip fractures every year. This number is rising a bit, but not dramatically. So, we are able to plan accordingly."

"I have a schedule and I look at it to see what I will be doing this week and when. There is no point in looking further ahead, because everything will change anyway."

These two seemingly contradictory statements from a surgeon in Slingeland Hospital nicely illustrate what organizing healthcare is about. As John Lennon put it, 'life often happens to you while you're busy making other plans'[1]. While healthcare is about life, about preserving and improving it, organizing healthcare is about making sure that the resources to do so are there at the right place and time, even when, or rather, in particular when 'things happen'. From the perspective of large numbers of people having similar and more or less predictable life cycles, healthcare could perhaps be planned. For individual people with specific needs or experiencing extraordinary events such as accidents or long-term illness, adaptation to specific and changing circumstances is key. And, as healthcare services have become increasingly specialized and patient centered, patients more and more have become unique cases. In this context offering affordable and accessible healthcare services on a large scale has become a tremendous challenge.

Worldwide, there have been concerns on how to maintain and improve the accessibility and affordability of healthcare. In the past decades concerns were raised with regard to increased healthcare expenditure. In most countries affiliated with the Organisation for Economic Co-operation and Development (OECD) health spending rises faster than economic growth[2]. The health spending per capita is estimated to grow further at an average annual rate of 2.7% up to an average of 10.2% of the gross domestic product (GDP) by 2030[2].
More recently, the Covid-19 pandemic showed that in many countries healthcare delivery to all people in need of care was put under heavy pressure[3]. In particular hospitals were struggling to provide the healthcare that was asked for and it was observed that even advanced health systems were stretched beyond their capacity[4]. Given these circumstances we believe that new organizational concepts or models are required for keeping our healthcare system 'healthy', i.e., effective, affordable and accessible. This applies in particular for hospitals, because hospitals are a major cost item[5,6].

Fortunately, several researchers before us have thought about hospitals and studied how they can be improved. It is often argued that more attention should be given to hospital logistics and operations, thereby following industries outside the field of healthcare[7-9]. The development of traditionally fragmented logistics in the army[10] to total system integration through concepts such as supply chain management (SCM) is often mentioned as an example for hospitals[7,11-13]. In a hospital context, the concept of integration includes the hospital-wide alignment and coordination of activities along the patient or material flow. In integrated hospitals, patient processes and resources are planned from the perspective of the total system[14], in which the coordination of operations between the different members of the chain should improve the entire patient flow[15]. Hospital-wide cooperation is a key issue in achieving high efficiency and quality in hospitals[16].

Literature also states that despite the much advocated integration in literature, the question of how integration is achieved in practice is relatively unaddressed, and improving hospitals is considered complex[8], hard[12], extremely challenging[17,18] or even problematic[11]. Inspired by the work of Jullien[19], who explains that a full understanding of factors that determine the course of things is important for achieving effective transformation, we therefore ought to take a deep dive into hospital practice. As described by Jullien in the context of warfare, this means that 'any operation to be undertaken before engaging in battle must be an operation not of planning but of 'evaluation', or more precisely, 'assessment'[19]. Therefore, the main part of the research undertaken for this thesis involves the assessment of functioning of hospitals and of integration and the inextricably linked differentiation in particular. The concepts underlying this assessment are introduced in this chapter and summarized in Table 1.1.

Integration, differentiation and fragmentation

Much has been written on integration, and it is used by people in different meanings[20]. Because little research has been conducted on how integration is achieved in a healthcare context[11], we look at other fields of research, where the concept of integration has been more developed. The word is related to the Latin verb 'integer', which means 'to complete'. It has to do with bringing things together, things that would have been otherwise separated. With regard to organizations, Drupsteen et. al.[21] state that integration involves aligning different departments in such a way that an organization functions 'as a unified whole'. In the context of organizations, integration is typically referred to in terms of interaction, collaboration, and cooperation[20].

Lawrence and Lorsch[22] have studied integration in several industries and found that both integration and differentiation are essential in order for organizations to perform effectively. They made a major contribution to contingency theory, which views organizations as open systems in which the behaviour of members are interrelated. They define integration as 'achieving unity of effort among the various subsystems in the accomplishment of the organization's task'[22]. Differentiation refers to 'the state of segmentation of the organizational system into subsystems'[22]. Subsystems execute a part of the organization's task and 'develop particular attributes in relation to the requirements posed by their relevant external environment'[22]. Subsystems and how these are defined, therefore depend on the requirements of the external (sub)environment and how tasks are divided into subtasks and this may change over time. When subsystems perform subtasks individually, without the efforts of each subsystem being integrated to achieve unity of effort, there is fragmentation. Subsystems can develop a primary concern with their own goals when dealing with their particular (sub)environment. This may lead to different parameters being used and pursued by different parts in one organization.

Social network analysis

The more recent research field of social network analysis (SNA) also addresses integration. Social network analysis offers a means of mapping connections between agents, e.g., people or organizations, in a mathematical way. Many of the concepts in SNA are derived from graph theory[23], as points and lines represent agents and their connections, called ties. SNA includes several metrics that characterize the nature of the network and the positions of agents in it, as defined in Table 1.1.

For integration in organizations, several authors[23-25] mention network metrics to indicate integration or networks, thereby often referring to coordination between people, groups or organizations. Differentiation is also mentioned in literature pertaining to social network analysis, when referring to tasks being differentiated[24,26], but there are no specific metrics used that refer to differentiation explicitly. In his book, Kilduff[23] states in a chapter on social network analysis that 'we await a full-blown contingency theory analysis of how trust-based coordinating mechanisms facilitate differentiation and integration'. The fact that this theory doesn't yet exist could be attributed to the widely reported 'embryonic' stage[27] of social network analysis, as shown by two literature reviews[27,28].

At the same time, several studies view social network analysis as promising[23-27,29,30]. Benham-Hutchins and Clancy[29] view social network analysis as a new and creative method that is required to meet the complex problems of leaders in modern healthcare organizations. In multiple, mostly exploratory studies, a relation between network structure and the performance of healthcare organizations or networks has been reported, both in terms of quality of care as well as efficiency. For example, Provan and Sebastian[24] indicate that organizations perform more effectively when integration is established through small groups of highly connected agents, when agents are included in multiple groups. Haythornwaite[30] points out that groups with strong relationships facilitate information exchange. Several authors mention the utility of 'brokers' or 'integrative devices' that join groups which are disconnected[22-24,30]. Various studies report tentative results in which a link is made between the network structure and performance parameters such as surgery lead time[31], hospitalization cost[26,32], process efficiency[33], readmission rate[26] and patient quality and safety outcomes[34]. At the same time, these studies are said to provide weak evidence, which is attributed to the fact that social network analysis is an upcoming method[28].

Rules and coordination mechanisms

In both social network theory and literature pertaining to integration often coordination is mentioned as a core activity[22-25,35]. According to Mintzberg[35], different types of coordination connect differentiated activities, which result from the division of labor. For each coordination mechanism, as defined in Table 1.1, different interaction between agents is required.

Coordination mechanisms are based on rules. For example, direct supervision (Table 1.1) is based on hierarchical rules, i.e., who is given the authority to make decisions and issue directives. Standardization of work (Table 1.1) is based on rules on how to perform tasks, which may result in interaction between those who design work processes and those who perform the tasks defined in it. According to Mintzberg, healthcare organizations are typically characterized as 'professional bureaucracies' because much of the coordination is taken care of by standardization of skills and knowledge[36]. As a result of their training, health care professionals know what to expect from one another, often work alone, and consultations between colleagues are limited to 'a few words scribbled on a paper'[36]. Put differently, and in line with the surgeon's statement at the start of this chapter, healthcare professionals simply know what to expect, based on their professional training and experience.

Table 1.1: Definition of concepts.

Concept	Definition
Integration	The coordination and alignment of tasks, thus achieving 'unity of effort among the various subsystems in the accomplishment of the organization's task'[22]
Differentiation	The state of segmentation of the organizational system into subsystems'[22]
Fragmentation	The state in which subsystems perform subtasks individually and no effort is made to achieve unity of effort, while demands from the environment require integration.
Social network analysis	
Node	An agent
Tie	A communication link between two agents via email, text message, telephone or face-to-face.
Clique	A set of agents who are all connected to one another.
Density	The number of ties a set of agents has in relation to the number of possible ties they can have.
Clique overlap	The percentage of agents who are members of more than one clique for a specific task.
Degree	The number of ties of one agent.
Betweenness centrality	The number of times a node (agent) lies on the shortest path between other nodes (agents).
Multiplexity	The percentage of agents in a clique for a task who are also members of cliques for other tasks
Rules and coordination mechanisms	
Rule	A defined, accepted or agreed way of performing tasks, which includes what is done, how it is done and what is allowed and what is not allowed.
Mutual adjustment	An agent interacts with other agents about a rule; i.e., what it entails or how to apply it in a specific situation or the application of the rule requires interaction.
Direct supervision	A rule is set and monitored by people with formal authority.
Standardization of work processes	Rules result from specified or programmed working processes.
Standardization of output	Rules include specified output in terms of predetermined standards for services or performance.
Standardization of skills	Rules include specified skills and knowledge.
Standardization of norms	Rules result from a common culture or ideology and specify norms for behaviour.

However, the much advocated integration in hospitals suggests that there is more to hospital effectiveness than the healthcare professionals' confidence in knowing what to expect. By identifying all coordination mechanisms in the hospital, the interaction between agents is explained, thereby mapping the information processing structure. As a consequence, the network structure, i.e., integration and differentiation, is explained.

AIM AND OUTLINE

Aim

The aim of this thesis is to thoroughly understand how a hospital's logistical system works, i.e., to what extent there is integration and differentiation and how rules and coordination mechanisms shape the hospital's network structure. To this end, the current state of affairs in literature with regard to hospital logistics and operations was studied, and three case studies were conducted in Slingeland Hospital. More specifically, four steps were undertaken for this research, each with a more specific aim:

1. To understand the state of affairs in hospitals with respect to logistics and integration and, in particular, identify logistical parameters that are mentioned in the international literature with regard to hospital logistics and the way literature reflects integration in hospitals.
2. To understand how a hospital's logistical system works in practice and in particular to what extent there is integration and differentiation.
3. To explain the integration and differentiation in a hospital by studying the rules and coordination mechanisms that facilitate differentiation and integration.
4. To evaluate whether integration, differentiation, coordination mechanisms and performance change after an organizational intervention that involves the introduction of a hospital planning centre (HPC).

Important to underline is that even though much has been written on the concepts introduced in this chapter and defined in Table 1.1, we take the stance that before we are able to say anything on how integration and differentiation may improve the performance of hospitals, we first need to know how a hospital and, in particular, its logistical system works in practice from a system-wide perspective. The concepts as introduced, are instrumental to this, and not regarded as a proven concept or model. Therefore, a naturalistic inquiry[37] approach as described by De Vries and Beuving, was followed, which basically involves 'studying people in their everyday circumstances'[37], thereby taking 'society as it presents itself naturally'[37]. This approach is particularly suitable for exploration of relatively unknown phenomena and for which a step-wise research planning is required, by defining each research step on the basis of the findings of the previous step.

Outline

The current state-of-affairs with regard to integration in hospitals is presented in **Chapter 2** by identifying the logistical parameters that are mentioned in international literature on hospital logistics.

Chapter 3 describes how a hospital organizes logistical processes and identifies the agents and the interactions for organizing logistical processes; it establishes the extent to which there is differentiation, and whether these tasks are coordinated and aligned, thus achieving integration. **Chapter 4** explains the integration and differentiation according to **Chapter 3** by describing the rules and coordination mechanisms that agents in a hospital network use. **Chapter 5** evaluates the changes in integration, differentiation, coordination mechanisms and performance after a hospital planning centre (HPC) was introduced. In **Chapter 6,** the main findings of this study are described and the theoretical and methodological aspects of this study are reflected upon. In addition, in **Chapter 6** future directions for practice, policy and research are discussed.

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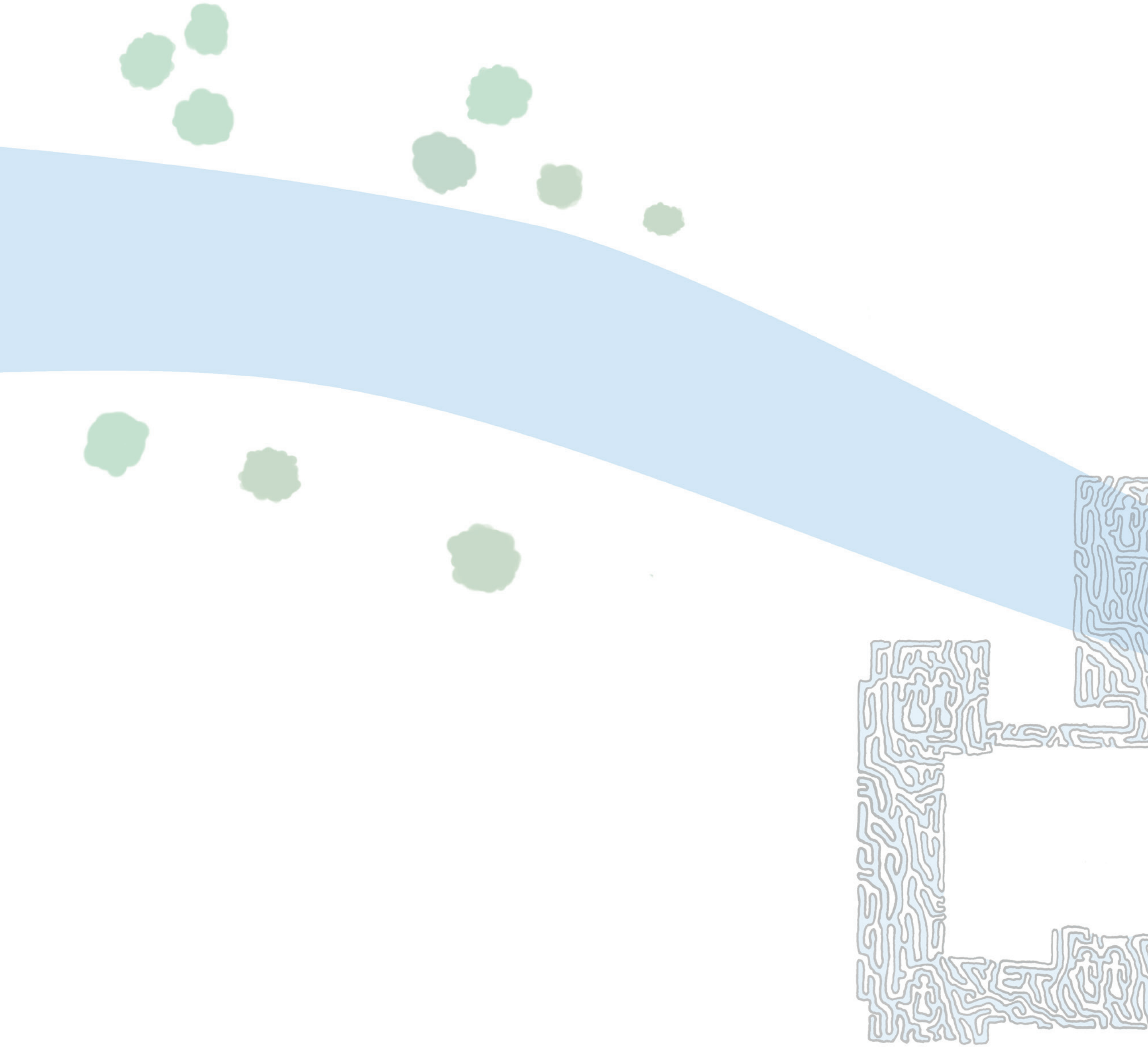

CHAPTER 2

IDENTIFYING LOGISTICAL PARAMETERS IN HOSPITALS: DOES LITERATURE REFLECT INTEGRATION IN HOSPITALS? A SCOPING STUDY

Annelies van der Ham, Henri Boersma, Arno van Raak, Dirk Ruwaard and Frits van Merode

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ABSTRACT

In order to improve the quality and efficiency of hospitals, they can be viewed as a logistical system in which integration is a critical factor for performance. This paper describes the results of a scoping study that identifies the logistical parameters mentioned in international research on hospitals and indicates whether literature reflects system integration. When subsystems collaborate in order to accomplish the task of the entire organization, there is integration. A total number of 106 logistical parameters are identified in our study. In addition, the flow type – patients, materials and staff – and hospital subsystems were registered. The results presented in international literature show that logistics is highly fragmented in hospitals. Studies also show integration, though this takes place mainly within the subsystems of hospitals. A multi-agent perspective on hospitals is proposed, following the view that both integration and differentiation are essential for effective organizational performance. Given the widely recognised importance of controlling hospital costs and the potential of logistics to help in this process, it is important to gain more knowledge of hospitals as network organizations, as well as knowledge regarding the degree of integration and the logistical parameters that are required for better hospital performance.

INTRODUCTION

Healthcare costs are increasing in many countries[1]. Governments are looking for ways to control healthcare costs to guarantee, maintain or even improve the quality, accessibility and affordability of their healthcare systems[2]. There is increasing concern about the growth of healthcare spending[3]. Hospitals are a major cost item[4], so there is a particular focus on hospitals when it comes to controlling the costs of health care.

In many industries outside the field of health care it is argued that well-functioning logistics positively affects the operations of an organization[5]. Logistical optimisation has led to cost efficiency, quality improvement and customer satisfaction. It is argued that this can also be applied to hospitals[6,7].

In the literature it is argued that, although a well-functioning logistical system is critical for the overall functioning of healthcare operations, this support service is largely underestimated in hospitals[8]. Further, it is stated that 30 to 40% of hospital expenses are invested in various logistical activities[5,6,9], and that almost half of the costs associated with supply chain processes could be eliminated through the use of best practices. These claims suggest that logistics is not given the attention it deserves.

Before the 1950s, logistics was thought of in military terms[10]. In those years, activities that are currently associated with logistics were organised in a fragmented way. There have been many changes since then; over time, a more integrated and broader perspective on logistics has been adopted[5,11]. With the introduction of Supply Chain Management (SCM), the perspective changed from that of total cost integration to total system integration. SCM includes a chain orientation[11], encompassing all activities from their origin to the point of consumption[5]; it aims to increase performance through the better use of internal and external capabilities[12] and is about everything that adds value for the customer and enhances competitive advantages[13]. In addition to SCM, there have been other theories and methods, such as lean six sigma, that promote integration[14].

Healthcare logistics has been addressed in several studies, including overviews of literature on healthcare logistics[5,6,11,15] and operations management[16]. These studies consistently point out that academic research in this field is lacking[6,16] and that existing knowledge in the field is fragmented. It is suggested that health care is behind with respect to implementing SCM practices[11].

The alignment of activities along the patient or material flow, often referring to the concept of integration, is central in the literature pertaining to logistics, SCM and lean perspectives in hospitals. Several papers state that the lack of integration within a hospital setting is attributable to the functional organization of medical disciplines and their facilitating departments, which do not share fixed resources[16-18]. In integrated hospitals, patient processes and resources are planned from the perspective of the total system[19], in which the coordination of operations between the different members of the chain improves the entire patient flow[20]. Aronsson states that in order for an organization to be effective, a supply chain strategy is required for the system as a whole[6]. In a more integrated perspective, attention is claimed for all hospital processes and resources[21], instead of focusing on an individual department, such as the Operating Room (OR) or the Intensive Care Unit (ICU). On a regional level, Poulin claims that horizontal inter-organizational arrangements in relation to supply chain management are largely understudied[9]. It is not surprising that the literature argues that a systematic logistical approach to hospital strategy would lead to more efficient hospitals[6,20]. With regard to cooperation, Ludwig, Van Merode and Groot[17] state that cooperation is a key issue in achieving high efficiency and quality in hospitals, not only on a departmental, but also on a hospital-wide level. Evidence was found that efficient departments in a hospital did not necessarily make the entire hospital efficient[10]. Inter-departmental cooperation not only increases efficiency but also leads to better service for patients[22,23]. Accordingly, cooperation is considered essential for hospital efficiency on a departmental as well as on the hospital-wide level.

Despite the evident need for more integration, De Vries[11] remarks that the question of how integration can be achieved is relatively unaddressed in healthcare settings. In addition, he states that the application of SCM is considered to be more complex in healthcare settings and may require a different approach than in other industries.

Lawrence and Lorsch state that both integration and differentiation are essential in order for an organization to perform effectively[24]. They define integration as ‘achieving unity of effort among the various subsystems in the accomplishment of the organization's task’. Differentiation refers to ‘the state of segmentation of the organizational system into subsystems’. Subsystems execute a part of the organization’s task and ‘develop particular attributes in relation to the requirements posed by their relevant external environment’. A subsystem therefore is not necessarily a fixed part of the organization, but its definition depends on the requirements of the external (sub)environment and how tasks are divided into subtasks[24].

When subsystems perform subtasks individually, without the efforts of each subsystem being integrated to achieve unity of effort, there is fragmentation. Therefore, when studying hospital logistics, all the relevant parts of the system should be included, rather than examining the contribution of each department individually[16]. A strong emphasis on process orientation in research[11], instead of focusing on functional silos, is in line with this perspective.

According to Lawrence and Lorsch[24], subsystems can develop a primary concern with their own goals when dealing with their particular (sub)environment. This may lead to different parameters being used and pursued by different parts in one organization. Given the recommendations in the literature on logistical approaches and more integration in hospitals, it would be interesting to know which logistical parameters are used in hospitals. Therefore, in order to thoroughly understand the state of affairs in hospitals with respect to logistics and system integration, this research addresses two questions. Which logistical parameters are mentioned in the international literature with regard to hospital logistics? In what way does the literature reflect system integration in hospitals?

METHODS

As hospital logistics is a broad topic, a scoping study was conducted. As opposed to a systematic review, this type of literature research addresses broader topics in which many different study designs are applicable[25].
Given the breadth of the concepts included, it was considered unlikely that we would be able to address very specific research questions or that we would be able to assess the quality of the studies included, as most systematic reviews aim to do. It is argued that scoping studies can be undertaken as methods in their own right, especially in the case of complex topics that have not been extensively reviewed previously[25]. We believe that this is the case with our research. The main goal of the scoping study is to summarise and thus disseminate our findings to strategy and policy makers, as well as to hospital practitioners.

Identifying relevant studies was done through a number of searches in PubMed, Ebscohost and JSTOR. PubMed was selected because it includes a large number of international and clinical articles. Ebscohost is also internationally oriented and has a large number of articles, but is focused on business economics. In addition, JSTOR was used for both areas, as business and life sciences are included in this database, as well as mathematics and statistics, which are often used in logistics.

Only articles written in English and from the period 2006-2016 were included. Even with these restrictions, initial searches using the keywords 'Logistics' and 'Hospital' led to over 400,000 articles. It was therefore decided to start with a search for these keywords in the Title and Abstract of articles only. The argument was that this would result in a set of articles for which the main topic would be logistics in hospitals.

The first search for 'Hospital' and 'Logistics' in PubMed, Ebscohost and JSTOR resulted in 414 articles. In order to identify other search terms, articles referenced in the 414 articles were analysed. Through an iterative process of searching, the following keyword searches identified:

- Hospital AND Logistics
- Hospital AND Process AND Flow
- Hospital AND Supply Chain Management
- Hospital AND Operations Management

The articles found in these searches were all recorded in an Endnote database. All articles were screened for logistical parameters by reading the abstract. For each article, the parameters mentioned were noted. These could be parameters that were explicitly studied or parameters considered relevant to the research topic.

For each of the articles that mention logistical parameters, not only was the parameter captured in a database, but the logistical flow type in hospitals – patients, materials and staff – was also noted. The first argument for this was to see what parameters were used in the context of each flow type and to see whether there were similarities or differences in the parameters between these different flows and processes. The second argument was to see whether these flows, which come together at the end of the supply chain in, for example, the operating room, have been studied in relation to one another. In cases where a combination of these flow types was included in the article, such data was registered as well. In addition to this, for each article it was noted whether the logistical parameters were used in a hospital-wide context or in a specific part of the hospital. In case the abstract did not reveal the context, the full text of the article was read. The part of a hospital a study focuses on was also included in the database.

The logistical parameters found were then clustered into concepts. The concepts were identified by first splitting all logistical parameters into separate words – i.e. 'Transport Distance' resulted in two words: transport and distance. All words that represent a variable that could be quantified were labelled as a performance variable. Thus, in the example of 'Transport Distance', 'Distance' was labelled as a variable. All parameters that included the same variable were clustered into a concept. In the example of 'Transport Distance', all parameters including the term 'distance' were clustered in the concept of 'Distance'.

In order to establish the saturation level in a systematic way, the number of new parameters accumulated with each search was counted. One search is defined as one unique combination of keywords in one database (PubMed, Ebscohost, JSTOR), i.e. 'Hospital and Logistics' in PubMed. Saturation was reached when, in two searches, no new parameters were found. In addition to this, the number of new logistical parameters accumulated with each article in relation to the other articles was also calculated.

The parameter occurrence was measured as follows:
$P_n=p_x/n$ the number of times a unique parameter is mentioned ($p_1 \ldots p_{106}$) in relation to the total number of articles (n), presented as a percentage.

An independent reviewer assessed the search results by reproducing them. In addition, the reviewer took samples from the article database to see whether the logistical parameters identified matched those in the articles. The saturation level and the results were also verified by the reviewer. To ensure saturation was still established when using Web of Science, we selected and screened the abstracts of papers using the defined keyword searches.

RESULTS

Articles

The searches led to a total of 1,093 articles in the three above-mentioned databases (Figure 2.1). Of the 1,093 articles, 47 duplicates were excluded. All the remaining 1,046 articles were screened for logistical parameters by reading the abstract. No logistical parameters were found in 759 articles, so these articles were thus excluded from further analysis. In 287 articles, logistical parameters were mentioned (Figure 2.1). For these 287 articles, included in Appendix 2.1, the parameters mentioned were noted. These could be parameters that were explicitly studied or parameters considered relevant to the research topic.

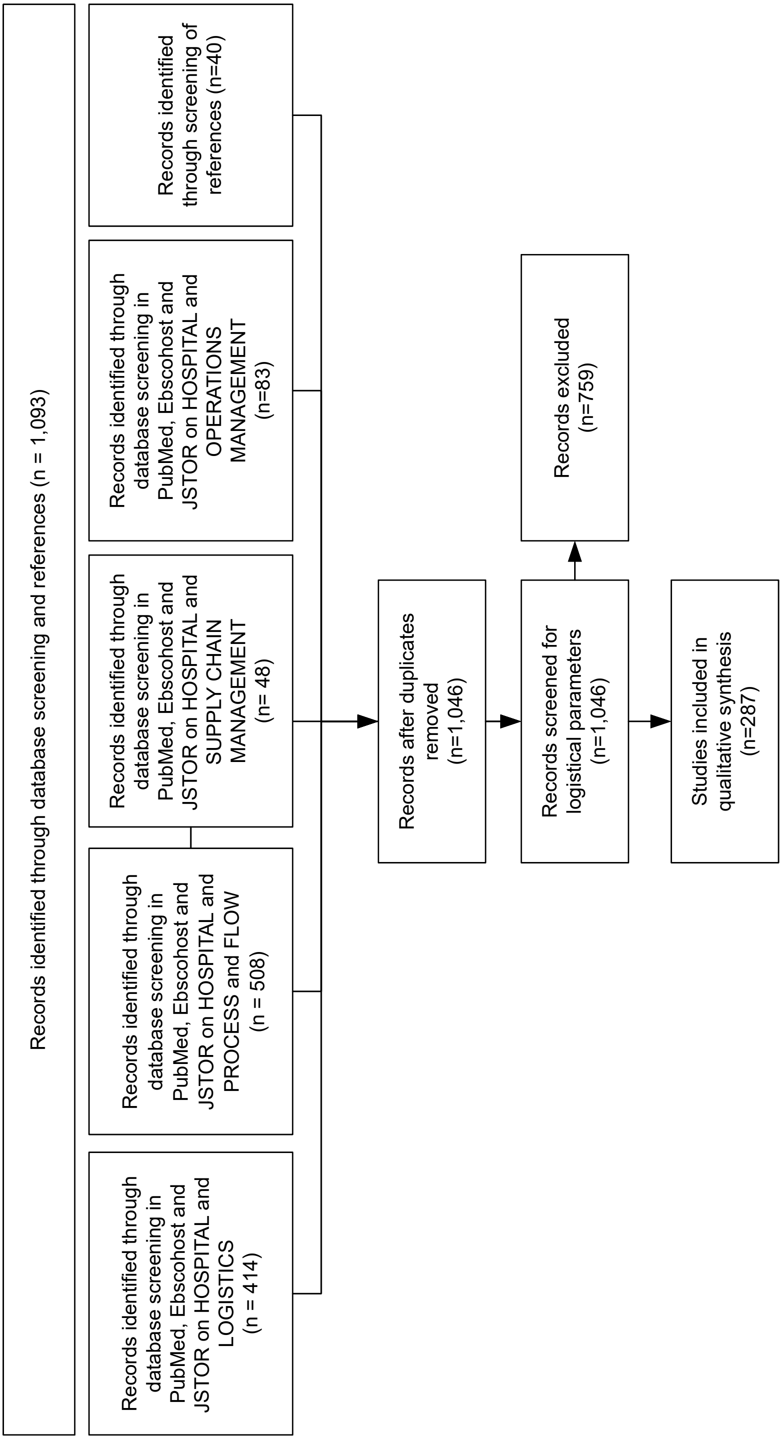


Figure 2.1 Search strategy presented according to PRISMA[26]

Logistical parameters

In the 287 articles, 106 different logistical parameters were found. The saturation level was reached when at some point no new parameters were found in the consecutive screening of abstracts. Another indication that no other logistical parameters were to be found and saturation had been reached was the fact that in 82 articles a new parameter was found and in 209 articles no new parameters were found. Based on this, it was considered unlikely that more new logistical parameters would be found and saturation was established. This was confirmed by an independent reviewer. In Appendix 2.2, all 106 parameters are presented in alphabetical order, including the relative number of times that a parameter was, as a percentage, mentioned in the set of 287 articles.
In total, 24 parameters comprise 80% of the total number of times a parameter was found in an article. The remaining 20% is made up of 81 different parameters. It is also observed that 79 parameters are mentioned in less than 1% of all articles. This suggests a relatively large variety of logistical parameters, which, perhaps, are not frequently used under the same name.

To provide an overview on the parameters mentioned most, Figure 2.2 shows the 27 parameters that are mentioned in more than 1% of the articles. Length of stay is the most mentioned parameter, cited in 30% of the 287 articles, followed by waiting time and wait time (28% in total), resource utilisation (18%) and lead time (16%). Cost and delay are also mentioned frequently, in 15% and 10%, respectively, of the articles.

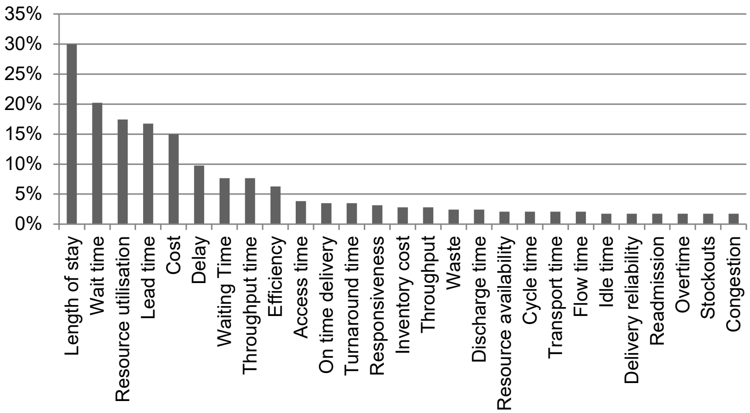


Figure 2.2 Parameter occurrence (P_n) of 27 parameters in relation to the total number of articles (%)

Looking at all the parameters, it is noticeable that the same or similar words are used in the names of different parameters. In all 106 logistical parameters, 11 words referring to a performance variable were used in the name of more than one parameter: Time, Cost, Availability, Utilisation, Distance, Spent, Throughput, Efficiency, Length, Occupancy and Reliability. These terms refer to concepts, in which the parameters could be clustered. In the definition of the concepts, 'Spent' and 'Occupancy' were eliminated as separate concepts. 'Spent' was eliminated as a cluster, since it refers to either time or money (cost) spent. 'Length' was also not considered as cluster, because it refers to time or distance. 'Occupancy' was seen as similar to 'Utilisation'. This resulted in eight clusters. In total 81 logistical parameters fit into one of these concepts. Another nine parameters referred to four additional concepts that were then added: Waste, Responsiveness, Rework and Waiting patients. The remaining 16 parameters were not clustered into a concept, but labelled as 'Miscellaneous'.

In total 90 parameters could be clustered into 12 concepts. The results of the clustering are presented in Appendix 2.3. Time is clearly the concept mentioned most: 39 logistical parameters refer to time and 14 of the most mentioned parameters (Figure 2.2) are related to time. Note that 'Length of stay' and 'Delay' are included in the concept of Time. In this case, it is clear that 'length' does not refer to distance but to time duration. 'Delay' is also clearly expressed as time duration.
Cost also seems to be important, as parameters related to cost are mentioned in 11% of all the parameters noted. Utilisation and availability both refer to resources; the resources mentioned in the logistical parameters are beds, materials (e.g. inventory, stock), space, infrastructure (e.g. floors, elevators, warehouse) and staff.

Given the argument that logistics includes an integral way of thinking, it is remarkable that 47% of the articles refer to one parameter. Two parameters are mentioned in 26% of the articles and more than three different parameters are mentioned in 27% of the articles.

Logistical parameters according to flow types

Most articles found are on patients, as shown in Figure 2.3. In 83% of the articles, patient flows are the only logistical flow mentioned. Almost 12% of the articles are on materials. The minority of articles is on staff (2%) or had no specific focus (2%). In 1% of the articles, both materials and patients were mentioned.

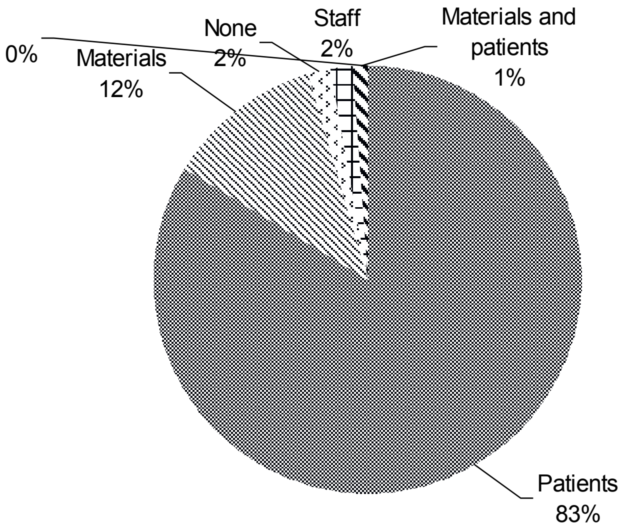
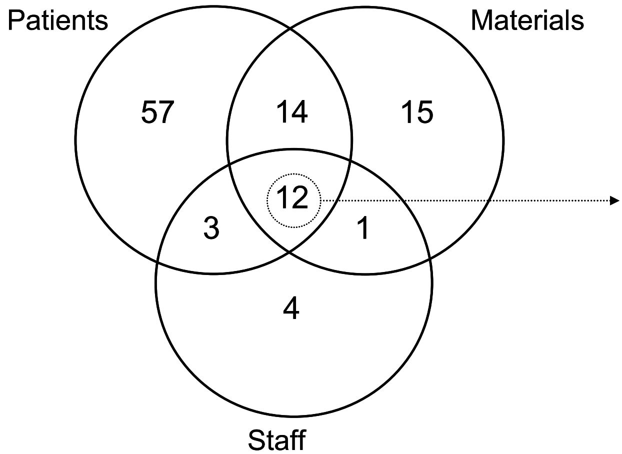


Figure 2.3 Flow types in the articles.

By observing what logistical parameters are mentioned for each flow type, it can be observed that each flow type has both different and similar parameters. First of all, it is remarkable that the terminology used in a patient flow context is different from the terminology used in a material or staff flow context. If we look at the ten most mentioned parameters per flow type, 'Efficiency' and 'Lead time' are the only two parameters which are mentioned in all three contexts of patients, materials and staff. In addition to this being a difference in terminology, it suggests different priorities per flow type.

Figure 2.4 shows how many logistical parameters are mentioned in the context of each flow. A total of 76 parameters are mentioned in the context of one flow type: 57 parameters in the context of patient flow, 15 in materials and four in staff flows. Twelve parameters are mentioned in all flow type contexts, i.e. in patient, material and staff flows.



Logistical parameter	Parameter occurance (Pn)
Lead time	16%
Cost	15%
Waiting Time	8%
Efficiency	6%
Access time	4%
Responsiveness	3%
Resource availability	2%
Delivery reliability	2%
Stockouts	2%
Capacity utilisation	0,3%
Inventory waste	0,3%
Occupancy rate	0,3%
Processing waste	0,3%

Figure 2.4 Number of logistical parameters per flow type or combination of flow types.

Hospital-wide or subsystem

Looking at the context of the studies in the 287 articles, 15% of all articles mention logistical parameters in a hospital-wide context[20,27,28]. The other 85% of the articles mention logistical parameters in a specific context or subsystem of a hospital. We regard a subsystem as a part of the organization that performs a portion of the organization's task. We found three types of subsystems: a department, flow type and process type.
There are several studies on the Emergency department (18%), the Operating Theatre department (6%), the Intensive Care department (3%) and Nursing departments (3%).
Studies on specific flow types focus, for example, on blood logistics (2%) or orthopaedic patients (1%). There are also studies on specific processes, such as the discharge process (2%) or the internal transport process (2%).

In total we identified 92 subsystems in 287 articles, as presented in Appendix 2.4. For 64 subsystems (22%), there was only one article in that specific context mentioning logistical parameters. As an example, we mention ten subsystems for which our database includes one article: ancillary services departments, the process of giving injections, paediatric cardiac patients, hip fracture patients, the pre-operative department, HIV/aids patients, ambulatory surgery patients, the inpatient rehabilitation department, patient transfer, laparoscopic patients, the sterilisation department and medical equipment.

DISCUSSION

The results of this scoping study indicate that there is fragmentation of logistics in hospitals, as reported in the international literature. The 106 parameters could be clustered into 12 concepts, but the fact that these parameters are used in 92 subsystems leaves us with questions as to whether logistical parameters have the same meaning or serve the same purpose in these different subsystems. A clear integrated view of hospital performance control or improvement could not be derived from the international literature on logistical parameters.

It is also observed that many logistical parameters were either defined in an ambiguous way or were not defined at all in the literature. Wait time and waiting time are clearly two words with the same meaning, but lead time and throughput time are, perhaps, not. Moreover, in a patient flow context, lead time could be measured in a different way than when examined in a material flow context. In many articles this was neither explained nor specified.

Fragmentation is also demonstrated as almost 50% of the articles mention only one parameter, indicating that many studies fail to analyse performance along more than one dimension. In addition, different parameters seem to be important to different logistical flows. Frameworks that have been developed in the past provide structure, but employ a limited perspective on material flows[29] and/or on patient flows[30].

At the same time, there is a certain integration included in the studies analysed in this scoping study. Several studies apply an integrative approach to a part of the hospital. This could be a department, flow type or process. However, integration of patient and material flows within one department or process does not necessarily mean that an entire hospital's performance will increase. If a study shows, for example, that the integration of the healthcare process for acute patients improves the hospital's performance for these patients, it is not clear whether this benefits the entire hospital. The articles found show separate parameters without cohesion. There does not seem to be a clear concept on how logistics for the hospital should function as a whole and how integration and differentiation of tasks contribute to the hospital's performance overall.

From this scoping study we therefore conclude that logistical parameters are numerous, ambiguous, and used in very different contexts in the international literature. When combined, these do not reflect an integrated approach with regard to (the study of) hospital logistics. This leads to the question of the possible reasons for this, especially when considering that integration is regarded as essential.

We could argue that research has not yet given much attention to logistics from the perspective of integration. However, given the many articles that claim the necessity for integration in hospitals, logistics does not appear to be irrelevant to hospitals. In a patient context, there is certainly attention shown in the international literature for improving both length of stay and waiting times, as illustrated by the 143 articles that mention these parameters. Also, numerous studies have been conducted on logistics in Emergency Departments. Moreover, frameworks have been developed for assessing logistical performance, clearly indicating a need for controlling and improving hospital logistics. Repeatedly, the relevance of an integrated perspective on hospitals is presented in the literature[6,11,17,19,20,22].

Several studies note that logistics in a hospital could be too hard to oversee. Researchers state that understanding and improving hospitals is complex[6], hard[32], extremely challenging[30,31] and problematic[11]. This scoping study supports evidence for this argument. Studying 106 different parameters in three different flow types and in 92 subsystems appears to be something of a 'mission impossible' for researchers. This might explain why there is no complete, empirical-based theory of hospital logistics.

The challenges faced by researchers on hospital logistics might also have serious implications for the management of a hospital, particularly for strategic management. Given the large investments made in hospitals, and the need to control healthcare costs, we consider an integrative perspective on hospitals and the inclusion of logistical parameters in strategic decision making to be important. However, we agree with De Vries[11] that there is a current need to better understand *how* to do so. We would like to add the question of *what* integration is in a hospital.

We believe integration includes coordination and cooperation between entities that function together as a unified whole. Hospitals should be seen as a network of more or less dependent agents. Agents are capable of autonomous actions and base their actions on the environment in which they are situated in order to meet their own objectives[33]. To what extent integration is required depends on what services are demanded from agents by their environment and to what extent they need to align and coordinate their activities with those of other agents in order to deliver the required service.
It is also important to state that integration should serve a purpose. The purpose depends largely on what demands agents in the hospital's environment put to the hospital or its

agents. Agents in the environment could be patients, general practitioners or entire communities. In theory, there could be too much integration, especially when it does not add further value. Following the same reasoning, fragmentation could be effective if an agent is capable of providing good service without having to coordinate with other agents. In that case we should rather speak of differentiation[24].

It would be interesting to gain more knowledge of the cases in which integration and differentiation are essential for hospital performance and what circumstances play a role in this. We need to know what agents are part of a hospital, to what degree they should or should not act independently, and to what extent integration or alignment between agents is required for improvement of a hospital's overall performance. Further research should lead to new frameworks, consisting of multiple parameters relating to the interests of individual agents, as well as, on hospital-wide level, relating to the various demands stemming from the hospital's environment.

This scoping study certainly has its limitations: the international literature does not, by definition, reflect what really happens in hospitals. It could be the case that multiple agents in the hospital interact, negotiate or coordinate activities, but that this is not known publicly, perhaps for reasons of confidentiality. Another reason could be that there is literature on integrative approaches, but that it is not described in logistical terms. This could be explained by the fact that most people working in hospitals – i.e., doctors, nurses – do not use logistical terms. Further empirical research on how logistical networks of agents in hospitals work, what parameters they use, and whether and when integration or differentiation are detrimental or in fact beneficial to a hospital's performance is therefore recommended.

This study provides an overview of all possible logistical parameters in hospitals; these are used in several contexts and need further structuring in order to be useful in practice. It should therefore be seen as a starting point for further research in which these findings are explored from a multi-agent perspective. In future research, hospital agents could be identified, as well as the various networks of agents interacting in subsystems. The study of what logistical parameters they use for optimising their interests and how these should be used and managed in an integrated way could make an important contribution to the improvement of hospital performance.

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APPENDIX 2.1: REFERENCES RESULTING FROM THE SCOPING STUDY

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APPENDIX 2.2: LOGISTICAL PARAMETERS FOUND IN THE SCOPING STUDY

In this appendix all 106 parameters are presented in alphabetical order including the percentage of 287 articles in which each of the parameters is mentioned at least once. The parameters with a higher percentage of occurrence are presented in darker colours.

Table A2.2.1 Logistical parameters

Logistical parameter	Parameter occurrence P_n
Access block	0.35%
Access time	3.83%
Admission time	0.70%
Admission wait time	0.35%
Admittance rate	0.35%
Bed assignment time	0.35%
Bed availability	1.39%
Bed occupancy	1.39%
Bed turn time	0.35%
Bed utilisation	0.35%
Cancelled procedures	0.35%
Capacity utilisation	0.70%
Congestion	1.74%
Cost	14,98%
Crowding	0.35%
Cycle time	2.09%
Dead-bed time	0.35%
Delay	9.76%
Delivery reliability	1.74%
Delivery time	0.35%
Discharge rate	0.35%
Discharge time	2.44%
Distance cost	0.35%
Down time	0.35%
Efficiency	6.27%
Fleet operating costs	0.70%
Floors travelled on elevators	0.35%
Flow efficiency	0.35%
Flow time	2.09%
Hospital cost	0.35%
Hospital occupancy	0.35%
Idle time	2.09%
Immobilized stock	0.35%
Inventory cost	2.79%
Inventory performance	0.35%
Inventory waste	0.35%
Lead time	16.72%
Left without being seen	0.35%
Length of stay	29.97%

Table A2.2.1 (continued)

Logistical parameter	Parameter occurrence P_n
Management cost	0.35%
Material availability	0.35%
Number of waiting patients	1.05%
Number of waits	0.70%
Occupancy rate	0.35%
On time	0.35%
On time delivery	3.48%
On time start	0.35%
Operating cost	0.35%
Outdated inventory	0.35%
Overtime	1.74%
Overtime cost	0.35%
Patient throughput	0.35%
Processing time	0.70%
Processing waste	0.35%
Product availability	0.70%
Productivity	0.35%
Queue length	0.35%
Readmission	1.74%
Reliability	0.35%
Reoperation	0.70%
Resource availability	2.09%
Resource utilisation	17.42%
Response time	0.70%
Responsiveness	3.14%
Safety stock	0.35%
Shelf life	0.70%
Shortage	0.70%
Shortage rate	0.35%
Space availability	0.35%
Space utilisation	0.35%
Staff time spent on logistics	1.05%
Stock cost	0.35%
Stock level	1.39%
Stockouts	1.74%
Supply cost	0.35%
Surgery time	0.70%
Throughput	2.79%
Throughput time	7.67%
Time needed to deliver the service	0.35%
Time spent	0.35%
Time spent on patient	0.35%
Timeliness	0.35%
Total distance traveled	0.35%
Transfer process time	0.35%
Transfer time	0.70%
Transport cost	1.05%
Transport distance	0.70%
Transport frequency	0.35%

Table A2.2.1 (continued)

Logistical parameter	**Parameter occurrence P_n**
Transport time	2.09%
Transport volume	0.35%
Transportation cost	0.35%
Transportation time	0.35%
Treatment time	1.39%
True completion time	0.35%
Turnaround time	3.48%
Turnover ratio	0.35%
Turnover time	1.05%
Usage rate	0.35%
Utilisation of staff	0.35%
Wait time	20,21%
Waiting patients	0.35%
Waiting Time	7.67%
Walking distance	0.35%
Warehouse operation cost	0.35%
Waste	2.44%
Work time spent on work orders	0.35%

APPENDIX 2.3: 106 LOGISTICAL PARAMETERS CLUSTERED INTO 12 PARAMETER CONCEPTS AND 'MISCELLANEOUS'

Table A2.3.1 Logistical parameters clustered

Parameter concept	Logistical parameter by original name	
Time	Access time	Response time
	Admission time	Staff time spent on logistics
	Admission wait time	Surgery time
	Bed assignment time	Throughput time
	Bed turn time	Time needed to deliver the service
	Cycle time	Time spent
	Dead-bed time	Time spent on patient
	Delay	Timeliness
	Delivery time	Transfer process time
	Discharge time	Transfer time
	Down time	Transport time
	Flow time	Transportation time
	Idle time	Treatment time
	Lead time	True completion time
	Length of stay	Turnaround time
	On time	Turnover time
	On time delivery	Wait time
	On time start	Waiting time
	Overtime	Work time spent on work orders
	Processing time	
Cost	Cost	Overtime cost
	Distance cost	Stock cost
	Fleet operating costs	Supply cost
	Hospital cost	Transport cost
	Inventory cost	Transportation cost
	Management cost	Warehouse operation cost
	Operating cost	
Utilisation	Bed occupancy	Occupancy rate
	Bed utilisation	Resource utilisation
	Capacity utilisation	Space utilisation
	Hospital occupancy	Utilisation of staff
	Immobilized stock	Usage rate
Availability	Bed availability	Shortage
	Material availability	Shortage rate
	Product availability	Space availability
	Resource availability	Stock level
	Safety stock	Stockouts
Efficiency	Efficiency	Flow efficiency
Responsiveness	Responsiveness	
Throughput	Throughput	Patient throughput
Waste	Inventory waste	Waste
	Processing waste	

Table A2.3.1 (continued)

Parameter concept	Logistical parameter by original name	
Waiting patients	Number of waiting patients	
	Number of waits	
	Waiting patients	
Reliability	Delivery reliability	
	Reliability	
Rework	Readmission	
	Reoperation	
Distance	Total distance travelled	
	Transport distance	
	Walking distance	
Miscellaneous	Access block	Left without being seen (LWBS)
	Admittance rate	Outdated inventory
	Cancelled procedures	Productivity
	Congestion	Queue length
	Crowding	Shelf life
	Discharge rate	Transport frequency
	Floors traveled on elevators	Transport volume
	Inventory performance	Turnover ratio

APPENDIX 2.4: OVERVIEW OF CONTEXTS IN WHICH LOGISTICAL PARAMETERS ARE APPLIED

Table A2.4.1 Contexts in which logistical parameters are applied

Logistical parameter	Flow type	Object of study	Specification object
1.. Access block	Patients	Department	Emergency department
2. Access time	Patients	Department	Ancillary services department
			Emergency department
			Department of Otorhinolaryngology and nephrology department
			Nursing departments
			Operating Room Department
			Outpatient department
		Flow group	Low acuity patients
		Hospital wide	-
3. Admission time	Patients	Flow group	Emergency colorectal surgery patients
			Emergency patients
4. Admission wait time	Patients	Department	Nursing departments
5. Admittance rate	Patients	Department	Emergency department
6. Bed assignment time	Patients	Hospital wide	-
7. Bed availability	Patients	Department	Nursing departments
		Flow group	Critical care patients
		Hospital wide	-
		Process specific	Discharge process
8. Bed occupancy	Patients	Department	Gynaecology department
			Inpatient departments
			Intensive care department
	Staff	Flow group	Nurses
9. Bed turn time	Patients	Department	Emergency department
10. Bed utilisation	Patients	Flow group	Cancer patients
11. Cancelled procedures	Patients	Process specific	Discharge process
12. Capacity utilisation	Materials, patients and staff	Hospital wide	-
	Patients	Flow group	Psychiatric patients
13. Congestion	Patients	Department	Emergency department
			Outpatient department
		Hospital wide	-

Table A2.4.1 (continued)

14. Cost	All	Hospital wide	-
	Materials	Department	Laboratory department
			Pharmacy department
		Flow group	Assets
			Blood
			Building materials
			Medical equipment
			Medical supplies
			Medication
		Process specific	Transport
	Materials and patients	Department	Pharmacy department
		Process specific	Discharge process
	Materials, patients and staff	Hospital wide	-
	Patients	Department	Emergency department
			Endoscopy department
			Medical nuclear medicine department
			Nursing departments
			Operating Room Department
			Outpatient department
		Flow group	Emergency patients
			Gynaecology patients
			Outpatient surgery patients
			Palliative care patient
			Radiation therapy patients
		Hospital wide	-
15. Crowding	Patients	Department	Emergency department
16. Cycle time	Materials	Department	Nursing departments
	Patients	Department	Department of Otorhinolaryngology and nephrology department
		Flow group	Cardiology patients
			Outpatient surgery patients
		Process specific	Discharge process
			Transport
17. Dead-bed time	Patients	Department	Emergency department
18. Delay	Patients	Department	Cardiology department
			Emergency department
			Endoscopy department
			Intensive care department
			Operating Room Department
			Outpatient department
			PACU
		Flow group	Acute patients
			Cardiology patients
			Emergency patients
			Gynaecology patients
			Nephrology patients
			Neurosurgery patients
			Pregnant women
		Hospital wide	-
		Process specific	Discharge process
			Perioperative process
			Transport
	Staff	Flow group	Nurses

Table A2.4.1 (continued)

19. Delivery reliability	Materials	Flow group	Medical instruments
			Medication
	Patients	Department	Nursing departments
		Process specific	Transport
	Staff	Process specific	Cleaning
20. Delivery time	Materials	Flow group	Medication
21. Discharge rate	Patients	Department	Nursing departments
22. Discharge time	Patients	Hospital wide	-
		Department	Inpatient departments
			Operating Room Department
		Flow group	Cardio surgical patients
			Emergency patients
			Paediatric patients
		Process specific	Discharge process
23. Distance cost	Patients	Process specific	Transport
24. Down time	Materials	Department	Pharmacy department
25. Efficiency	Materials	Hospital wide	-
		Process specific	Transport
	Materials, patients and staff	Hospital wide	-
	Patients	Department	Emergency department
			Intensive care department
			Operating Room Department
		Flow group	Mamma patients
		Hospital wide	-
		Process specific	Patient transfer
			Transport
	Patients and Materials	Hospital wide	-
	Staff	Flow group	Nurses
26. Fleet operating costs	Patients	Process specific	Transport
27. Floors travelled on elevators	Staff	Flow group	Nurses
28. Flow efficiency	Patients	Department	Operating Room Department
29. Flow time	Patients	Department	Emergency department
			Operating Room Department
		Hospital wide	-
30. Hospital cost	Patients	Flow group	Neurosurgery patients
31. Hospital occupancy	Patients	Department	Emergency department
32. Idle time	Patients	Department	Outpatient cancer department
			Radiology department
		Process specific	Transport
33. Immobilized stock	Materials	Department	Outpatient department
34. Inventory cost	Materials	Department	Logistics department
			Nursing departments
			Pharmacy department
			Sterilization department
		Flow group	Doctors employment
			Medical supplies
		Hospital wide	-
35. Inventory performance	Materials	Flow group	Blood
36. Inventory waste	Materials, patients and staff	Hospital wide	-

Table A2.4.1 (continued)

37. Lead time	All	Hospital wide	-
	Materials	Department	Nursing departments
			Pharmacy department
		Flow group	Medical supplies
			Medication
	Materials and patients	Department	Pharmacy department
	Patients	Department	Ancillary services department
			CT department
			Emergency department
			Inpatient rehabilitation department
			Laboratory department
			Nursing departments
			Operating Room Department
			Outpatient cancer department
			Patient transport department
			Radiology department
		Flow group	Acute patients
			Cardiology patients
			Emergency patients
			Head and neck cancer patients
			Hip fracture patients
			Mental patients
			Nephrology patients
			Orthopaedic patients
			Psychiatric patients
		Hospital wide	-
		Process specific	Discharge process
			Perioperative process
			Phlebotomy process
			Preoperative assessment
			Triage process
	Staff	Process specific	Cleaning
38. Left Without Being Seen (LWBS)	Patients	Department	Emergency department

Table A2.4.1 (continued)

39. Length of stay	Materials and patients	Process specific	Discharge process
	Patients	Department	Emergency department
			Emergency dept, OR, bed management
			Inpatient departments
			Intensive care department
			Nursing departments
			Operating Room Department
			Stroke department
		Flow group	Acute patients
			Ambulatory surgery patients
			Bariatric surgery patients
			Cardiac patients
			Cardiology patients
			Cardiac surgical patients
			Cardiovascular patients
			Colorectal cancer patients
			Critical care patients
			Emergency patients
			Gynaecology patients
			Kidney patients
			Laparoscopic patients
			Low acuity patients
			Nephrology patients
			Neurosurgery patients
			Obese lung patients
			Obstetric patients
			Orthopaedic patients
			Paediatric cardiac patients
			Paediatric patients
			Plastic surgery patients
			Stroke patients
			Surgery patients
			Trauma patients
		Hospital wide	-
		Process specific	Discharge process
40. Management cost	Materials and patients	-	-
41. Material availability	Materials	Flow group	Medical supplies
42. Number of waiting patients	Patients	Department	Emergency department
		Flow group	Orthopaedic patients
43. Number of waits	Patients	Department	Emergency department
		Flow group	Emergency patients
44. Occupancy rate	Materials, patients and staff	Hospital wide	-
45. On time	Patients	Hospital wide	-
46. On time delivery	Materials	Department	Nursing departments
		Flow group	Medication
		Process specific	Transport
	Patients	Department	Emergency department
			Endoscopy department
			Intensive care department
			Operating Room Department
		Hospital wide	-
		Process specific	Transport

Table A2.4.1 (continued)

47. On time start	Patients	Department	Operating Room Department
48. Operating cost	Patients	Department	Gynaecology department
49. Outdated inventory	Materials	Department	Laboratory department
50. Overtime	Patients	Department	Chemotherapy department
			Outpatient cancer department
			Outpatient department
			Radiology department
51. Overtime cost	Staff	Flow group	Nurses
52. Patient throughput	Patients	Process specific	Discharge process
53. Processing time	Patients	Flow group	Outpatient surgery patients
		Process specific	Transport
54. Processing waste	Materials, patients and staff	Hospital wide	-
55. Product availability	Materials	Flow group	Medical supplies
	Patients	Process specific	Giving injections
56. Productivity	Patients	Department	Operating Room Department
57. Queue length	Patients	Department	Pharmacy department
58. Readmission	Patients	Department	Emergency department
		Flow group	Bariatric surgery patients
			Hysterectomy patients
			Surgery patients
59. Reliability	Patients	Process specific	Transport
60. Reoperation	Patients	Flow group	Hysterectomy patients
			Surgery patients
61. Resource availability	Materials	Department	Intensive care department
	Patients	Department	Emergency department
		Flow group	Emergency patients
		Process specific	Transport
	Staff	Flow group	Nurses
		Process specific	Cleaning
62. Resource utilisation	Materials	Department	Nursing departments
			Pharmacy department
		Flow group	Medical supplies
	Patients	Department	Ancillary services department
			Chemotherapy department
			Emergency department
			Inpatient departments
			Intensive care department
			Nursing departments
			Operating Room Department
			Outpatient cancer department
			Outpatient department
			Patient transport department
			Pharmacy department
			Radiology department
			Stroke department
		Flow group	Acute patients
			Cardiovascular patients
			Emergency patients
			Outpatient surgery patients
			Paediatric patients
		Hospital wide	-
		Process specific	Discharge process
			Telephone communication
			Transport
		-	-

Table A2.4.1 (continued)

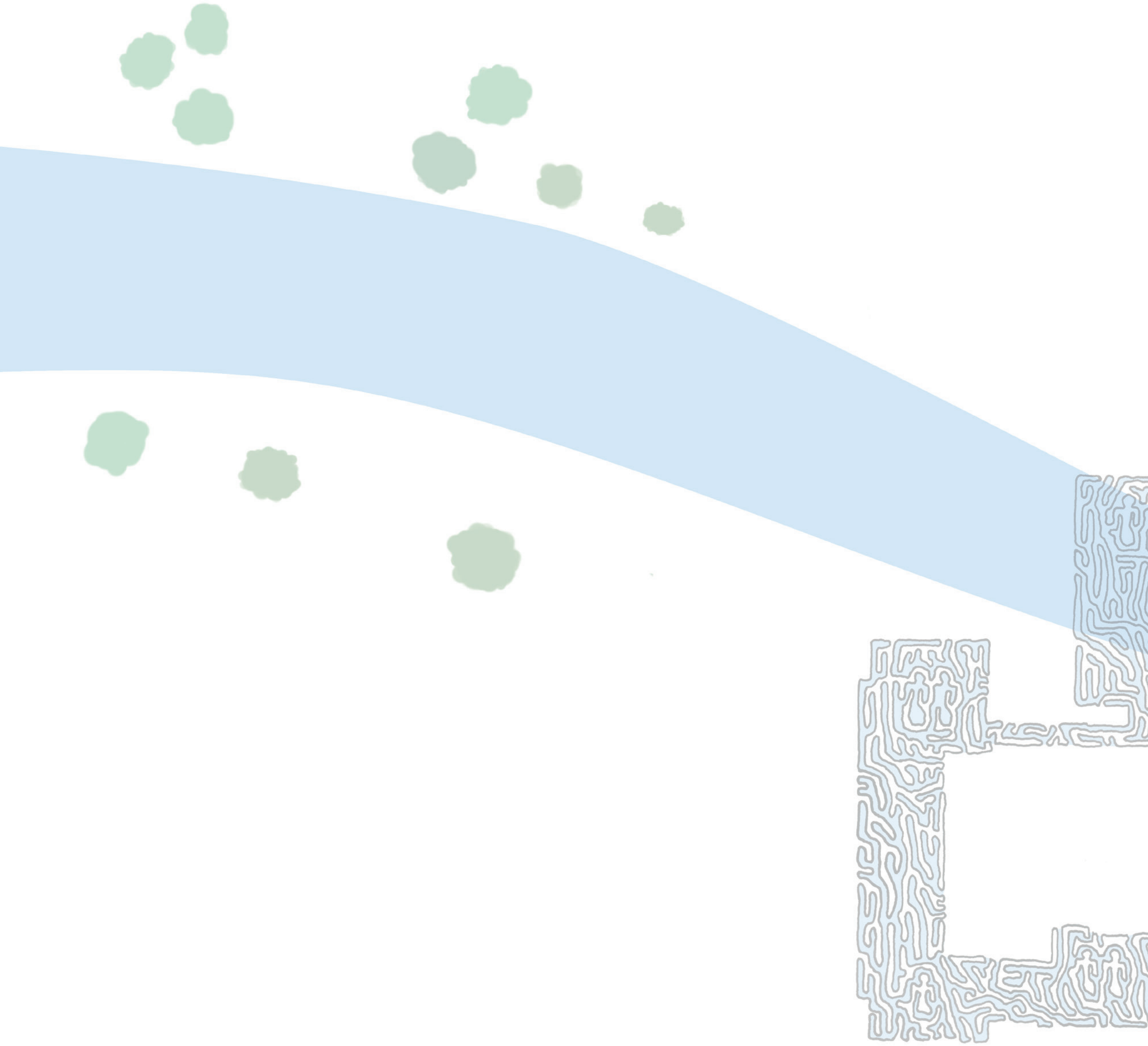
63. Response time	Patients	Hospital wide	-
		Process specific	Transport
64. Responsiveness	All	Hospital wide	-
	Materials	Department	Nursing departments
		Process specific	Transport
	Patients	Flow group	Emergency patients
		Hospital wide	-
		Process specific	Transport
	Staff	Flow group	Nurses
65. Safety stock	Materials	Flow group	Medication
66. Shelf life	Materials	Flow group	Blood
	Patients	Flow group	Cytostatics
67. Shortage	Materials	Flow group	Blood
			Medication
68. Shortage rate	Materials	Flow group	Medication
69. Space availability	Patients	Department	Emergency department
70. Space utilisation	Patients	Department	Laboratory department
71. Staff Time spent on logistics	Materials	Process specific	Transport
	Staff	Department	Operating Room Department
		Process specific	Transport
72. Stock cost	Materials	Flow group	Medication
73. Stock level	Materials	Department	Nursing departments
		Flow group	Medical supplies
	Patients	Hospital wide	-
74. Stockouts	All	Hospital wide	-
	Materials	Department	Paediatric trauma department
		Flow group	Pregnant women
		Hospital wide	-
	Patients	Flow group	HIV/aids patients
75. Supply cost	Patients	Flow group	Medical supplies
76. Surgery time	Patients	Department	Operating Room Department
		Process specific	Transport
77. Throughput	Patients	Department	Emergency department
			Outpatient cancer department
		Hospital wide	-
78. Throughput time	Materials and patients	Department	Pharmacy department
	Patients	Department	Emergency department
			Operating Room Department
			Pharmacy department
		Flow group	Closed femoral shaft fractures patients
			Diabetes patients
			Emergency patients
			Lung cancer patients
			Medication
			Outpatient surgery patients
			Skin cancer patients
		Hospital wide	-
		Process specific	Discharge process
79. Time needed to deliver the service	Patients	Flow group	Outpatient surgery patients
80. Time spent	Patients	Flow group	Outpatient surgery patients
81. Time spent on patient	Patients	Department	Emergency department
82. Timeliness	Patients	Flow group	Outpatient surgery patients
83. Total distance travelled	Staff	Department	Operating Room Department
84. Transfer process time	Patients	Flow group	Trauma patients

Table A2.4.1 (continued)

85. Transfer time	Patients	Department	Operating Room Department
		Hospital wide	-
86. Transport cost	Materials	Department	Sterilization department
	Patients	Department	Laboratory department
		Process specific	Transport
87. Transport distance	Materials	Department	Pharmacy department
	Patients	Hospital wide	-
88. Transport frequency	Materials	Process specific	Transport
89. Transport time	Patients	Department	Patient transport department
		Flow group	Medical supplies
		Hospital wide	-
		Process specific	Transport
	Staff	Flow group	Nurses
90. Transport volume	Materials	Process specific	Transport
91. Transportation cost	Patients	Process specific	Transport
92. Transportation time	Patients	Process specific	Transport
93. Treatment time	Patients	Department	Emergency department
		Flow group	Bariatric surgery patients
			Emergency patients
94. True Completion Time	Patients	Department	Endoscopy department
95. Turnaround time	Materials	Department	Nursing departments
	Patients	Department	Emergency department
			Laboratory department
			Operating Room Department
		Flow group	Bariatric surgery patients
		Hospital wide	-
96. Turnover ratio	Patients	Hospital wide	-
97. Turnover time	Patients	Department	Endoscopy department
			Nursing departments
			Operating Room Department
98. Usage rate	Materials	Department	Pharmacy department
99. Utilisation of staff	Materials	Department	Nursing departments
100. Wait time	Materials	Flow group	Blood
	Patients	Department	Chemotherapy department
			Emergency department
			Department of Otorhinolaryngology and nephrology department
			Nursing departments
			Operating Room Department
			Outpatient department
			Pharmacy department
			Preoperative department
			Radiology department
		Flow group	Cardiology patients
			Emergency colorectal surgery patients
			Emergency patients
			Head and neck cancer patients
			Hip fracture patients
			Low acuity patients
			Mamma patients
		Hospital wide	-
		Process specific	Consultation with a doctor and pharmacy
			Discharge process
			Preoperative assessment
			Transport
			Triage process

Table A2.4.1 (continued)

101.	Waiting patients	Patients	Department	Emergency department
102.	Waiting Time	Materials, patients and staff	Hospital wide	-
		Patients	Department	Emergency department
				Operating Room Department
				Outpatient cancer department
				Patient transport department
				Radiology department
			Flow group	Breast cancer patients
				Cardiovascular patients
				Critical care patients
				Psychiatric patients
				Skin cancer patients
			Hospital wide	-
			Process specific	Discharge process
				Telephone communication
103.	Walking distance	Staff	Flow group	Nurses
104.	Warehouse operation cost	Patients	Process specific	Transport
105.	Waste	Materials	Department	Pharmacy department
			Flow group	Blood
				Medication
		Materials and patients	Department	Pharmacy department
		Patients	Department	Emergency department
				Operating Room Department
106.	Work time spent on work orders	Information	Process specific	Service management process



CHAPTER 3

IDENTIFYING INTEGRATION AND DIFFERENTIATION IN A HOSPITAL'S LOGISTICAL SYSTEM: A SOCIAL NETWORK ANALYSIS OF A CASE STUDY

Annelies van der Ham, Frits van Merode, Dirk Ruwaard, Arno van Raak

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ABSTRACT

Background

Integration, the coordination and alignment of tasks, has been promoted widely in order to improve the performance of hospitals. Both organization theory and social network analysis offer perspectives on integration. This exploratory study research aims to understand how a hospital's logistical system works, and in particular to what extent there is integration and differentiation. More specifically, it first describes how a hospital organizes logistical processes; second, it identifies the agents and the interactions for organizing logistical processes, and, third, it establishes the extent to which tasks are segmented into subsystems, which is referred to as differentiation, and whether these tasks are coordinated and aligned, thus achieving integration.

Methods

The study is based on case study research carried out in a hospital in the Netherlands. All logistical tasks that are executed for surgery patients were studied. Using a mixed method, data were collected from the Hospital Information System (HIS), documentation, observations and interviews. These data were used to perform a social network analysis and calculate the network metrics of the hospital network.

Results

This paper shows that 23 tasks are executed by 635 different agents who interact through 31,499 interaction links. The social network of the hospital demonstrates both integration and differentiation. The network appears to function differently from what is assumed in literature, as the network does not reflect the formal organizational structure of the hospital, and tasks are mainly executed across functional silos. Nurses and physicians perform integrative tasks and two agents who mainly coordinate the tasks in the network, have no hierarchical position towards other agents. The HIS does not seem to fulfill the interactional needs of agents.

Conclusions

This exploratory study reveals the network structure of a hospital. The cross-functional collaboration, the integration found, and position of managers, coordinators, nurses and doctors suggests a possible gap between organizational perspectives on hospitals and reality. This research sets a basis for further research that should focus on the relation between network structure and performance, on how integration is achieved and in what way organization theory concepts and social network analysis could be used in conjunction with one another.

BACKGROUND

Literature in the field of health care calls for more integrative approaches to the logistical or operational system of hospitals[1-3]. Such an approach includes aligning activities and planning resources from the perspective of the total system, taking hospital-wide processes and resources into account[4]. This is considered important because of a widely felt need to improve the quality, accessibility and affordability of healthcare systems[5] and of hospitals in particular, given the fact that hospitals are a major cost item of the healthcare system[6]. There is a wide consensus in literature that an integrated perspective on hospitals, which is a central concept in supply chain management, and in lean and other operations management theories, can contribute to the improvement of hospital performance[4,7-12]. Integrated hospitals plan patient processes and resources from the perspective of the total system[9]. A lack of integration is attributed to the functionalistic organization structure of medical disciplines and departments, often referred to as functional silos[1,4,8,10]. Ludwig et. al. found evidence that hospitals that perform well score high on cooperation, while efficient departments within a hospital don't necessarily contribute to the hospital's overall efficiency[8]. There are, however, a few studies that show system-wide performance improvement when adapting integrative practices such as lean[12]. In an earlier scoping study[13] we found that research on logistics in hospitals typically focuses on one specific logistical flow (patients, material or staff) or on specific departments, but not on a system-wide level. The fact that 106 logistical performance parameters were identified which were applied in 92 subsystems[13], illustrates the absence of a hospital-wide performance framework for logistics. In addition, De Vries and Huijsman[7] point out that little is known on how to achieve integration in healthcare settings, and that this may require a different approach than in other industries.

Both contingency theory and social network theory offer perspectives on integration that could be useful in further exploring integration in the logistical system of hospitals.
Lawrence and Lorsch, who made a major contribution to contingency theory, view organizations as open systems in which the behaviors of members are interrelated[14]. They state that not only is integration important, but also that differentiation is essential in order for integration to be effective[15]. They define integration as 'achieving unity of effort among the various subsystems in the accomplishment of the organization's task'. Differentiation refers to 'the state of segmentation of the organizational system into subsystems'. Subsystems execute a part of the organization's task and can develop particular attributes in relation to the requirements posed by the relevant external environment[15]. From this perspective, integration is not an absolute quality or ideal. The necessary degree of integration is determined by 'the felt need for joint decision making',

which also depends on the organization's specific circumstances. To what degree and in what way integration and differentiation are effective may even depend on the 'unique characteristics of each type of network studied'[16].

Research in the field of social network analysis also addresses integration. Several authors mention network metrics to indicate integration in organizations or networks, thereby often referring to coordination between people, groups or organizations[16-18]. Differentiation is also mentioned in literature pertaining to social network analysis, when referring to tasks being differentiated[16,19], but there are no specific metrics used that refer directly to differentiation. In his book, Kilduff[17] states in a chapter on social network analysis that 'we await a full-blown contingency theory analysis of how trust-based coordinating mechanisms facilitate differentiation and integration'. The fact that this theory doesn't yet exist could be attributed to the widely reported 'embryonic' stage[18] of social network analysis, as shown by two literature reviews[20,21]. At the same time, several studies view social network analysis as a promising method. Benham and Clancy[22] view social network analysis as a new and creative method that is required to meet the complex problems of leaders in modern healthcare organizations. In multiple promising, though mostly exploratory studies, a relation between network structure and the performance of healthcare organizations or networks has been reported, both in terms of quality of care as well as efficiency. For example, Provan and Sebastian[16] indicate that organizations perform more effectively when integration is established through small groups of highly connected agents, when agents are included in multiple groups. Haythornwaite[23] points out that groups with strong relationships facilitate information exchange. Several authors mention the utility of 'brokers' or 'integrative devices' that join groups which are disconnected[15-17,23]. Various studies report tentative results in which a link is made between the network structure and performance parameters such as surgery lead time[24], hospitalization cost[19,25], process efficiency[26], readmission rate[25] and patient quality and safety outcomes[27]. At the same time these studies are said to provide weak evidence, which is attributed to the fact that social network analysis is an upcoming method[21].
In short, both contingency theory and social network analysis provide useful concepts for addressing the issue of integration in the logistical system of hospitals, but this needs to be explored further. Before we are able to say anything on how integration and differentiation may improve the performance of hospitals, we first need to know how a hospital and in particular its logistical system works. We need to know what the tasks are, who executes these tasks, how all tasks are aligned and whether we see integration and differentiation in the hospital system. Accordingly, the general objective of this research is to understand how a hospital's logistical system works and in particular to what extent

there is integration and differentiation. Specific objectives for achieving the general objective are:

1. Identify the agents and the interactions between them for organizing logistical processes
2. Describe how the hospital organizes logistical processes
3. Identify integration and differentiation as they exist in the entire hospital network.

We believe that understanding how a hospital's logistical system works is a necessary first step towards improving the functioning of the hospital system. In this study, the hospital logistics are described from a system-wide perspective using social network analysis. To the best of our knowledge, this type of study has not been done before. Therefore this study should be considered exploratory. For this purpose a case study was conducted in a general hospital in the Netherlands, in which a social network analysis of the hospital's logistical system was performed.

In line with our objectives, we focus on the following three questions:

1. What are the tasks executed for hospital logistics and which agents execute these tasks?
2. Which agents interact in executing these tasks?
3. To what extent do we see integration and differentiation in the network?

METHODS

In this section we explain how and in what setting the study was performed, what data were collected and how they were analyzed through a social network analysis.

Setting

The study is based on the case study research method devised by Yin[28]. We selected Slingeland Hospital for our study because it is a relatively small Dutch hospital, has well-reported performance and the circumstances were relatively stable, as no large scale transformation projects were taking place. Additional selection criteria were good access to people and data. As a result of the merger with the Queen Beatrix Hospital in Winterswijk in 2017, this hospital became part of the larger Santiz group, but it functions largely as an independent full service hospital. The logistical operations for surgery across facilities were not combined in any way at the time of our research.

Slingeland Hospital has around 1,600 staff members, including 120 physicians and 426 nurses. It services around 200,000 people in the area, and has 350 beds, which is below the average number of 450 beds for hospitals[29]. Slingeland Hospital performs higher on most logistical indicators than the average Dutch hospital, according to a Dutch OTC benchmark[30]. With an average of 89% operating room utilization in 2016, Slingeland has higher operating room (OR) utilization than the 82% average of Dutch hospitals that participate in a national benchmark. For other parameters, such as lateness and average surgery time, Slingeland performs better than the average hospital in the Dutch benchmark.

Study design

With regard to our first two objectives and research questions on the tasks that are executed for hospital logistics and the agents who interact in executing these tasks, data were collected from multiple sources and then analyzed through data triangulation following a mixed method approach. With regard to our third objective, to establish integration and differentiation, a social network analysis was performed[31]. This analysis reveals the structure of the hospital network; the metrics developed in social network analysis methodologies can indicate the degree of differentiation or integration.

Using a system-wide perspective, ideally we would describe the entire intra-organizational network of a hospital. However, given the exploratory nature of our research and to reduce complexity and increase feasibility, it was decided to focus on the social network that includes all agents of all departments that execute tasks for the benefit of surgery patients. This includes agents of outpatient departments, the preoperative screening department, the nursing departments, the Operating Theatre Complex, the Central Sterilization Unit and the holding and recovery areas. By including all departments that take part in organizing patient flows, material flows and staff flows, a large part of the hospital system was included, which is in line with a system-wide approach. Moreover, the network in place for surgery patients is important, given the fact that more than 60 percent of patients who are admitted to a hospital are treated in the operating theatre complex (OTC)[32] and the OTC accounts for more than 40% of a hospital's total revenue, and a similar proportion of its total expenses[33]. We studied the entire intra-organizational network of the hospital, because internal agents are primarily responsible for organizing logistics for patients, thereby focusing on the integration and differentiation within the bounds of the hospital.

Data collection and analysis

For establishing the tasks that are executed for hospital logistics (question 1) and which agents interact when executing these tasks (question 2), data were collected from four different sources: the Hospital Information System (HIS), documentation, observations and interviews. The data collection focused on identifying all tasks for surgery patients in 2017, including the interaction between the agents involved in these tasks. The collection and analysis of data from the HIS and documentation took place in January and February of 2018. Following that, observations took place between March and April of 2018. The findings from the data and from the observations resulted in some knowledge gaps, which were further explored in 11 interviews; these took place between May and September 2018.

The HIS data include registrations of surgeries performed in 2017, including date of surgery, staff involved, materials used and timestamps of different stages of the surgery patient's process, as well as of the nursing wards the patients were in before and after surgery. Other data of the HIS include, for example, the number of staff members and the planning schedules.

Documentation includes planning schemes, working procedures and internal presentations on internal processes which were valid at the time these were collected, at the start of 2018.

The daily work of 12 departments was observed on 14 different days. The observations took place in three outpatient departments, at the preoperative screening department, in two nursing departments, in the OTC and the Central Sterilization Unit and in the holding and recovery areas. The departments were selected because they execute tasks that contribute to the overall task of performing surgery. A total of 98 people were observed, including both staff and patients. Observations were conducted using a naturalistic approach, as described by Beuving and De Vries[34]. Each observation day was prepared by studying HIS data and working procedures in that department on the day before the observation took place. These data were used to formulate broad questions for the observer to keep in mind during the observation. In order to avoid creating a formal setting, the observer had casual conversations with the observed staff only when staff initiated this and if the observer felt that this contributed to keeping the situation natural. The observer made field notes of events including timestamps, conversations and observed behaviour, which were reported in an observation report.

For the interviews we selected people of different agent types that we had met during the observations, but with whom we had not spoken comprehensively, and we also selected people who were suggested to us by hospital staff whom we had met during data collection and observations. Two surgeons, one anesthesiologist, the cluster manager for the OTC and Services, two OTC team leaders, the OTC capacity planner, a business controller and the application controller were interviewed. For each interview a topic list was prepared; topics include the logistical tasks and interaction with other agents, which demands the agent has to deal with in relation to these other agents and how the network functions as a whole. All interviews were recorded and transcribed ad verbatim.

With these data, the logistical tasks that are executed for patients who have surgery and the order in which they are executed were identified. A task is seen as a 'complete input-transformation-output cycle'[15] for a particular intended result. The focus was on tasks which are triggered directly by the patient and for which interaction between agents was found. Interaction includes face-to-face contact or communication via telephone, email or text messages. Tasks relating to small surgeries that are performed in the outpatient departments were excluded.
Each source was used to identify the interaction relations between the agents involved in each task. For this, the data from the four sources, both quantitative and qualitative, were combined using data triangulation[28]. Interactions were first of all directly derived from HIS data; for example, who was involved in each surgery in 2018 is registered in the system, and it was observed that these agents interact during the surgery. Interactions were also derived from standard working procedures, which were both described and observed; these are interactions as they generally take place between agents with the same function or role. In addition, interviewees were asked specific questions on which agents interact with whom for task execution. In most cases the interactions were derived by combining data from all sources. For example, in the observations we saw that the surgeon visits the nursing ward to see his patients. In the interviews the surgeon explained that this is a daily activity and that he then always interacts with a ward nurse. From the HIS data it was derived how many surgeons and ward nurses there are and on which ward the patients of each surgeon were located. Appendix 3.1 shows which sources provided the input for establishing the interactions for each task.

For each task the working procedures and interactions were first described in text and then the interaction for task N between agent A and B, B and C and so on were registered in an Excel database. Each agent was anonymized by using a code that consists of three letters of either the department or the medical discipline the agent works for and an abbreviation of the function of the agent and a number. A Urology surgeon is UROS1 with URO being the medical discipline, S for surgeon and 1 for the specific agent. This resulted in a structured database of 39,055 rows. Each line in the database represents an undirected communication link – a tie - between agents A and B for a specific task N.

Each node in the network represents an agent, who is an individual person. Because this study focuses on identifying integration and differentiation by analyzing the social network structure, the interaction frequency was not included in the research and the ties do not have any weight. All interactions described are a result of working procedures and common ways of repetitively executing tasks throughout the year.

Having established the tasks, agents and interaction, a social network analysis was performed in order to elicit integration and differentiation (question 3). The social network was built up from the identified interactions between agents per task, as recorded in the database. The database was inserted in NodeXL, which was used to construct the social network, The Harel Koren Fast Multiscale Algorithm was used for structuring the network. This algorithm was developed specifically for the fast and clear visualization of large social networks[36]. It structures the network in such a way that agents who are linked and have similar links to other agents are positioned close to each other in the network. In addition, agents with a relatively high number of ties in comparison with other agents are positioned in the center of the network.

Specific concepts and measures of the social network that are related to the concepts of integration and differentiation were analyzed. In line with Provan[16], Kilduff[17] and Haythornwaite[23], density, degree, betweenness centrality and clique overlap were used as indications for integration. No metrics were found for differentiation in social network literature, but Kilduff[17] and Monge[18] associate differentiation with the existence of groups or cliques that consist of highly connected agents. There is a clique when all agents in a group are connected. These measures are presented in Table 3.1.

On a network level, the entire hospital network was analyzed to identify groups of densely connected agents. A group consists of highly connected agents in which case there is high density. Density is defined as size relative to the number of possible ties and calculated by the ratio of the number of actual links between nodes and the maximum possible edges for the network[31]. A relatively low density for the entire network suggests differentiation or, put the other way around, a lack of integration.
In addition to density we also looked at clique overlap and at multiplexity for integration in the entire network. There is clique overlap when agents are part of more than one clique, thereby connecting different cliques[16,17]. Clique overlap was calculated by dividing the number of agents participating in multiple cliques by the total number of agents. When there is clique overlap across different tasks, there is multiplexity[16]. Multiplexity is the percentage of agents in a clique for a task who are also members of cliques for any other task.

Table 3.1 Definition of network concepts and metrics

Concept	Definition
Node	An agent
Tie	A communication link between two agents via email, text message, telephone or face-to-face
Group	A set of agents who are closely connected to one another
Clique	A set of agents who are all connected to one another
Subsystem	A set of agents who are highly connected and execute a part of the organization's overall task
Broker	An agent who connects (otherwise) disconnected groups
Density	The number of ties a set of agents have in relation to the number of possible ties they can have
Clique overlap	The percentage of agents who are members of more than one clique for a specific task
Degree	The number of ties of one agent
Betweenness centrality	The number of times a node (agent) lies on the shortest path between other nodes (agents)
Multiplexity	The percentage of agents in a clique for a task who are also members of cliques for other tasks.
Centralization	The extent to which a set of nodes (agents) are organized around a central node (agent)

The clique analysis per task was performed in order to see how the organizational system is segmented into subsystems, following Lawrence and Lorsch's definition of subsystems[15]. Breaking down the structure of the overall task of the hospital network into smaller tasks reveals in what way tasks are differentiated. This was done by filtering the database by task and analyzing this part of the network in NodeXL accordingly. Cliques were also identified for each task, revealing possible smaller subsystems.

We looked at betweenness centrality for agents who act as a broker[16,17] in the network. According to Haythornthwaite[23] brokers are 'connections between disorganized others' and they carry information from one group to another. Agents with a high betweenness centrality have an intermediary position between others in the network[23,31]. This metric represents the number of times a node lies on the shortest path between two other nodes[37] and was calculated with the algorithm used in NodeXL[38].

Further, we looked at centralization, which is defined as 'the extent to which a set of actors are organized around a central point'[23]. In a centralized network there is a high standard deviation in the degree of agents, i.e., in the number of ties, because some agents have a high degree and most others have a low degree[39]. Centralization may suggest differentiation, as agents around the central agents could be isolated from the rest of the network, as is the case for nodes F to J in the example presented in Figure 3.1. It is important to note that centralization in social network analysis is different from the widely accepted definition of Mintzberg, who states that centralization is related to decision- making power[40].

In Figure 3.1 an example of the social network analysis is presented, including the metrics.

Network parameter	Value	Differentiation		Integration
Number of agents	14			
Number of ties	19			
Density	0.2	Low	———	High
Number of cliques	2	High	———	Low
Clique overlap	1/14 = 7%	Low	———	High
Multiplexity	1/14 = 7%	Low	———	High

Agent parameter	Differentiation		Integration
	Lowest	Average	Highest
Degree	1	3	6
Betweenness centrality	0	11	50

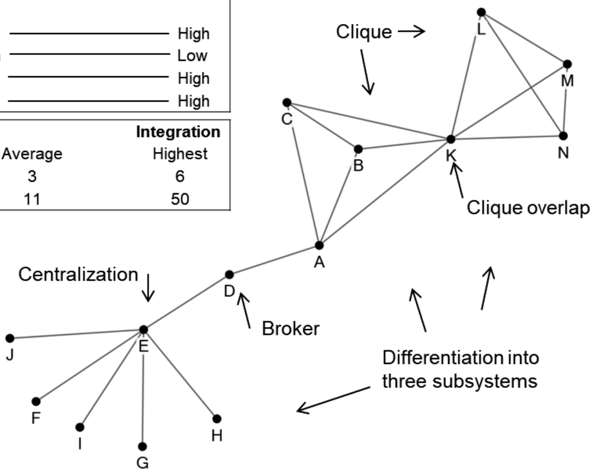

Figure 3.1 Example network with SNA concepts and metrics.

Network validation

For validation purposes, the social network per task was discussed face-to-face between August 2018 and November 2018 with ten hospital staff members who were also involved in the observations and interviews. Specific details were asked via email to specific members of hospital staff who perform the tasks identified. Remarks from hospital staff were reported in a validation report.

RESULTS

All tasks and interaction taking place between agents in executing these tasks are described in this section. Further, the entire hospital network, which is built up by these interactions, is presented and integration and differentiation are described. We start this section with some key figures on surgeries in Slingeland Hospital.

Output of the social network

In 2017, 10,157 surgeries were performed in Slingeland Hospital. The number of surgeries varies from a minimum of 4 to a maximum of 246 surgeries a week. Of all surgeries, 83% are planned beforehand, i.e., they are not emergency procedures. Different types of surgeries are performed, which are registered according to 394 treatment codes in the HIS. These treatment codes are divided among nine medical disciplines: general surgery, orthopedics, Ear Nose Throat (ENT) surgery, eye surgery, urology, gynecology, plastic surgery, dental surgery and neurosurgery. Of all 394 treatment codes, on average 66% are performed once a month or less and 9% are performed on a weekly basis. More than half of the treatment codes are executed by only one or two specific surgeons. For example, 103 treatment codes are performed by one specific, but not the same, surgeon. For 42% of all surgeries, there was a unique one time combination of treatment code, surgeon and anesthesiologist. This and the fact that in 2017 a total of 2,881 unique combinations of medical instrument sets were used, suggest that human and material resources are not fit for a large variety of surgeries, but are mostly suitable for specific surgeries.

Agents and tasks performed for surgery

The main task of the logistical system is to get the right patient, surgeon, anesthesiologist, nurses, materials and infrastructure together at the right time and in the right place. There are 23 tasks that are executed in order to achieve this, as presented in Table 3.2. Figure 3.2 shows the relation between 22 tasks, mostly based on the chronological order in which these are executed. In addition, the arrow between two tasks means that the output of a task is input to the task to which it is connected. Task 23, managing the OTC, is not specifically time dependent, nor is there specific output of this task and therefore it is not mentioned in Figure 3.2. Tasks 1 to 5 are at the tactical level because these concern master scheduling in the medium-term[41]. The other tasks are operational because they are related to short-term allocation of resources and execution. Long-term strategic tasks such as demand forecasting were found, but these do not relate directly to the tasks shown in Figure 3.2. Overall, two main groups of tasks are visible in Figure 3.2: tactical and operational planning 6 months ahead until the day before surgery and the execution of the surgery process.

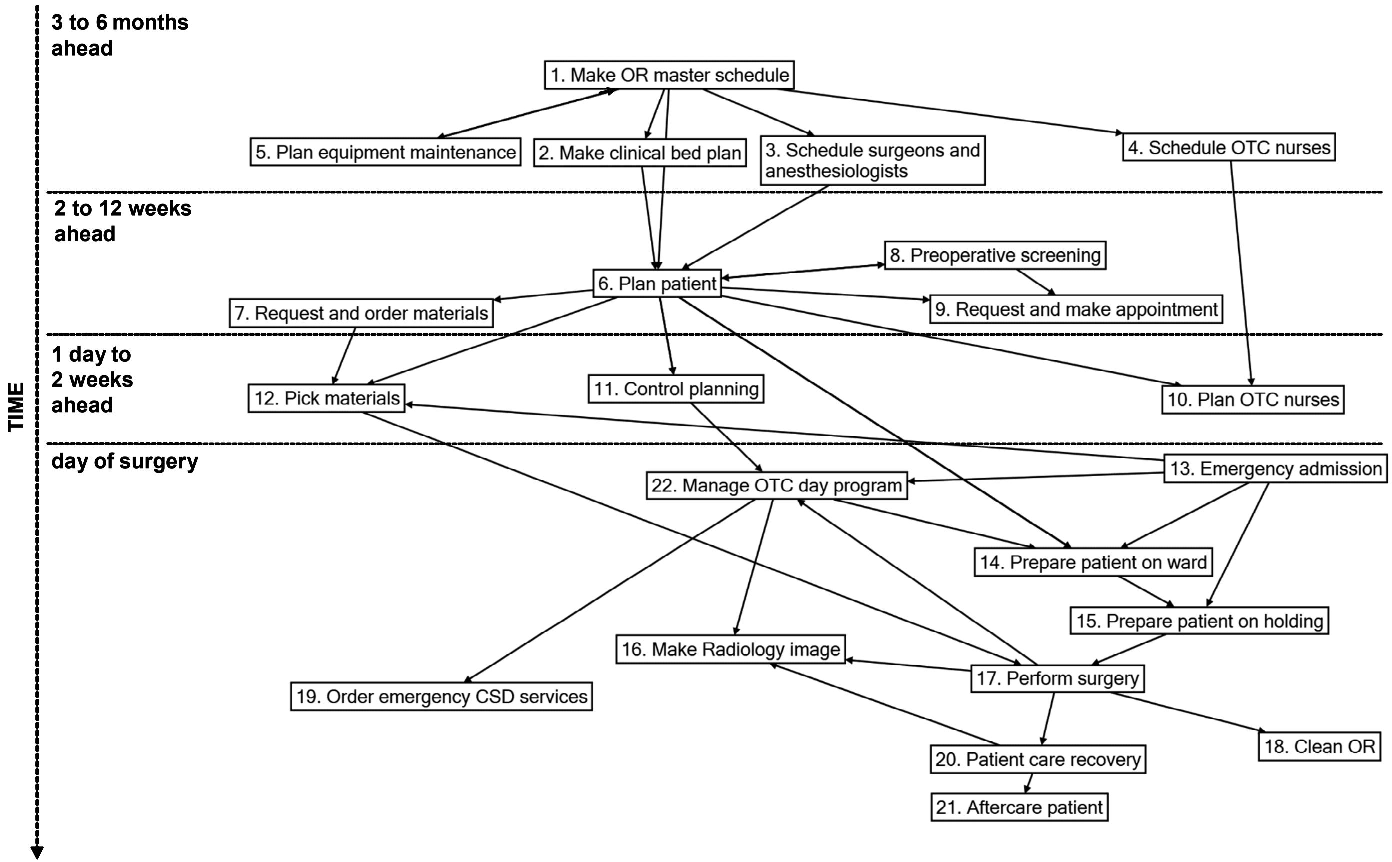

Figure 3.2 The links between tasks performed for patient surgery/ Task 23 is not included because it is not time-related to one of the other tasks.

Table 3.2 Tasks and agent types involved in these tasks.

		MSC	OTC	MSC	Cluster OTC and Services	CSD	ER	ER	MIS	OTC	OTC	OTC	OTC	OTC	OTC	OTC	OTC	Outpatient dpt (5)	Pharmacy dpt	Preop dpt	Preop dpt	Radiology dpt	OTC	MSB	Nursing ward (7)	Nursing ward A2	Nursing ward (7)	
	Tasks	Anesthesiologist	Nurse anesthetist	Assistant surgeon	Cluster manager	CSD staff member	ER physician	ER nurse	Equipment maintenance staff	Holding nurse	OTC capacity planner	OTC cleaning staff	OTC day coordinator	OTC Logistical staff	OR nurse	OTC secretary	OTC team leader	Outpatient secretary	Pharmacy assistant	Preoperative nurse	Preoperative secretary	Radiology staff	Recovery nurse	Surgeon	Ward nurse	Clinical bed plan boss	Ward team leader	**Task description**
1	Make OR master schedule	x			x						x							x						x				Make the OR master schedule in which operating time for each medical discipline is allocated to the operating rooms for even and uneven weeks
2	Make clinical bed plan										x															x	x	Make the clinical bed plan in which beds are allocated to medical disciplines per nursing ward for even and uneven weeks.
3	Schedule surgeons and anesthesiologists	x																x						x				Determine the working hours for every surgeon and anesthesiologist for the upcoming three to six months, including where they are working, i.e., in the outpatient department and the OTC.
4	Schedule OTC nurses		X							x			x		X		x						x					Determine the working hours for every nurse anesthetist, OR, holding and recovery nurse for the upcoming three to six months.
5	Plan equipment maintenance								x		x		x				x											Determine which OTC equipment will be maintained on what day and time and how long the equipment will be unavailable for use.
6	Plan surgery										x							x						x		x		Determine the time and date that the patient will be operated on and register this in the OR master schedule.
7	Order materials												x		X			x						x				Request specific materials for one specific surgery and order these materials at external supplier(s)
8	Preoperative screening	x																	x	x	x							Determine what type of anesthetic technique fits the patient, what potential risks should be considered during the patient's surgery, and what is the best preparation for the surgery of this patient.

9	Make appointment	x																x			x							Request visits to physicians, laboratory or radiology tests for preparation of the patient for the surgery.
10	Plan OTC nurses		X							x			x		X								x					Determine the working hours for every nurse anesthetist, OR, holding and recovery nurse for the upcoming week, including what surgeries they assist.
11	Control planning										x		x			x	x	x			x				x			Check all requirements for the surgery to be able take place, determine the final order of the surgeries for each OR and if necessary revise planned surgeries.
12	Pick materials										x		x	x	X													Collect materials required for surgeries from the storage rooms and deliver these to the operating rooms.
13	Emergency admission	x		x			x	x					x											x	x			Define diagnosis and treatment for patients admitted to the Emergency Department and plan and prepare the patient for surgery.
14	Prepare patient on ward		X																						x		x	Admit the patient to the nursing ward, administer premedication to the patient and further prepare the patient for surgery.
15	Prepare patient in holding		X							x															x			Transfer the patient from the nursing ward to holding, further prepare the patient for surgery and transfer the patient to the nurse anesthetist.
16	Make Radiology image												x		X	x						x	x					Ask the radiology department to make an image of the patient in a specific place (OR or recovery) and time.
17	Perform surgery	x	X	x											X									x				Perform the surgery with the OR team.
18	Clean OR											x			X													Ask the cleaning services to clean the operating room right after transferring the patient to recovery.
19	Order emergency CSD services					x							x															Call the central sterilization department to ask for immediate cleaning and sterilization of medical instruments, as these may be re-used for surgery on the same day.
20	Patient care recovery	x	X																				x		x			Take care of the patient after surgery, making sure the patient is well enough to be transferred to the nursing ward.
21	Aftercare of patient																							x	x		x	Take care of the patient after surgery, making sure the patient is well enough to go home.
22	Manage OTC day program	x	X							x	x		x		X		x	x					x	x				Coordinate and manage the daily OR program, making sure that all surgeries planned for each day are well-executed and on time, and review this over time.
23	Manage OTC tasks				x						x		x				x											Coordinate and manage OTC operations over the long term.
	Total number of tasks involved	8	7	2	2	1	1	1	1	4	8	1	11	1	8	2	5	7	1	1	3	1	5	8	6	2	3	

MSC = Medical Specialty Company; CSD = Central Sterilization Department; MIS = Medical Instrumental Services; OTC = Operating Theatre Complex; ER = Emergency Room department; Preop dpt. = Preoperative Screening department; (n) = number of departments

First the OR master schedule is made for a three-month period (task 1), two quarters ahead; the OR master schedule for Q2 of any year is made in Q4 of the previous year. In the OR master schedule, time slots for all ORs are allocated to the nine medical disciplines that operate in the OTC. The clinical bed plan (task 2), equipment maintenance planning (task 5) and staff schedules (tasks 3 and 4) are all derived from the OR master schedule. Around two to twelve weeks before surgery, patients are planned into the OR program (task 6) and preparations start: patients are screened by an anesthesiologist (task 8), materials are ordered (task 7) and patients are seen by other physicians or take radiology or laboratory tests (task 9). In the days before surgery further preparations are made: the OR day program is planned in more detail (task 11), staff is allocated to specific surgeries (task 10) and materials are picked (task 12). On the day of surgery the patient is prepared and held on the ward (task 14) before the actual surgery takes place (task 17) and is afterwards taken care of in the recovery area (task 20) and ward (task 21). In some cases a radiology image is made during or after surgery (task 16). After surgery the OR is cleaned (task 18) and if necessary the medical instruments are immediately cleaned for reuse (task 19). Patients can also be admitted for an emergency surgery (task 13), in which case all tasks are executed within a short period of time. All tasks have been specified in more detail in Appendix 3.2.

Tasks are related to patient, staff and material flows. Tasks 5, 7, 12, 18 and 19 are related to materials and tasks 1, 3, 4 and 10 are about staff flows. Tasks 2, 8, 9, 13 and 16 are related to patient flow. The other tasks are related to more than one flow; for example, preparing a patient on the ward before surgery involves both the patient and medication.

For each task a number of agent types is involved, as presented in Table 3.2. The OTC day coordinator participates in 11 of the tasks and has the highest involvement in multiple tasks. The OTC capacity planner, anesthesiologists, surgeons and the OTC nurses all participate in eight different tasks. The other agents participate in fewer tasks, with a minimum of one. The task with the most different agent types involved is managing the OTC day program; ten different agent types play a role in this.

With regard to the flows, most agents are involved in tasks related to patients, staff and materials. The CSD staff members, equipment maintenance staff, OTC cleaning staff and the OTC logistical staff are the only agents who deal with just one flow type, which is materials.

Table 3.2 shows that a number of tasks have an overlap in types of participating agents. This is particularly relevant when tasks are related. For example, tasks 2, 3, 4 and 5 are all related to task 1, and there is overlap in agent participation for the OTC capacity planner for tasks 1 and 2. The outpatient secretary, the anesthesiologist and the surgeon are all involved in both tasks 1 and 3. There are no overlapping agents for related tasks 1 and 4, 6 and 8, 6 and 14, 13 and 14 and 13 and 15. For tasks 4, 8 and 14 relevant information resulting from tasks 1 and 6 are communicated through the HIS, which then is the only information source for agents executing these tasks. For all other related pairs of tasks there are agents who participate in both tasks.

The entire social network

Figure 3.3 shows the entire social network with all agents and the ties between these agents. The names of all agents were abbreviated in the network figures and are explained in Appendix 3.3. Even though Figure 3.3 does not reveal the details of the network, it clearly shows that all agents are connected in one way or another and that there are no agents or cliques that are completely disconnected from the rest of the network. The relatively low density of 0.16, as shown in Table 3.3, indicates that there are agents or groups which are less connected, suggesting differentiation. The high number of cliques also indicates the presence of subsystems, demonstrating differentiation. However, 65% of all agents are part of multiple cliques across two related tasks. This high multiplexity value implies that there is integration as well. The spread between average and highest values for degree and betweenness centrality suggest that a relatively small number agents play an integrative role.

Figure 3.3 also shows groups of agents who are closely connected, which suggests the presence of subsystems. We see groups of agents who share the same task or knowledge, or they deal with a specific patient group depending on age, condition or required length of stay. Examples of agents sharing the same task and patient group are on the top side edges of the network where we see the ER nurses and on the right side the nursing wards, which are all cliques; clockwise the groups of nurses are visible with codes KDVNUR, N2NUR, B0NUR, N1NUR, N0NUR, B2NUR, A2NUR. Each code starts with the name of the nursing department as defined by Slingeland Hospital, e.g., KDVNUR1, KDVNUR2 et cetera are nurses from department KDV. They also form subsystems because these nurses are all involved in the same task. Interestingly, the team leaders (WTEAM) of nursing wards B0, N1, N0, B2, IC have fewer connections to others in the hospital in comparison with the nurses, illustrated by their peripheral position in the network.
The group of intensive care (IC) nurses (ICNUR) form a clique as well, but they are more centrally positioned. This is because IC nurses have connections to all other nursing wards, as IC patients are always transferred to another nursing ward before they are

discharged. Agents working in the daycare department F2, where patients stay because of their expected one-day length of stay, are also more centrally located because patients are transferred in case they need to stay the night.

All OR nurses (ORAS) also form a group, in three cliques, because they are divided into three clusters which are based on shared knowledge of medical disciplines. The holding and recovery nurses each have a clique as well. The anesthesiologists (AN) are visible as a group as well as the nurse anesthetists (ANNU), who are in the middle of the network. The surgeons do not form one group, but they form nine cliques that each share the knowledge of a specific medical discipline. Here we see separate subsystems according to medical discipline, which essentially all perform the same task. This is also the case for the secretaries of the outpatient departments, who are visible in the bottom left part of Figure 3.3.

The high number of cliques is largely explained by the fact that there are 7,640 unique cliques that perform surgery (task 17). This will be analyzed further in the network analysis of each task.

Table 3.3 Network metrics overall network.

Network Parameter		**Value**	
Number of agents		635	
Number of ties		31,499	
Density		0.16	
Number of cliques		8698	
Multiplexity		413/635 = 65%	
Agent parameter	**Lowest**	**Average**	**Highest**
Degree	1	99	399
Betweenness centrality	0	347	31,379

The average degree is 99 and standard deviation is 79, which suggests centralization, as there are relatively large differences between the number of ties of agents. The agent with the highest degree is a nurse anesthetist with 399 ties to other agents. The nurse anesthetists all have a high degree, with an average of 387 ties. On the day of surgery they have interaction with all surgery team members, including surgeons, anesthesiologists and OR nurses. Furthermore, they interact with all ward nurses, and with holding and recovery nurses throughout the year. This is also the case for holding and recovery nurses who have an average degree of 300 and 318, respectively. The agents with relatively low degrees are on the edges of the network in Figure 3.3, e.g., all staff from the Central Sterilization Department (CSD) on the top left. In Appendix 3.3 the degrees of all agents are presented.

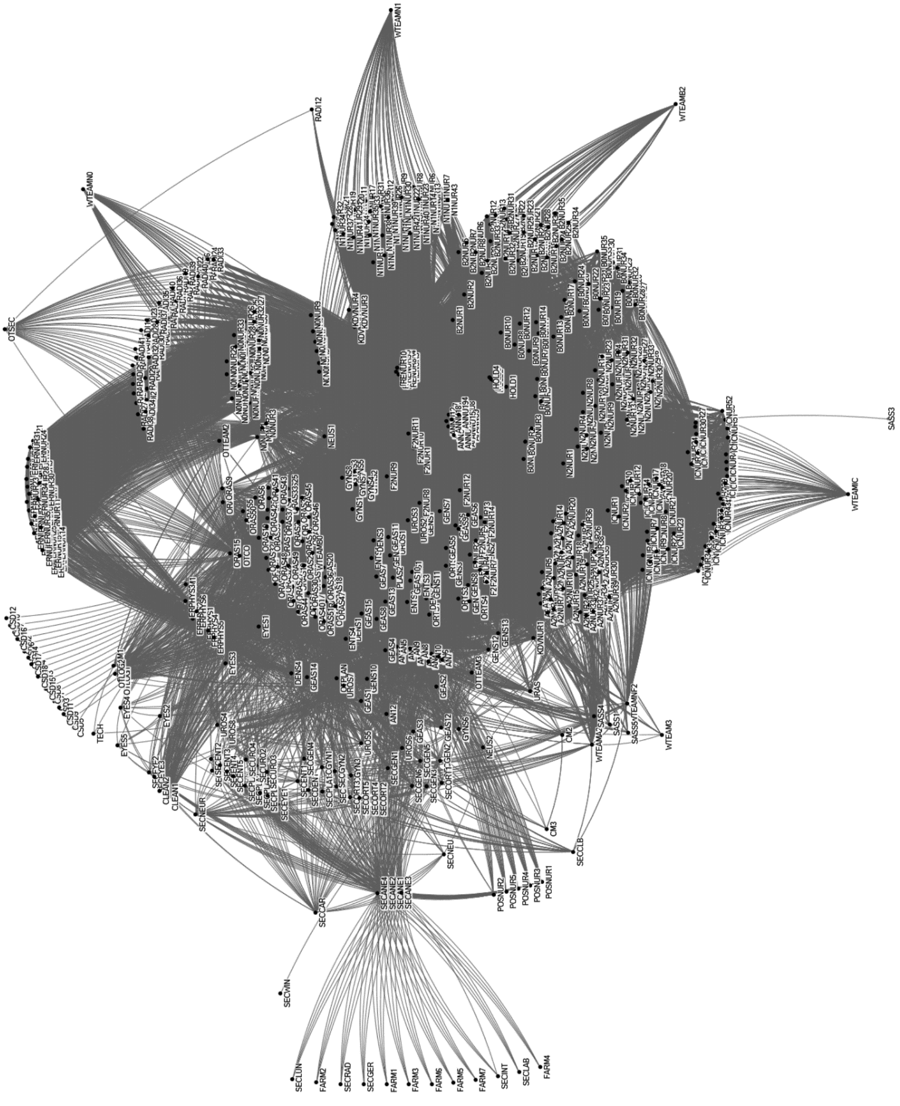

Figure 3.3 The social network of hospital logistics for surgery patients. The legend for the agent codes is included in Appendix 3.3

The OTC day coordinator (OTCO) has the highest betweenness centrality, which makes sense given the name of that function, but at the same time it is striking, because he does not contribute to multiplexity. The OTC capacity planner has the second highest centrality, and she has a strong integrative role between related tasks. The nurse anesthetists (ANNU) have high betweenness centrality as well as having a high degree, which also suggests a broker role.

The number of agents and communication links between them are different in the four time horizons which were presented in Figure 3.2. Table 3.4 clearly shows that the number of agents interacting and the density is higher on the day of surgery than before that day. If we look at the planning and execution phase, the density is 0.08 and 0.16 respectively. This suggests that, even though the overall network integration is low, in the months, weeks and days before surgery there is more differentiation and less integration than there is on the day of surgery. Furthermore, the OTC capacity planner plays a more prominent role before the day of surgery, whereas the OTC day coordinator is mainly involved on the day of surgery.

Table 3.4 Network metrics of the network over time.

Time horizon	Number of agents	Number of ties	Density	Highest betweenness centrality
3-6 months	168	1,041	0.07	OTPLAN
2-12 weeks	146	695	0.07	OTPLAN
1 day to 2 weeks	144	428	0.04	OTPLAN
Day of surgery	605	30,135	0.16	OTCO

In the next section we will go into more detail of the network for each task.

Network analysis per task

The social network per task is included in Figures A3.2.1 to A3.2.23 in Appendix 3.2. Table 3.5 shows the differences in network metrics between tasks. The number of participating agents varies from 4 to 391, the density from a low 0.01 to the maximum of 1, the number of cliques varies from zero to 7,640 and clique overlap is between zero and 92%.

Tasks with a relatively low density suggest differentiation. In Appendix 3.2 we see two network structures for such tasks: a network with weakly connected or disconnected cliques and a network with centralization. Task 3 (Figure A3.2.3 in Appendix 3.2) is a clear example of a network with ten cliques that are all disconnected. Here we see differentiation according to medical discipline with regard to how surgeons and anesthesiologists are scheduled. Each medical discipline represents a subsystem. This is also the case for task 6, but here the medical disciplines are situated around the OTC capacity planner in a star network.

Other tasks with a centralized network are 7, 9, 10, 12, 15, 18, 19, 20 and 22. The centralization is first explained by the fact that tasks are coordinated by the OTC day coordinator (tasks 7, 10, 19, 22). For the other tasks there is centralization because the central agent in each network interacts with each agent individually, while these agents do not interact with one another for that task. For example, on a regular basis the two logistical staff members ask all OR nurses, the OTC day coordinator and the OTC capacity planner for information on surgeries for which they pick the materials. Based on the definition of subsystems, these star networks do not have subsystems, because the agents are not highly connected.

Table 3.5 Network metrics for each task

	Tasks	**Number of agents**	**Number of ties**	**Density**	**Number of cliques**	**Clique overlap**		**Organization unit**
1	Make OR master schedule	28	110	0.3	2	6	21%	Cross functional
2	Make clinical bed plan	4	6	1.0	1	N/A		Cross functional
3	Schedule surgeons and anesthesiologists	70	206	0.09	10	0	0%	Cross functional
4	Schedule OTC nurses	88	801	0.2	6	1	1%	OTC
5	Plan equipment maintenance	4	6	1.0	1	N/A		Cross functional
6	Plan patient	92	315	0.08	48	1	1%	Cross functional
7	Request and order materials	61	139	0.08	0	N/A		Cross functional
8	Pre-operative screening	27	109	0.31	12	9	33%	Cross functional
9	Request and make appointment	56	140	0.09	0	N/A		Cross functional
10	Plan OTC nurses	85	84	0.02	0	N/A		OTC
11	Control planning	54	234	0.16	2	3	6%	Cross functional
12	Pick materials	55	107	0.07	53	2	4%	OTC
13	Emergency admission	139	2,840	0.30	1	N/A		Cross functional
14	Prepare patient on ward	314	11,071	0.23	171	19	6%	Cross functional
15	Prepare patient on holding	289	1100	0.03	285	4	1%	Cross functional
16	Make radiology image	53	491	0.36	0	N/A		Cross functional
17	Perform surgery	148	5,444	0.50	7,640	136	92%	Cross functional
18	Clean OR	53	102	0.07	0	N/A		OTC
19	Order emergency CSD services	19	18	0.11	0	N/A		Cross functional
20	Patient care recovery	241	2,355	0.08	285	10	4%	Cross functional
21	Aftercare of patient	391	12,537	0.16	178	266	68%	Cross functional
22	Manage OTC day program	184	189	0.01	1			OTC
23	Manage OTC tasks	6	14	0.93	2	4	67%	OTC

Interestingly, the central agents in these star networks do not have a hierarchical position towards the agents around them, because the networks are cross functional (tasks 6, 7, 15, 19, 20). For tasks 4, 10, 12, 18 and 22 the central agents do not have a formal hierarchical position towards the other agents either.

For tasks with a higher density such as tasks 1, 2, 5, 8 and 11 we see integration, either by the presence of one clique (tasks 2 and 5) or multiple cliques (tasks 1, 8, 11). Furthermore, we see a network for task 14 with a highly connected group or subsystem with multiple agents in the center (Figure A3.2.14 in Appendix 3.2). Doing surgery in the OR (task 17) looks like a cloud of connections (Figure A3.2.17 in Appendix 3.2) because surgeons, anesthesiologists, OR nurses and nurse anesthetists work together in 7,640 different cliques.
Besides density, clique overlap is an indication of integration. For tasks 1, 8, 17, 21 and 23 there is a relatively high overlap of 33% up to 92%, but for the other tasks clique overlap has a maximum of 6%, in which case the integration depends on just a few agents.
Remarkably, almost all tasks in which integration is observed are all organized in a cross functional manner. Managing the OTC tasks is the exception here, as this is done by agents who work only for the OTC department.
With regard to betweenness centrality per task, different agents act as a broker. The OTC capacity planner is most central for making the OR master schedule and planning surgeries. The OTC day coordinator is most central for scheduling and planning OTC nurses, for ordering materials and for responding to emergency orders from the CSD. For other tasks the agents with the highest betweenness centrality are two surgeons (task 3), the preoperative nurses and secretaries (task 8), the Neurology and Cardiology nurses (task 9), OTC logistical staff (task 12), the nurse anesthetists (task 14), holding nurses (task 15), one OR nurse (task 17), cleaning staff (task 18) and recovery nurses (task 20).

If we consider the four time periods of Figure 3.2 we see that the values for numbers of cliques and clique overlap are significantly higher on the day of surgery than for before that. This suggests that there is more differentiation as well as integration on the day of surgery than in the phases before. The high number of cliques is explained mainly by the fact that teams often interact for one specific patient; because these teams change frequently throughout the year, this results in a high clique overlap. In contrast, in the first phase, six to three months before surgery, there is a permanent smaller set of agents who make the OR master schedule, the clinical bed plan and equipment maintenance plan. Here we mainly see integration and no differentiation. At the same time the scheduling of surgeons and anesthesiologists (task 3) is executed by disconnected cliques, which shows differentiation.

DISCUSSION

This study aims to understand how a hospital's logistical system works and in particular to what extent there is integration and differentiation. The three specific objectives are (1) to identify the tasks that are performed in arranging the logistics for a hospital's surgery patients and (2) to establish which agents involved in these tasks interact with each other. In addition, (3) the degree of integration and differentiation in the entire hospital network is established. In total, 23 logistical tasks that are executed in-hospital for surgery patients have been identified. Twelve tasks are related to planning and eleven tasks are performed in executing surgeries by 635 different agents of 26 different agent types. The social network analysis shows that in the execution of these tasks there are 31,499 ties between these agents representing social interaction.

In the entire social network of the hospital both integration and differentiation are observed. The overall hospital network has a relatively low network integration, according to the low density, and there is differentiation in the execution of tasks per medical discipline, organizational unit and cross functional groups. Despite the overall low network degree, integration is demonstrated in cliques, in high clique overlap for several tasks and in multiplexity.

In contrast to the literature, which states that tasks are performed within functional silos[1,4], this study shows that most tasks in the case are executed across functional silos. Agents are involved in many different tasks, which are related to patient, material and staff flows. Apart from the way patients are admitted, there is no difference in tasks and involved agents between emergency and planned surgeries. There are several agents who act as a broker, but the OTC day coordinator and the OTC capacity planner are the only two agents whose primary task is to perform typical broker tasks such as network coordination and planning. Their betweenness centrality is substantially higher than for other agents. Besides these two agents, many nurses are brokers, as demonstrated by the relatively high degree and betweenness centrality of the nurse anesthetist, OR, holding, recovery and ward nurses. Other agents who integrate tasks are surgeons and anesthesiologists.

The social network analysis also demonstrates that agents with management roles, such as the cluster manager of the OTC and Services or team leaders, have a relatively low degree and betweenness centrality. Even in networks with centralization, the position of central agents is not based on hierarchy or formalized decision power. Almost all central agents in the networks per task have no hierarchical position with regard to other agents.

These findings suggest that the hospital's logistical system works differently than what is assumed in logistical and organizational literature with regard to hospitals. The network of Slingeland Hospital does not reflect its formal organizational structure. Nevertheless, interestingly enough, when we look at the hospital's performance, the system as described seems to function.
One explanation might be that in research, informal processes or interaction are not included, even though these take place in practice, due to the high variation in patient demand and uncertainty in the system. We could also argue that the hospital's logistical network is a relatively independent system, in which patient care is exclusively the domain of nurses and physicians, who have to solve issues and deal with situations each day as they present themselves. The social interaction that takes place on the day of surgery may imply that, despite the planning activities in the months and weeks before surgery, there is a continuous real-time adjustment process taking place in the system. This relates to a relevant topic, namely organizational structure versus governance. Provan states that network structures can be very effective in terms of learning ability, efficient resource use and problem solving capacity, but that little is known about how to control and manage these networks[42]. The fact that managing agents seem to have a relatively low integrative role in the network that was studied could be a risk. This is particularly the case because this integration lies mainly with two agents and there is little redundancy of agents performing integrative roles.

The fact that there appears to be so much social interaction also raises questions with regard to the HIS, because the IT system does not seem to replace the interaction needs of agents. This could be because IT systems, which require standardization and uniformity of operational processes[9], do not fit a reality that is much more varied and uncertain. There could also be a mismatch between the formal and informal organizational memory, in which data and knowledge are stored in both the IT system and in the heads of individuals, as stated by Van Merode et al.[9]. This mentioned possible shortcoming of an IT system to present data in line with reality is in line with van Merode et al.'s statement that 'processes may fail in unpredictable ways and may be difficult to trouble-shoot and correct'[9]. In addition, strategic decisions that impact the operational system could also have unexpected outcomes if these decisions are made without knowing how the operational network functions. We believe it is important to link the operational and the strategic systems of hospitals and study how these should be integrated and differentiated.

The findings of this case study raise the important question as to what extent the logistical hospital system generally functions as described here. A clear limitation of this study is

that this is a first case, both in using a system-wide perspective as well as the application of social network analysis theory to do so. Furthermore, the exclusion of external agents and the patients in our research limits our perspective on the functioning of the system in relation to its environment. A third limitation is the fact that interaction frequency and specific time aspects were excluded; consequently, the importance of one interaction over the other is not identified. Last but not least, based on this research, we do not know how network structure relates to the hospital's performance, which is highly relevant, since improving hospital performance is an important motivation for this type of study. However, in line with Yin, this exploratory study has seized the opportunity 'to shed empirical light on some theoretical concepts or principles'[28]. Rather than generalizing these findings statistically, this case study should be used for analytic generalization[28], either by defining new research or by reinterpreting other studies or cases in this field. There are several issues we propose to explore further.
First, an important question to consider is what is the relation between the network structure, in particular integration and differentiation and its performance. In social network theory, several statements have been made regarding the efficiency, effectiveness, flexibility and vulnerability of networks. Kilduff[17], for example, states that a clique 'represents maximum inefficiency'. Although this statement was put forth in a technical treatise of network structures, the redundant and repetitive interaction between agents in Slingeland Hospital raises questions with regard to the efficient use of resources, in particular concerning the efficient use of physicians and nurses. In relation to efficiency, Provan states that cliques should not be too large nor should the number be too high[16], and Volland states that relieving medical staff from activities that are not directly patient-related could improve the quality of health care[43]. On the other hand, the high number of cliques and redundancy may be effective in dealing with the complexity of the logistics of surgery. The fact that surgeons, OR nurses and nurse anesthetists collaborate in many different cliques may increase network flexibility. In order to assess hospital performance we believe a new framework is required, which must include multiple parameters relating to the interests of individual agents and the various demands stemming from the hospital's environment, both within parts of the hospital network as well as on a hospital-wide level[13].

A second topic is how integration is best achieved in hospitals. There are vulnerabilities in the network of Slingeland Hospital, because without the OTC capacity planner and the OTC day coordinator the system would fall into fragmented parts, creating so-called structural holes[17]. In addition, as nurses, surgeons and anesthesiologists perform integrative tasks, it may be a burden for them to perform tasks directly related to patient care. Also, it's important to address the role of management and brokers and whether they should coincide or not. Further research is necessary to determine how many brokers are required and how they should be positioned in relation to managers, physicians and nurses.

In addition, given the statements of Lawrence and Lorsch[15] and Provan[16] that integration and differentiation should fit the demands of the hospital environment, it is important to examine how the network structure fits the demands that are put on the hospital system, not just by patients but also by policy makers, insurance companies and other stakeholders. Van Merode et al. also state that organizations, 'according to contingency theory should adopt a mechanistic form if their task is simple and stable and their goal is efficiency and they should adopt an organic form if their task is complex and changing and their goal is therefore flexibility'[9]. From this network analysis no clear distinction between simple or complex tasks emerged. Following van Merode et al's statement that a different control system should be designed if there is no homogeneity in the hospital's services[9], it is important to study further the distinction between the more 'mechanistic' part of the hospital and tasks requiring more 'organic' flexible structures.

A third research area is how social network theory and the associated metrics relate to the concepts of integration and differentiation. The metrics used here represent a mathematical value for integration and need to be linked to concepts in organization theory. The concepts used in organization theory and social network analysis are not always the same. It is important to note, for example, that "centralization" as defined by Mintzberg[40] is not the same as centralization in social network theory. Mintzberg associates centralization with decision power. For instance, "vertical centralization" entails that decision-making power is centrally located at the strategic apex of an organization. An agent who is in a central position in a social network can be a member of the strategic apex, but this is not necessarily the case. For differentiation the concepts of social network theory are even less clear. In this study we explored these concepts, but we believe this has to be studied further for developing social network theory.

The main strength of this study is that it presents a new perspective on the hospital's logistical system and responds to the statement that most studies fail to address the entire hospital supply chain or network[1]. This study also responds to the fact that hospital-wide studies have not been performed using quantitative techniques, and optimization is often based on 'policy' and 'experience' rather than on data[43]. Although we have not studied optimization, this study could be a fruitful basis for doing that, thereby developing logistical and organizational theories that are coherent with the hospital's practice.

CONCLUSIONS

In conclusion, this social network analysis of a hospital's logistical network, the first as far as we know, sets a basis for further research on integration and differentiation. It identifies a possible gap between existing organizational perspectives on hospitals and the reality. This should be analyzed further in order to be able to increase the effectiveness of hospitals. A first step would be to replicate the methods applied here in other hospitals. More case study research in the future would enable academia to develop new theories on the organization of hospitals. This knowledge is important for healthcare policy makers and for the strategic management of hospitals; it can support the effective integration and differentiation of tasks in both the operational system and the strategic system, within hospitals or even in regional healthcare alliances.

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APPENDIX 3.1: DATA COLLECTED AND USED FOR SOCIAL NETWORK ANALYSIS PER TASK

#	Task	HIS data	Documents	Observations	Interview
1	Make OTC master schedule		Internal presentation on working procedures OTC master schedules		OTC capacity planner Surgeon Anesthesiologist
2	Make clinical bed plan		Clinical bed plan Internal presentation on clinical bed planning		OTC capacity planner
3	Schedule surgeons and anesthesiologists	Number of surgeons and anesthesiologists involved in surgeries in 2017	Number of surgeons and anesthesiologists on hospital website	Three outpatient departments with 7 secretaries Preoperative department with 1 secretary	2 surgeons 1 anesthesiologist OTC capacity planner
4	Schedule OT nurses	Number of OCT nurses involved in surgeries in 2017	Working schedules OTC nurses Overview of OTC nurses Clusters of OTC nurses Sign up forms working shifts Overview of working day preferences		3 team leaders of the OTC
5	Plan equipment maintenance				OTC capacity planner
6	Plan surgery	Number of surgeons and anesthesiologists involved in surgeries in 2017	Number of surgeons and anesthesiologists on hospital website Planning rules for general surgery Time out procedure	Three outpatient departments with 6 secretaries	OTC capacity planner 2 surgeons 1 anesthesiologist
7	Order materials		Overview of OTC nurses responsible for ordering materials for specific surgeries	3 outpatient departments with 6 secretaries OTC day coordinator	Team leader of the OTC OTC capacity planner
8	Preoperative screening	Number of anesthesiologists involved in surgeries in 2017	Overview of staff in preoperative screening Time out procedure	Preoperative screening department with preoperative secretary, preoperative nurse, pharmacy assistant and anesthesiologist	OTC capacity planner
9	Make appointment		Overview of staff in preoperative screening	Preoperative secretary 3 outpatient departments with 6 secretaries	
10	Plan OT nurses		Overview number of OTC nurses Planning of OTC nurses	OTC day coordinator	Team leader of the OTC
11	Control planning		Planning checklist OTC program	OTC day coordinator Surgeries in two Operating Rooms 3 outpatient departments with 6 secretaries	OTC capacity planner

#	Task	HIS data	Documents	Observations	Interview
12	Pick materials			Logistical staff on OTC	
13	Emergency admission			OTC day coordinator	• Team leader Emergency Department
14	Prepare patient on ward	Surgery registration data including the ward for each patient	• Overview of number of ward nurses for each nursing ward • Day program • Time out procedure	2 nursing wards	
15	Prepare patient in holding	Surgery registration data of 2017	• Holding checklists • Process flow scheme holding • Time out procedure	Holding	
16	Make Radiology image			• Surgeries in two Operating Rooms Recovery	
17	Doing surgery	• Surgeons, anesthesiologists, OTC staff involved in each surgery in 2017	• Time out procedure	• Surgeries in two Operating Rooms • OTC day coordinator	• 2 surgeons • 1 anesthesiologist
18	Clean OR			• Surgeries in two operating rooms	• OTC capacity planner
19	Order emergency CSD services			• OTC day coordinator • Central Sterilization Department	
20	Patient care recovery	• Surgery registration data	• Time out procedure	Recovery	• Team leader Recovery
21	Aftercare of patient	• Surgery registration data including the ward for each patient, surgeons involved in the surgery and patient transfers	• Overview of number of ward nurses for each nursing ward • Time out procedure	• 2 nursing wards	• 2 surgeons
22	Manage OT day program			• OTC day coordinator • Surgeries in two Operating Rooms	• 1 anesthesiologist • 2 surgeons
23	Manage OT tasks		• Emails including planning of management meetings		• Cluster manager OTC and Services • OTC capacity planner • 3 team leaders of the OTC

APPENDIX 3.2: SOCIAL NETWORK PER TASK

1. Make the OR master schedule

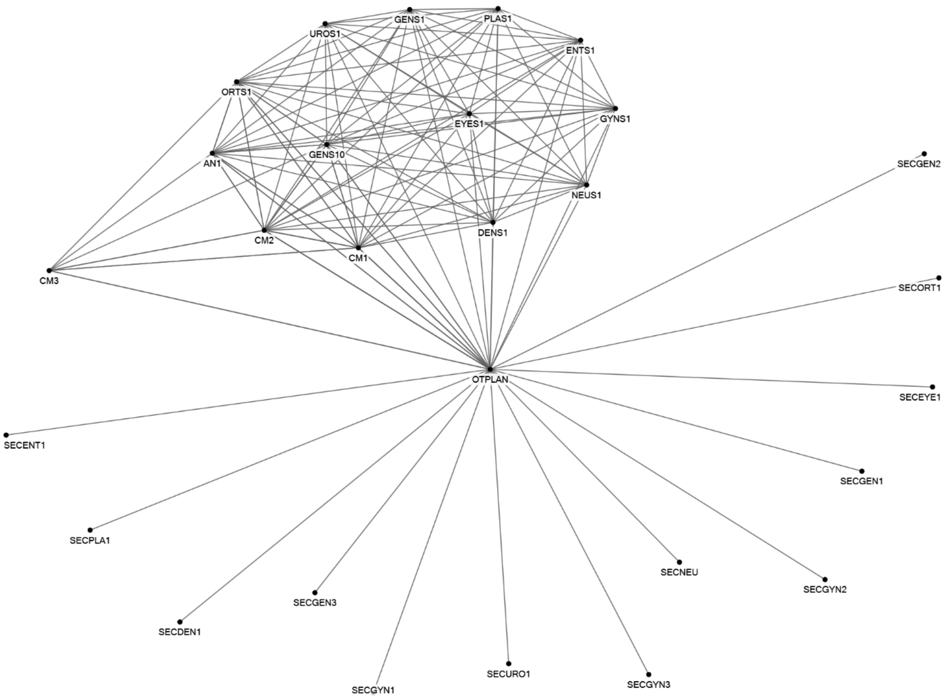


Figure A3.2.1 Social network of Task 1: Making the OR master schedule.

Parameter	Value
Number of agents	28
Number of unique ties	110
Density	0.29
Number of cliques	2
Highest betweenness centrality	OTPLAN

The Operating Room (OR) master schedule is made in the Tactical Planning Meeting (TPM). Three cluster managers who are responsible, respectively, for outpatient, inpatient departments and Operating Theatre Complex (OTC), three general surgeons, an orthopedic surgeon, an anesthesiologist and the OTC capacity planner participate in this meeting. The OR master schedule is prepared by four participants of the TPM, who then propose the scheme to the entire TPM. The OR master schedule is then presented to the OTC commission. The OTC commission discusses and advises OTC management on planning, staff and budget issues. The OTC commission includes one surgeon from every surgical discipline, the cluster manager responsible for the OTC and the OTC capacity planner. When the session schedule is final, the OTC capacity planner informs all outpatient secretaries of all changes made.

2. Make the clinical bed plan

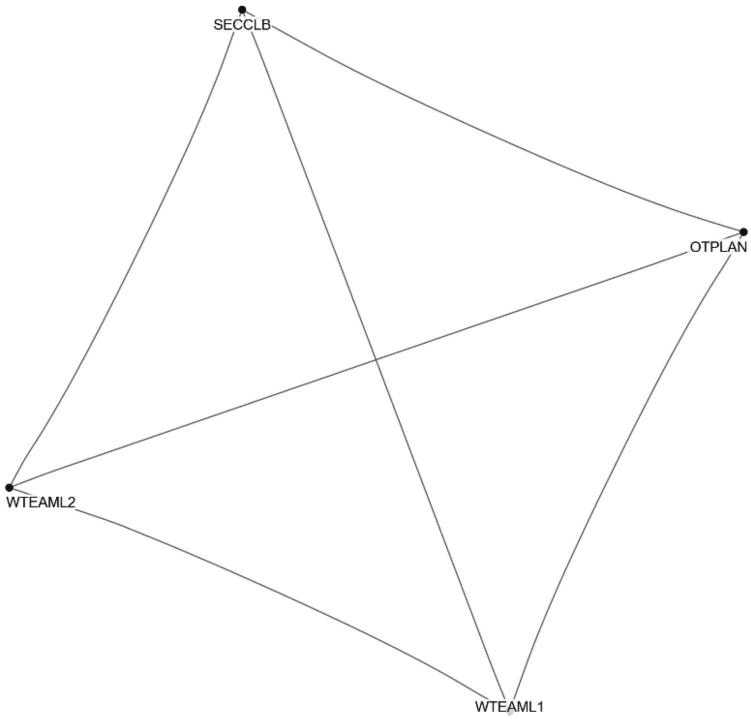


Figure A3.2.2 Social network of Task 2: Making the clinical bed plan.

Parameter	Value
Number of agents	4
Number of unique ties	6
Density	1
Number of cliques	1
Highest betweenness centrality	N/A

In the clinical bed plan, beds are assigned to a medical discipline for each nursing department. The clinical bed plan is established in consultation between the OTC capacity planner, one secretary from the nursing department and the two team leaders of the three nursing wards who host most surgery patients. The team leaders of these nursing wards are also involved in making the clinical bed plan, but one nurse ward secretary has the informal role of 'clinical bed plan boss'. She uses this plan to correct outpatient clinics when they take a bed they cannot claim.

3. Schedule surgeons and anesthesiologists

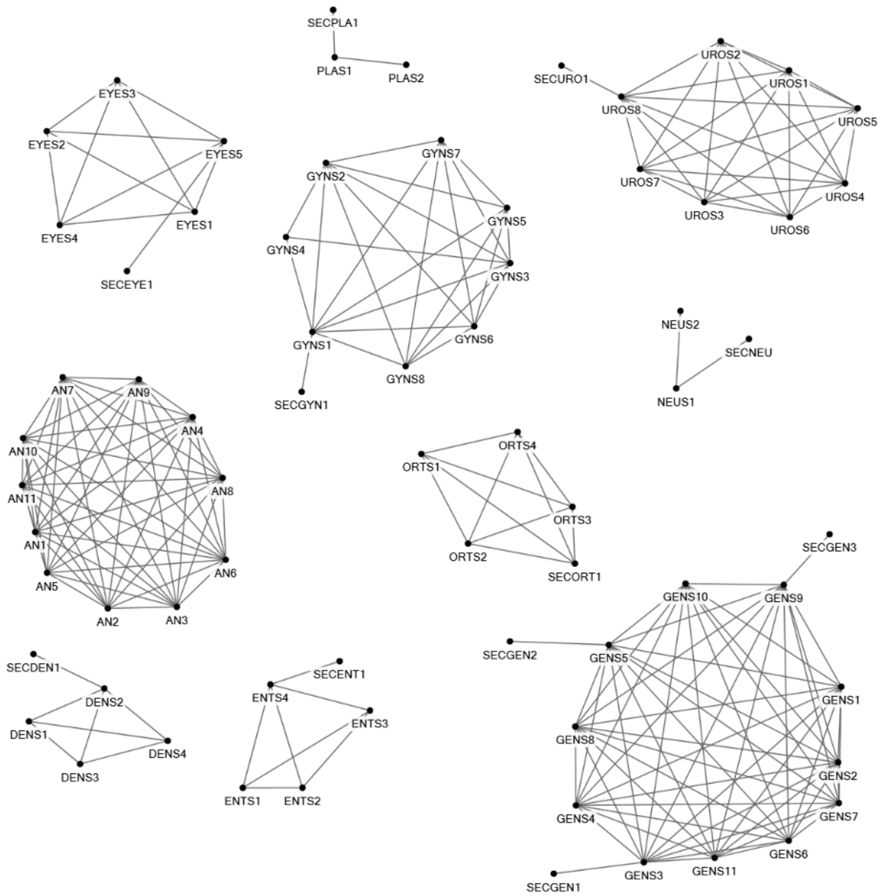


Figure A3.2.3 Social network of Task 3: Scheduling surgeons and anesthesiologists.

Parameter	Value
Number of agents	70
Number of unique ties	206
Density	0.09
Number of cliques	10
Highest betweenness centrality	GENS3/GENS9

The OR master schedule is also used for preparing staff planning schemes. The surgeons of each outpatient department and anesthesiologists make these schedules for themselves and allocate surgeons to the time slots in the OR master schedule. One surgeon within each medical discipline group proposes the schedule and discusses it with the other surgeons. In some outpatient departments the secretary of the outpatient department is involved in this.

4. Schedule OTC nurses

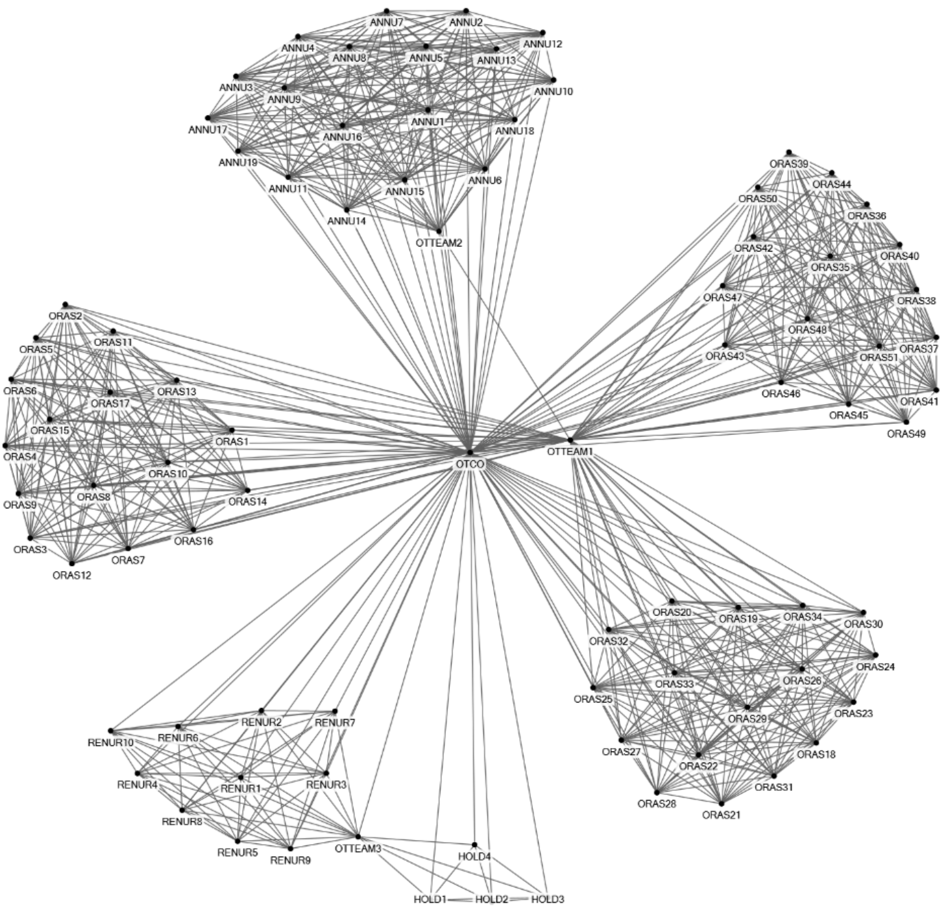


Figure A3.2.4 Social network of Task 4: Scheduling OTC nurses.

Parameter	Value
Number of agents	88
Number of unique ties	801
Density	0.2
Number of cliques	6
Highest betweenness centrality	OTCO

The OTC surgery team leader plans the schedule with the OR nurses. He makes a schedule based on the OR master schedule and communicates with OR nurses about it. In this planning process a number of factors which require interaction are taken into account. OR nurses sign up for shifts outside regular operating times on nights and weekends. The surgery team leader verifies if the nurses have signed up for the agreed number of shifts and, if necessary, makes changes in this scheme to create a fair division of shifts. When all shifts are filled, the team leader fills in the OR day schedule, taking into account the clusters of medical disciplines to which each OR nurse belongs. He also takes into account the employees who want to work on fixed days and after that the shifts for the more flexible nurses are planned. In the event of an expected shortage of OR nurses, the team leader sends an email to the OR nurses, asking them to volunteer for that particular day. If they do not volunteer, the surgery team leader picks someone. The complete OR schedule is then released to all OR nurses via the IT system. At this point OR nurses are allowed to exchange hours among themselves within the three clusters of medical disciplines. If a 'deal' has been concluded between two or more OR assistants and the date at issue is at least two weeks in advance, they make a proposal to the surgery team leader, who assesses this and agrees. If it concerns a date within the next two weeks, the proposal is presented to the OTC day coordinator and he approves or disapproves it. The OTC day coordinator is responsible for the daily operation of the OTC, making sure that all surgeries are performed according to plan.

The OTC anesthesia team leader makes the schedule for the nurse anesthetists and the team leader holding and recovery makes the schedule for the holding and recovery nurses following a similar procedure.

5. Plan equipment maintenance

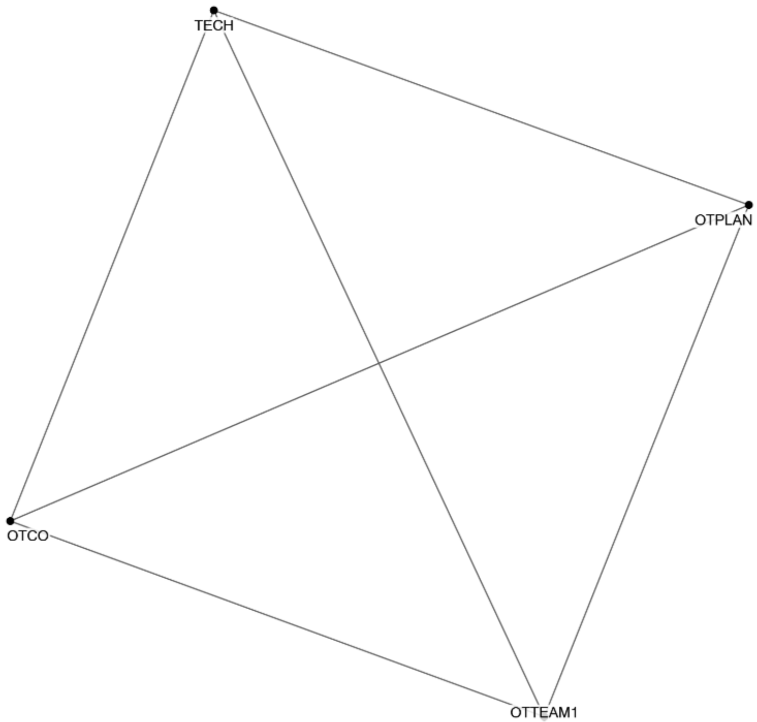


Figure A3.2.5 Social network of Task 5: Planning equipment maintenance.

Parameter	Value
Number of agents	4
Number of unique ties	6
Density	1
Number of cliques	1
Highest betweenness centrality	none

Planning is also made for OTC equipment maintenance. Technical staff from the Medical Equipment Department send an email to the OTC capacity planner with a request to perform maintenance on specific equipment. The OTC capacity planner checks with the OTC day coordinator and the surgery team leader whether this is possible, given the OR master schedule and (expected) surgeries in that period of time.

6. Plan patient

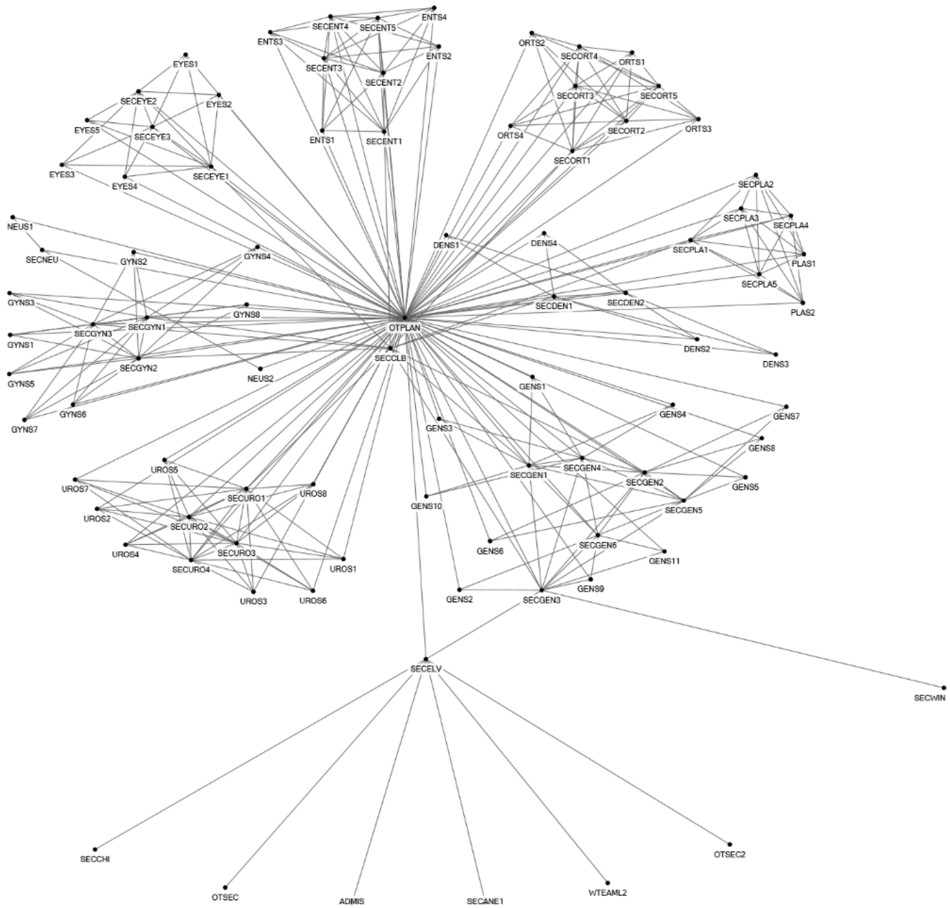


Figure A3.2.6 Social network of Task 6: Planning surgery.

Parameter	Value
Number of agents	92
Number of unique ties	315
Density	0.08
Number of cliques	48
Highest betweenness centrality	OTPLAN

The planning for surgeries takes place at one of the nine outpatient clinics after the diagnosis has been made by the physician. The surgeon agrees with the patient that he or she will be operated in an outpatient visit and takes the patient to a secretary of the outpatient department, who informs the patient about the surgery, what is to be expected and when and how the patient will be called to set a final surgery date. The secretary puts the patient on the waiting list or a surgery date right away. There can be interaction between secretaries and the OTC capacity planner on specific surgery requirements or in case the OR master schedule is almost filled.

Also sessions are 'traded' between the secretaries and the OTC capacity planner in case sessions are under or over utilized. Surgeons also email or phone the OTC capacity planner for specific patient cases that require tuning.

Vascular patients of the Queen Beatrix Hospital are operated on in Slingeland Hospital. For these patients the outpatient secretary of the vascular surgery in the Queen Beatrix Hospital emails the vascular surgery outpatient secretary of Slingeland Hospital, who then plans these patients in.

The 'clinical bed plan boss' checks how the secretaries fill in the OR master schedule and how many beds are planned. If the secretaries of the outpatient departments take too many beds, she corrects them. The OTC capacity coordinator and 'clinical bed plan boss' evaluate how the clinical bed plan is followed and provide feedback to the secretaries on their planning activities.

7. Request and order materials

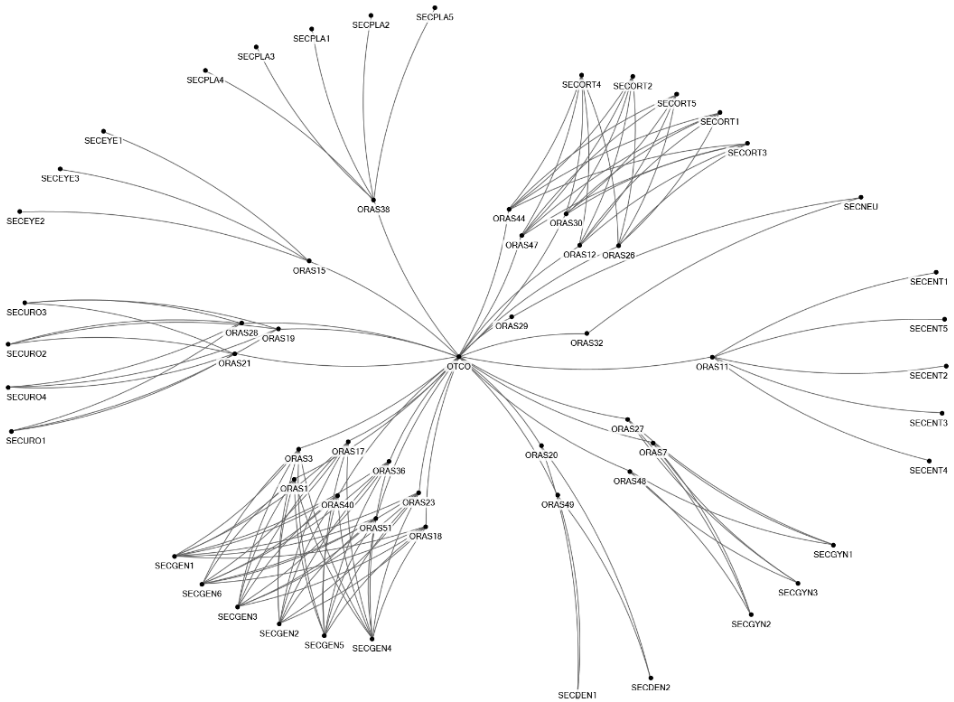


Figure A3.2.7 Social network of Task 7: Order materials.

Parameter	Value
Number of agents	61
Number of unique ties	139
Density	0.08
Number of cliques	0
Highest betweenness centrality	OTCO

If specific materials are required for an operation, the secretary of the outpatient clinic informs the OR assistant, who is specialized in the medical discipline it concerns. The OR nurse then orders the required materials via the OTC day coordinator, who then orders the materials from external suppliers via the Purchasing Department.

Other material related tasks are the cleaning of medical instruments which are delivered to the OTC by the Central Sterilization Department (CSD) every day. Further, medication, consumables and implants are delivered every day by a variety of external suppliers. One logistical staff member receives these materials and puts these in the right storage room.

8. Preoperative screening

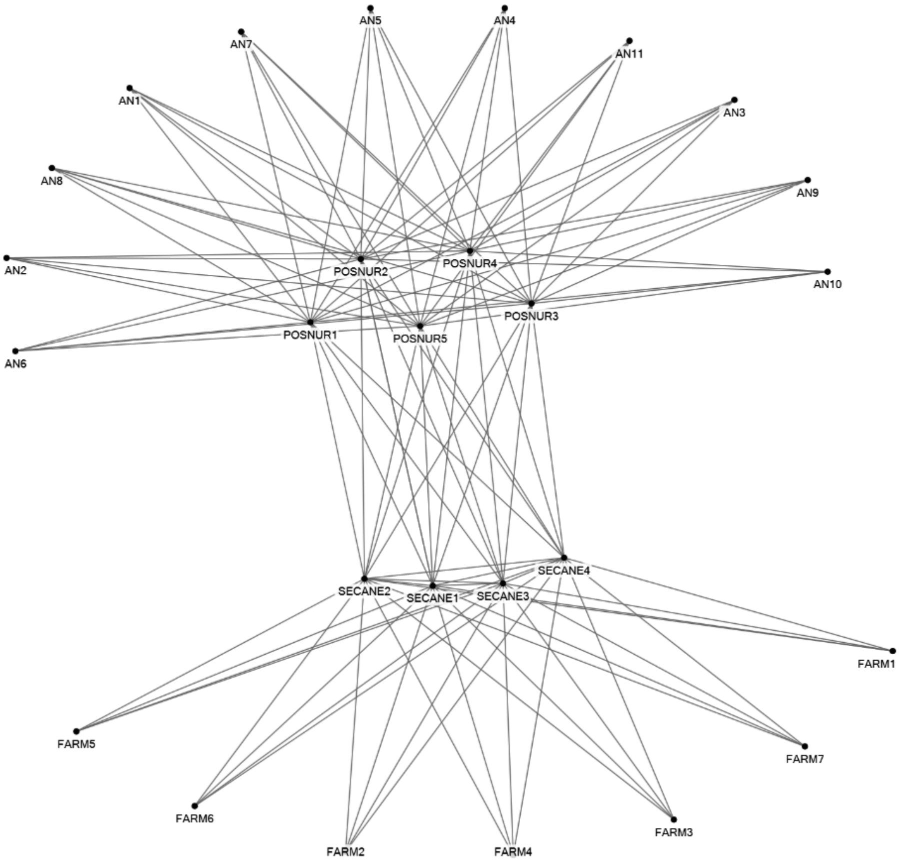


Figure A3.2.8 Social network of Task 8: Preoperative screening.

Before a final date can be set for the surgery, the patient must be screened by the anesthesiologist and prepared accordingly in the preoperative department. In the preoperative visit the patient first visits the pharmacy assistant (FARM), who checks which medication the patient is using. Subsequently, a physical examination is performed, after which the patient discusses with the anesthesiologist (AN) which anesthetic technique will be used, which medication he or she may continue to use on the day of the operation and then the anesthesiologist approves the operation. Right after this the patient meets the preoperative nurse (POSNUR), who further prepares the patient for surgery by providing information and discussing the preparations and aftercare the patient requires.

Parameter	**Value**
Number of agents	27
Number of unique ties	109
Density	0.31
Number of cliques	12
Highest betweenness centrality	All SECAN/ POSNUR

9. Request and make appointment

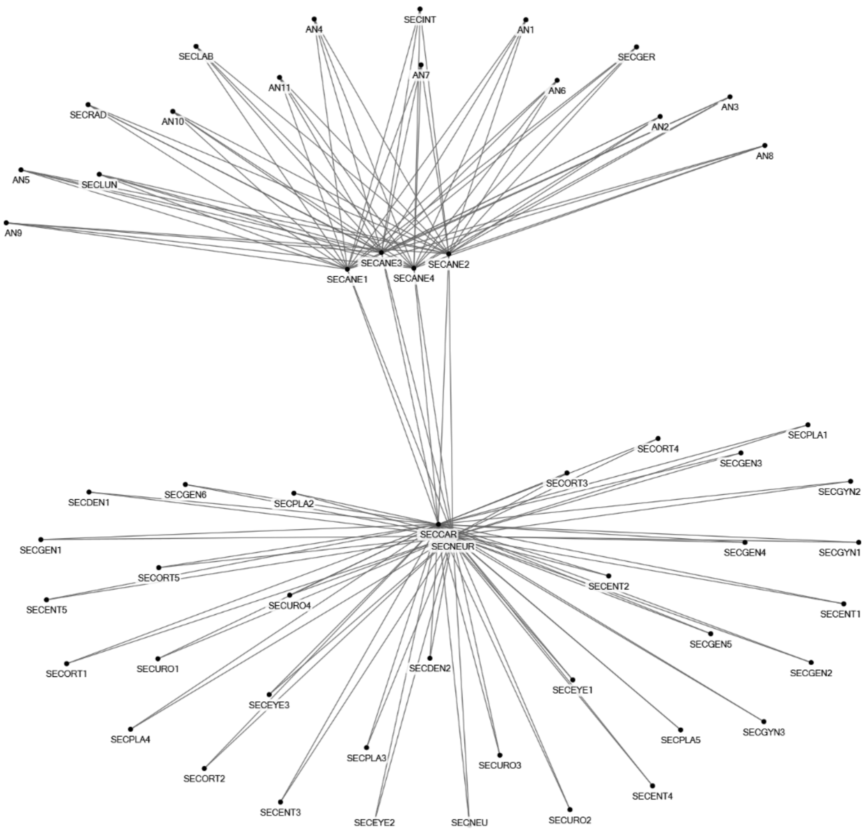


Figure A3.2.9 Social network of Task 9: Make appointment.

Parameter	Value
Number of agents	56
Number of unique ties	140
Density	0.09
Number of cliques	0
Highest betweenness centrality	SECNEUR/ SECCAR

The anesthesiologist can decide, based on the patient's health situation, that the patient has to visit other physicians, prior to the operation, such as the cardiologist or the neurologist. The secretary at the pre-operative outpatient clinic arranges this for the patient, as well as any necessary blood tests or making an ECG image. Any appointments that need to be made for this are made by the secretary of the preoperative outpatient department.

After the consultation with the anesthesiologist, the patient goes to a nurse who informs the patient about the operation and prepares him or her more extensively.

In case a patient uses anticoagulants, the outpatient department of the surgeon who will perform the surgery arranges a visit to the neurologist or cardiologist.

10. Plan OTC nurses

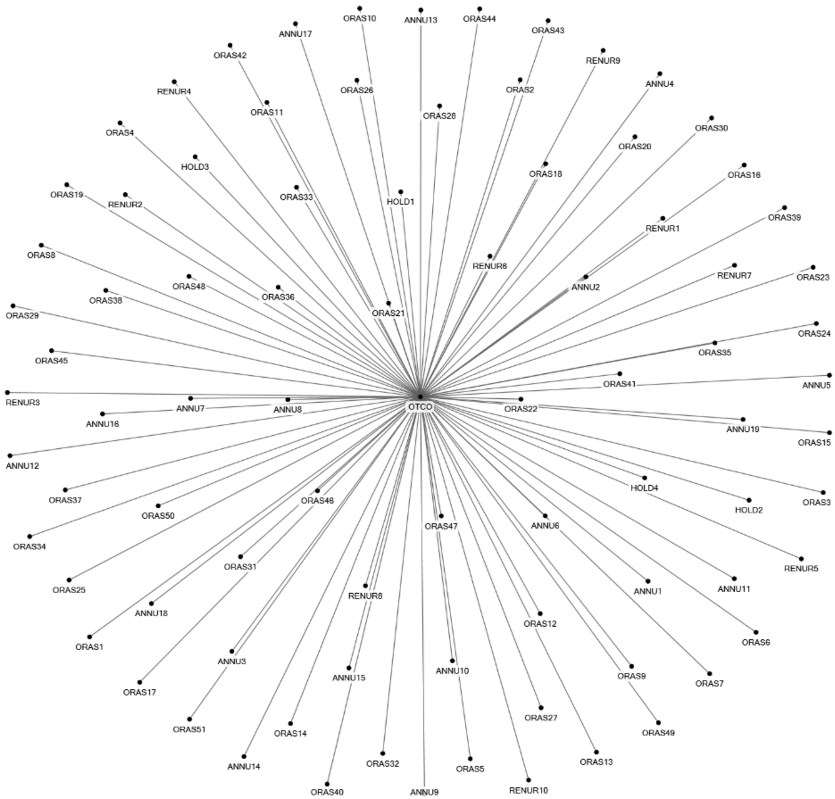


Figure A3.2.10 Social network of Task 10: Plan OTC nurses.

A week before surgeries are performed, the day coordinator allocates the OR nurses to surgeries for the upcoming week and he handles all communication with regard to their availability, illness or other casualties.

Parameter	Value
Number of agents	85
Number of unique ties	84
Density	0.02
Number of cliques	0
Highest betweenness centrality	OTCO

11. Control planning

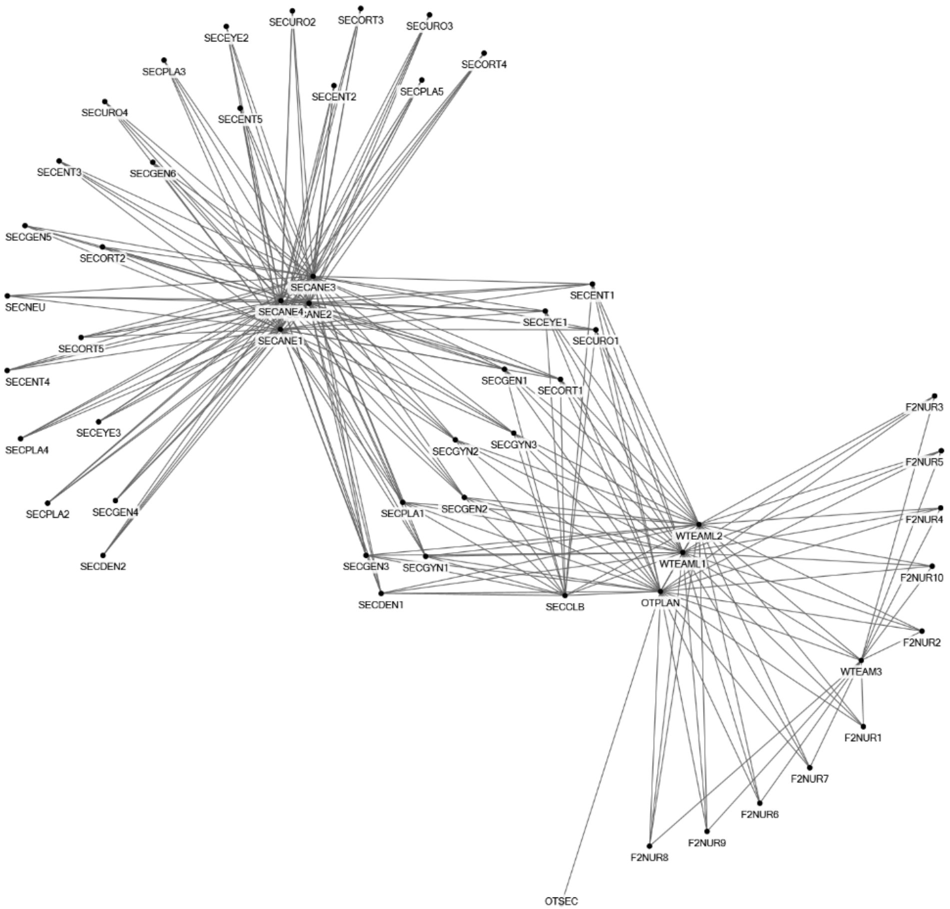


Figure A3.2.11 Social network of Task 11: Control planning.

Parameter	Value
Number of agents	54
Number of unique ties	234
Density	0.16
Number of cliques	2
Highest betweenness centrality	All SECANE

In the process towards the surgery taking place, the planning is checked and revised. Preoperative screening needs to be performed before the date of surgery is final. The preoperative secretaries interact with all outpatient secretaries on whether everything is arranged for the surgery to take place.

In the weekly 'Tuesday morning' meeting the planning for the upcoming week is discussed between the outpatient secretaries, the ward team leaders and the OTC capacity planner. Also a weekly bed meeting takes place between ward team leaders, a nurse and the OTC capacity planner. In this meeting all checks for the next day's OR program are made.

The OTC capacity planner views the daily OTC schedule the day before to determine the exact sequence of the operations. For planning surgeries and determining the sequence of the procedures, a large number of control rules are set and these need to be checked. The OTC capacity planner reviews the electronic patient file of each individual patient, checking if all information has been taken into account. When everything is checked, she informs the OTC day coordinator regarding any specific details in the next day's OTC program.

12. Pick materials

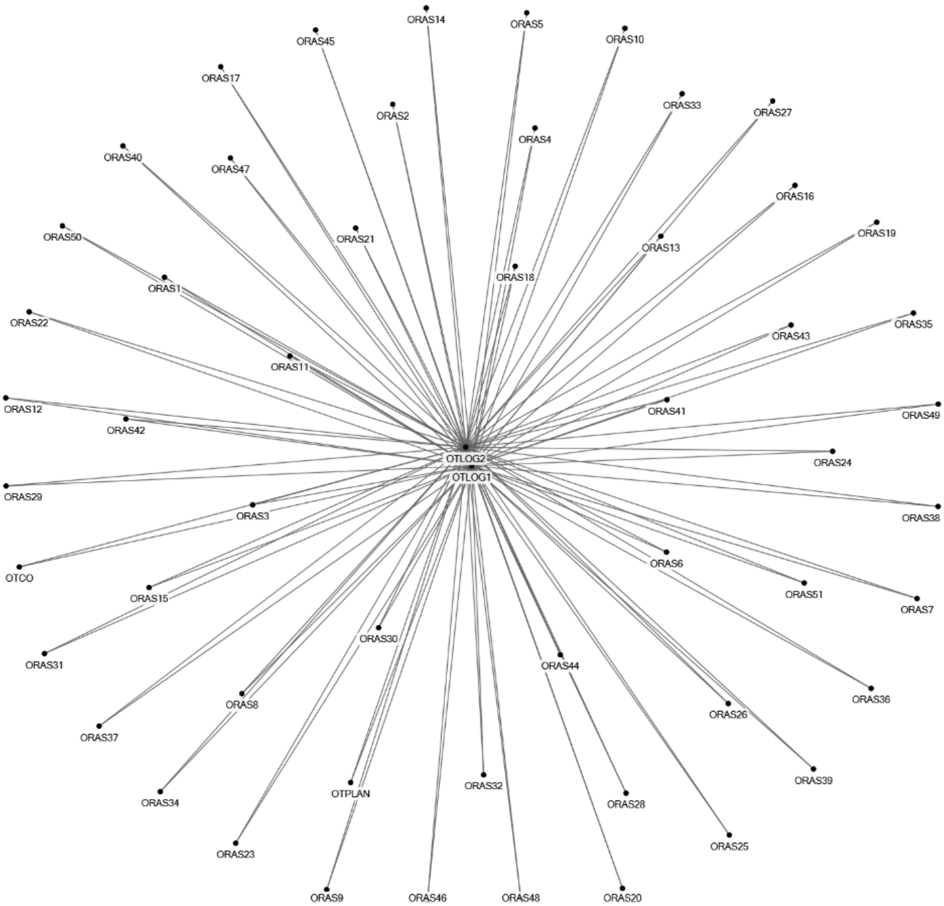


Figure A3.2.12 Social network of Task 12: Picking materials.

Parameter	Value
Number of agents	55
Number of unique ties	107
Density	0.07
Number of cliques	53
Highest betweenness centrality	All OTLOG

Medical instruments, consumables and implants are collected a day in advance by two logistical OTC staff members. Sterile and non-sterile materials stored in three storage rooms at the OTC are picked and placed in carts, which are then put in the preparation rooms which are located beside each OR. Materials are mainly collected on the basis of bills of material, which are available for every surgery. Logistical staff members consult the OTC capacity planner, OTC day coordinator and OR nurses on what particular surgeries involve, in case the bill of material doesn't provide enough information or in case they are not familiar with a surgery type.

13. Emergency admission

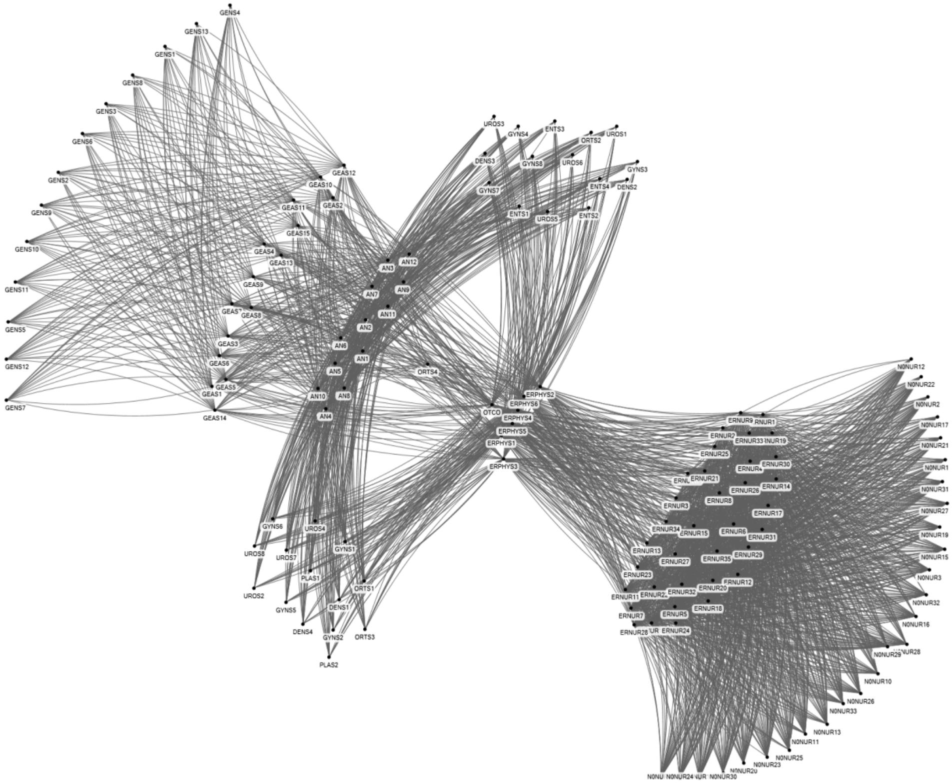


Figure A3.2.13 Social network of Task 13: Emergency admission.

Parameter	Value
Number of agents	139
Number of ties	2840
Density	0.30
Number of cliques	1
Highest betweenness centrality	OTC day coordinator (OTCO)

Patients who arrive at the Emergency Department (ED) are examined by the ED physician (ERPHYS). He calls the assistant surgeon or a surgeon if he thinks that the patient requires surgery. The assistant surgeon or surgeon comes to the ED and sets the diagnosis. If necessary blood samples or images are made. If they decide to operate, the general surgeon is called, as well as the OTC day coordinator. The ED nurse takes care of the patient and calls the OTC day coordinator as well to see if the patient goes straight to the OTC or to the nursing ward that admits emergency patients. The surgeon orders preoperative screening with the anesthesiologist, who executes this by screening the patient file. Planning the surgery into the OR program is done through communication between the OTC day coordinator, surgeon and anesthesiologist.

14. Prepare patient on ward

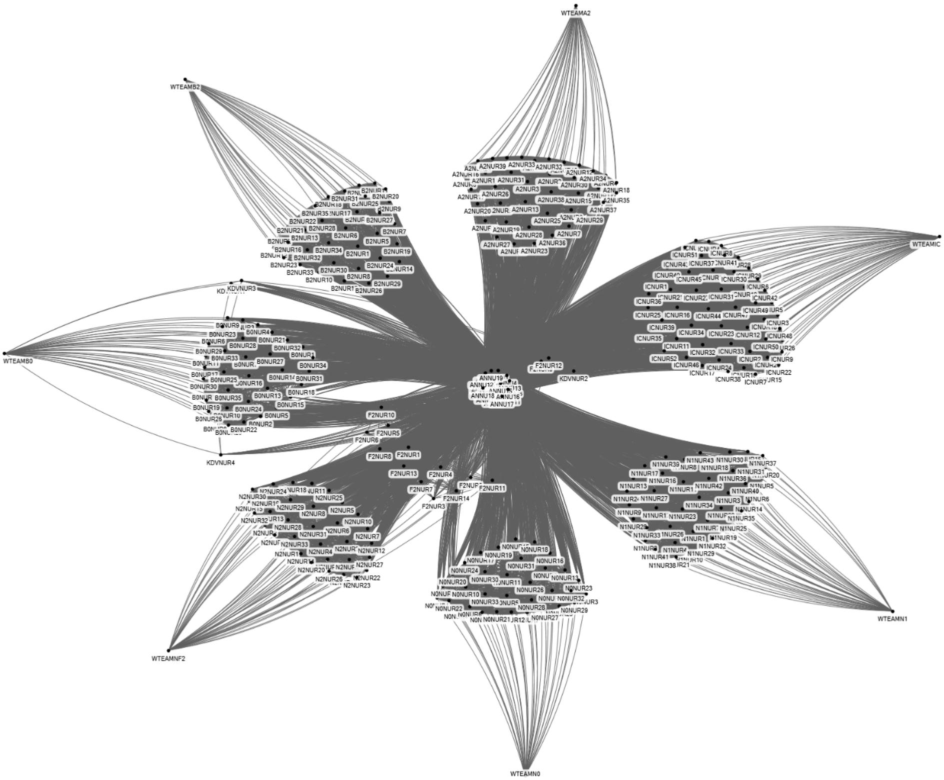


Figure A3.2.14 Social network of Task 14: Prepare patient on nursing ward.

Parameter	Value
Number of agents	314
Number of ties	11,071
Density	0.23
Number of cliques	9
Highest betweenness centrality	All ANNU

From the moment the patient is admitted to the hospital, a series of tasks including a lot of communication is performed within a short period of time. First the patient is admitted to one of the nursing wards. During the intake interview a number of checks are made to see if the patient is well prepared for the surgery. The nurse anesthetist then calls the nurse to indicate that premedication should be given to the patient, mostly 2 hours before the expected starting time of the surgery. The nurse anesthetist makes a second call to the nurse to say that the patient is to be taken to holding.

15. Prepare patient on holding

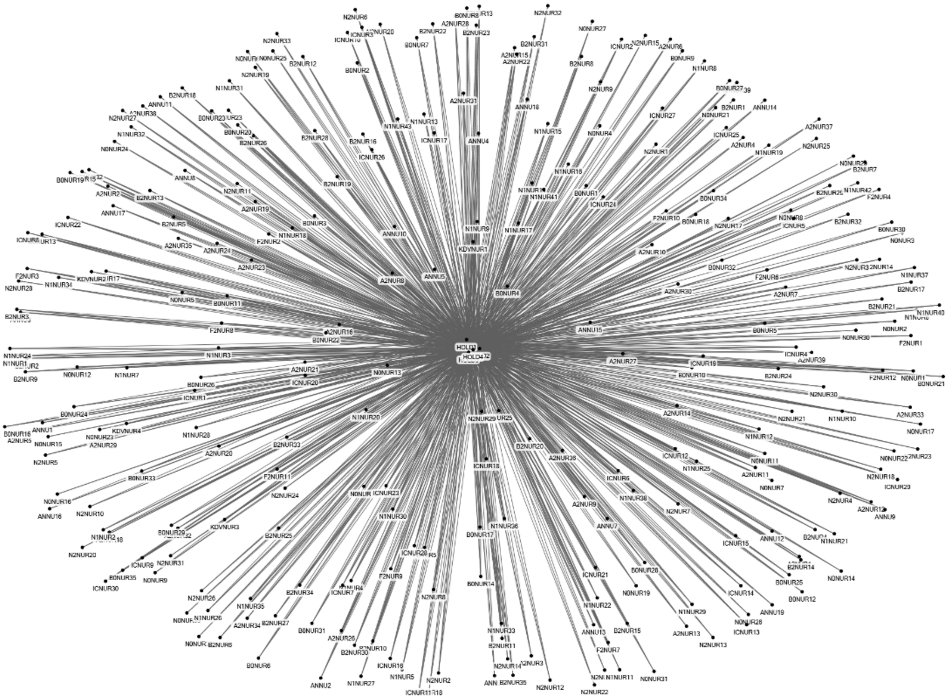


Figure A3.2.15 Social network of Task 15: Prepare patient in holding.

Parameter	Value
Number of agents	289
Number of unique ties	1100
Density	0.03
Number of cliques	65
Highest betweenness centrality	All ANNU

After the nurse hands over the patient to one of the holding nurses, following a standard transfer protocol, the second stage starts. The holding nurse prepares the patient by, among other things, preparing the infusion devices. When it is time to go to the OR the nurse anesthetist enters holding and has a small chat with the patient. The holding nurse hands the patient over to the nurse anesthetist, using the standard transfer protocol.

16. Make Radiology image

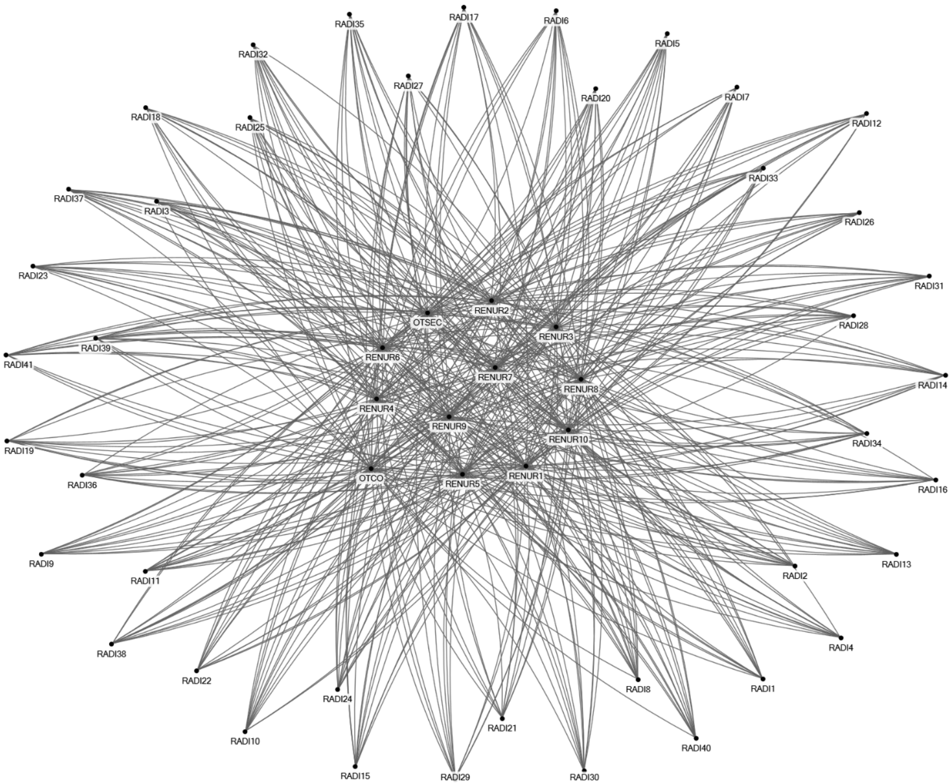


Figure A3.2.16 Social network of Task 16: Making radiology image.

Images can be made before or after surgery. When images are needed before surgery, the OTC day coordinator puts in a request to the radiology department, and they send someone in. When an image is required post-surgery, while the patient is in recovery, the recovery nurse calls the radiology department.

Parameter	Value
Number of agents	53
Number of unique ties	491
Density	0.36
Number of cliques	0
Highest betweenness centrality	All Recovery nurses, OTC day coordinator and OTC secretary

17. Perform surgery

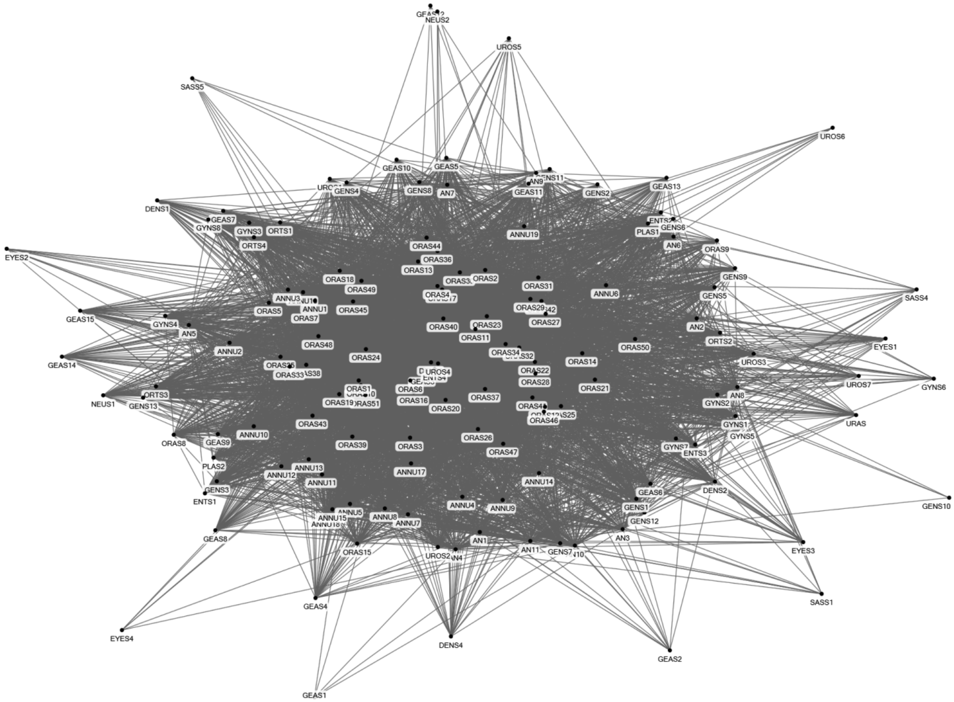


Figure A3.2.17 Social network of Task 17: Collaborating in the OR.

Parameter	Value
Number of agents	148
Number of unique ties	5444
Density	0.5
Number of cliques	7640
Highest betweenness centrality	ORAS17

Once the patient is in the OR the nurse anesthetist mentions any relevant details about the patient to the rest of the OR team. The anesthesiologist administers anesthetics prior to the surgery and leaves once the patient is asleep. The surgery is performed by the surgeon, assisted by the OR nurses. The nurse anesthetist monitors the patient and calls the anesthesiologist if necessary.

18. Clean the OR

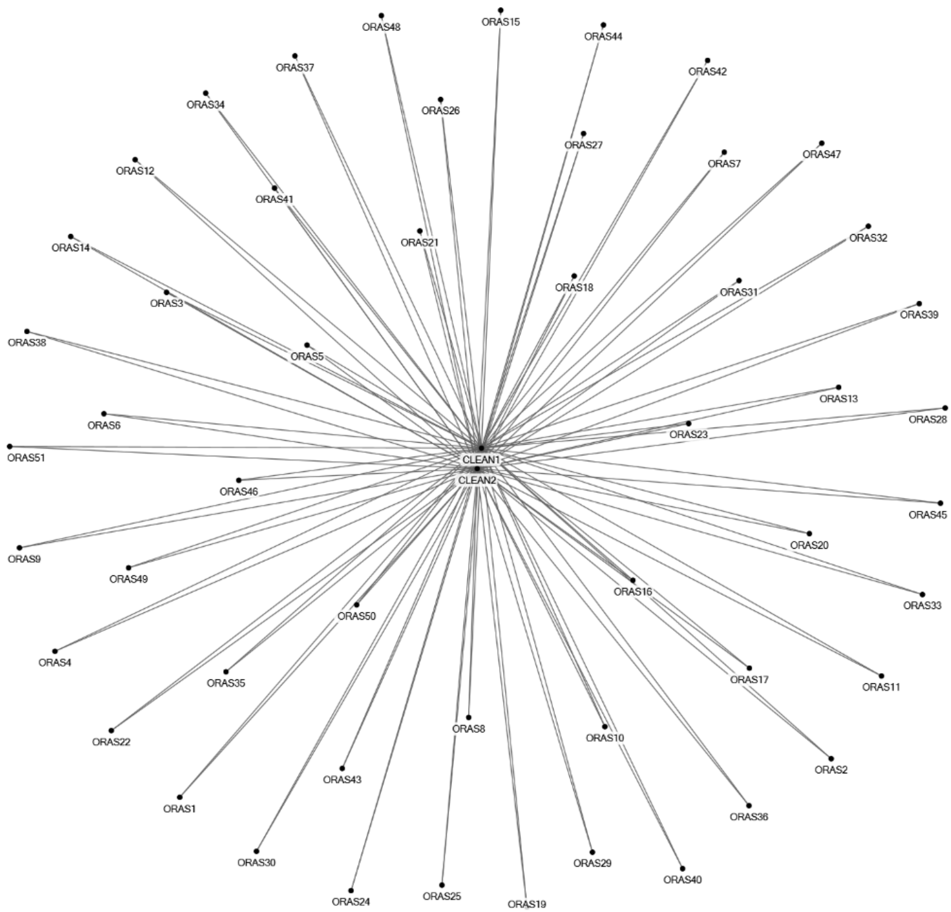


Figure A3.2.18 Social network of task 18: Cleaning the OR.

At the end of the surgery the anesthesiologist wakes the patient and the OR assistant calls the cleaning staff. If body tissue has been removed from the patient, it will be sent to pathology to investigate abnormalities.

Parameter	Value
Number of agents	53
Number of unique ties	102
Density	0.07
Number of cliques	0
Highest betweenness centrality	All CLEAN

19. Order emergency CSD services

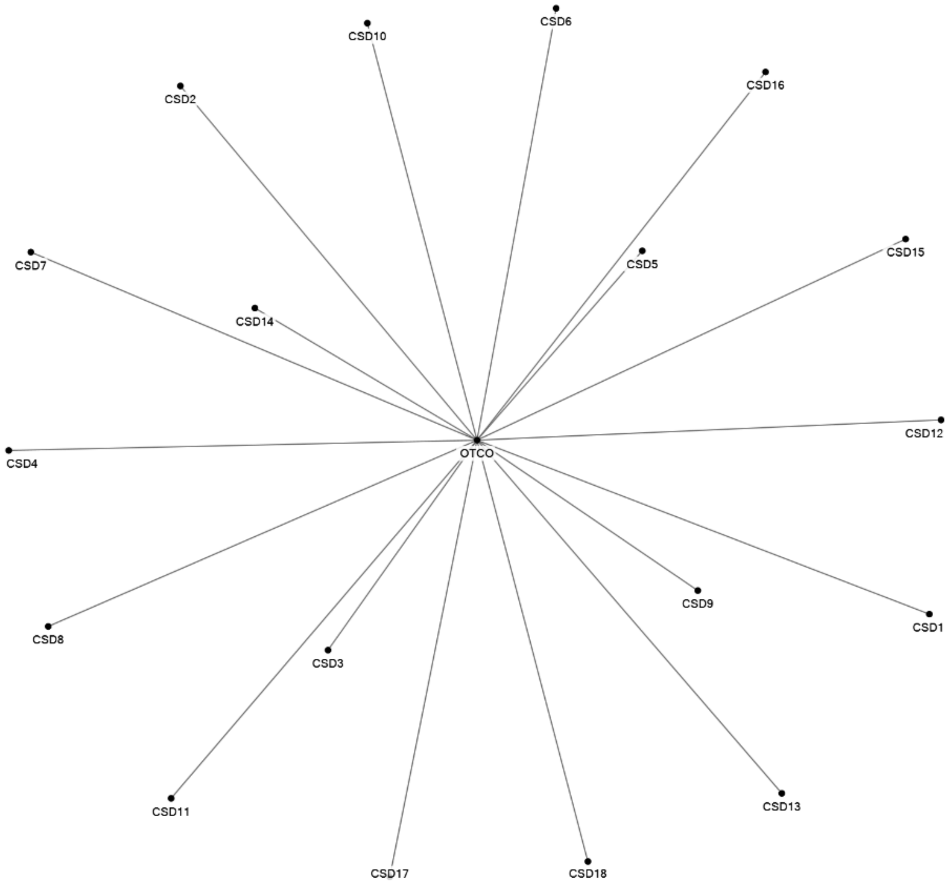


Figure A3.2.19 Social network of task 19: Order emergency CSD services.

Parameter	Value
Number of agents	19
Number of unique ties	18
Density	0.11
Number of cliques	0
Highest betweenness centrality	OTCO

After surgery an OR nurse presses a button that switches on a light at the CSD, signaling that the used medical instruments need to be collected and brought to the CSD. There is no social interaction for this, so it is not visualized in this figure. If medical instruments need to be cleaned and sterilized immediately, so they can be reused for a surgery on the same day, the OTC day coordinator calls the CSD with an emergency order.

20. Patient care in recovery

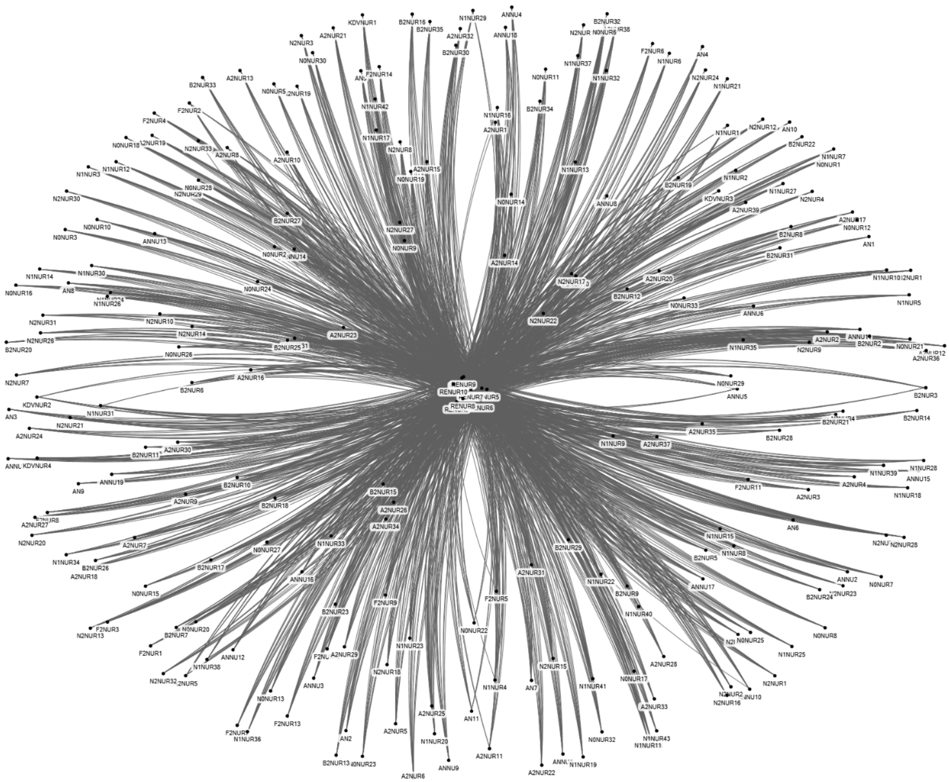


Figure A3.2.20 Social network of task 20: Patient care in recovery.

After surgery the patient is transferred to recovery by the nurse anesthetist. Again the transfer is performed using the standard transfer protocol. In recovery an image might be made of the surgery result, for which a radiology staff member is called. The recovery nurses interact with anesthesiologists on the medication policy if necessary.

Parameter	Value
Number of agents	241
Number of unique ties	2,355
Density	0.08
Number of cliques	PM
Highest betweenness centrality	PM

21. Aftercare of patient

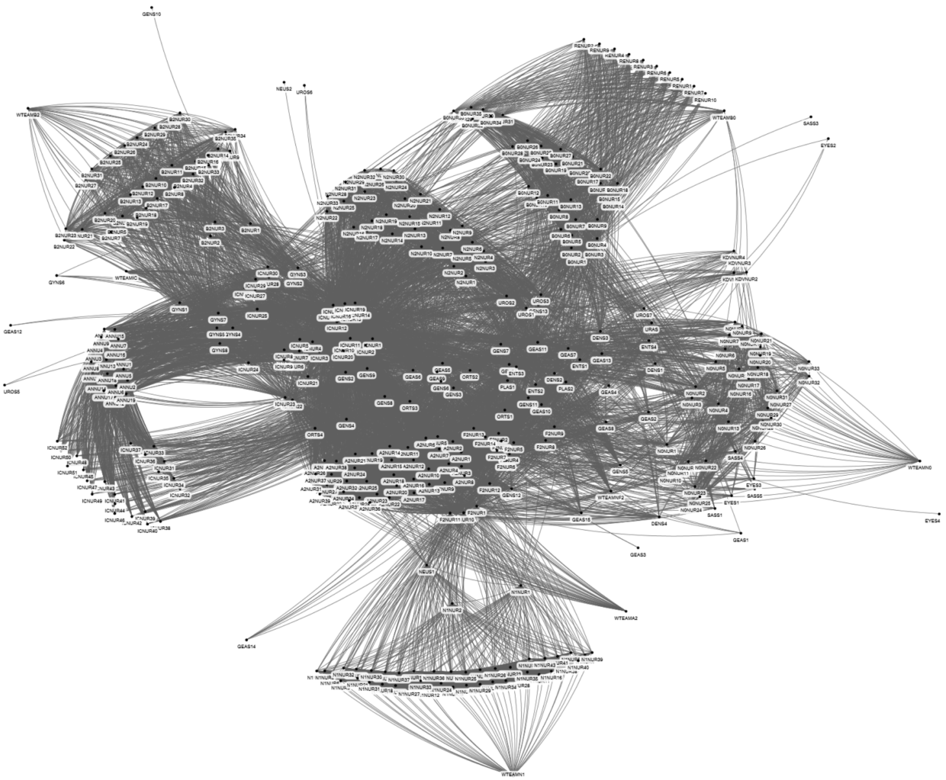


Figure A3.2.21 Social network of task 21: Aftercare of patient.

Parameter	Value
Number of agents	391
Number of unique ties	12,537
Density	0.16
Number of cliques	178
Highest betweenness centrality	Nurse 1 ward F2

When the patient is completely awake and is not experiencing too much pain in recovery, he is transferred to the nursing ward. The recovery nurse calls the nursing ward to indicate that the patient is to be picked up. The recovery nurse then hands the patient over to the ward nurse, using the standard transfer protocol. The patient is taken care of in one of the nursing wards until he or she is recovered well enough to be discharged. Some patients are transferred to another nursing ward and a transfer from nurses from one department to the nurse of the receiving department takes place. Surgeons visit the patients in the nursing ward and discuss their patients with the nurse and physician responsible for the ward on that day.

22. Manage the OTC day program

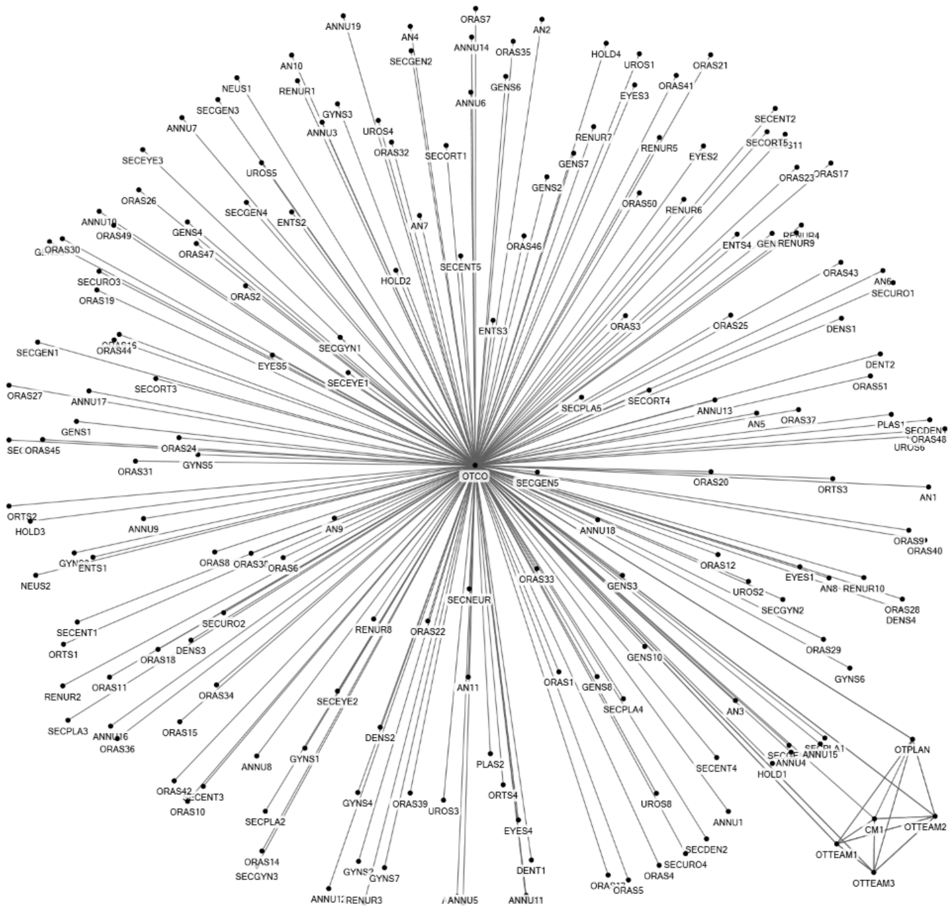


Figure A3.2.22 Social network of task 22: Managing the OTC day program.

Parameter	Value
Number of agents	185
Number of unique ties	181
Density	0.01
Number of cliques	2
Highest betweenness centrality	OTCO

There are several tasks, performed at various moments in time, aimed at making sure that the surgeries that are planned for one day are executed well and on time. Every day starts with a start of day meeting between the OTC day coordinator and the three OTC team leaders, in which the expectations and special surgeries are discussed.

During the course of the day the day coordinator monitors the progress of each OR, in order to prevent bottlenecks in case surgeries last longer than planned or unexpected events occur, such as emergency patients, failing equipment and such. If the day coordinator foresees that more than two ORs will be running late, he communicates with an anesthesiologist or surgeons about any alterations required in the OR scheme. The anesthesiologist plays a role here, because they work across different ORs throughout the day and they have an interest in the OR scheme being executed as planned. They are used as the intermediate between the day coordinator and the surgeons, who take more interest in completing the entire scheme, taking any overtime or reshuffling for granted. This relationship is included in the task Collaborating in the OR.

23. Manage OTC tasks

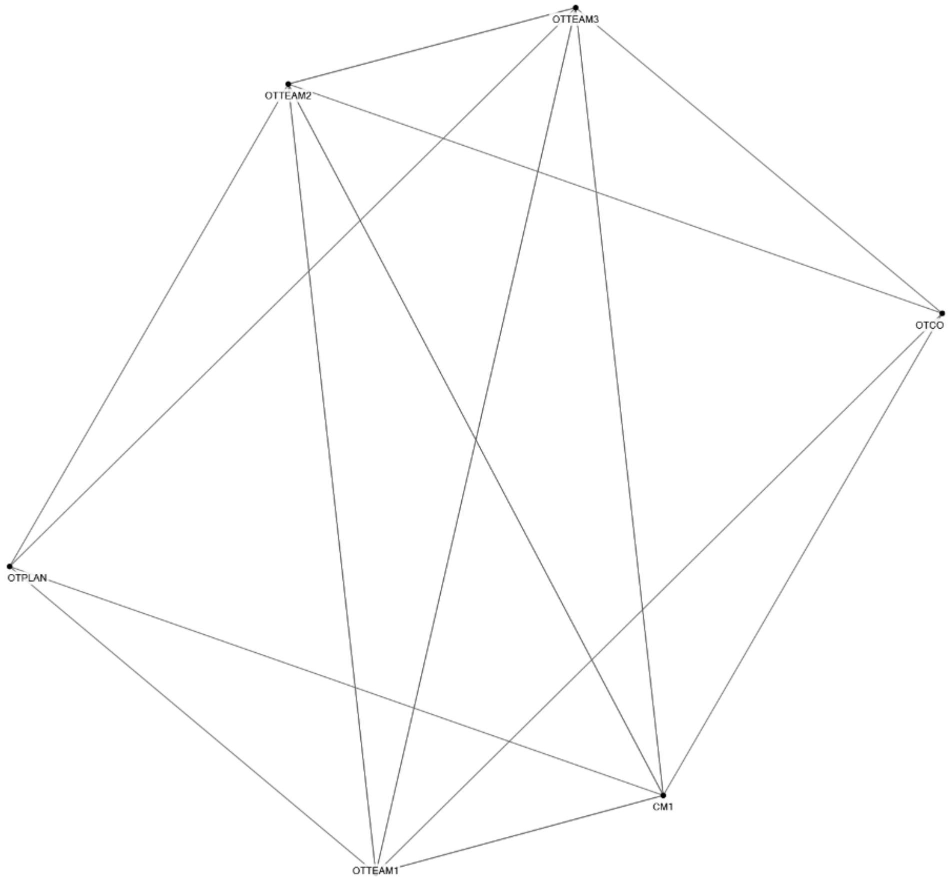


Figure A3.2.23 Social network of task 23: Manage OTC tasks.

There are several regular meetings between the OTC cluster manager, OTC team leaders, the OTC capacity planner and the OTC day coordinator to discuss operations over a longer period of time.

Parameter	Value
Number of agents	6
Number of unique ties	14
Density	0.93
Number of cliques	2
Highest betweenness centrality	CM1/ OTTEAM1/ OTTEAM2/ OTTEAM3

APPENDIX 3.3: DESCRIPTION AND DEGREE OF AGENTS IN SOCIAL NETWORKS

Agent code	Description	Degree
ANNU17	Nurse anesthetist 17	399
ANNU16	Nurse anesthetist 16	393
ANNU1	Nurse anesthetist 1	390
ANNU11	Nurse anesthetist 11	390
ANNU5	Nurse anesthetist 5	389
ANNU12	Nurse anesthetist 12	388
ANNU2	Nurse anesthetist 1	388
ANNU2	Nurse anesthetist 2	388
ANNU10	Nurse anesthetist 10	387
ANNU13	Nurse anesthetist 13	387
ANNU3	Nurse anesthetist 3	387
ANNU15	Nurse anesthetist 15	386
ANNU18	Nurse anesthetist 18	386
ANNU6	Nurse anesthetist 6	386
ANNU7	Nurse anesthetist 7	386
ANNU14	Nurse anesthetist 14	385
ANNU19	Nurse anesthetist19	384
ANNU4	Nurse anesthetist 4	384
ANNU9	Nurse anesthetist 9	384
ANNU8	Nurse anesthetist 8	383
RENUR1	Recovery nurse 1	318
RENUR10	Recovery nurse 10	318
RENUR2	Recovery nurse 2	318
RENUR3	Recovery nurse 3	318
RENUR4	Recovery nurse 4	318
RENUR5	Recovery nurse 5	318
RENUR6	Recovery nurse 6	318
RENUR7	Recovery nurse 7	318
RENUR8	Recovery nurse 8	318
RENUR9	Recovery nurse 9	318
HOLD2	Holding nurse 2	312
HOLD3	Holding nurse 3	312
HOLD4	Holding nurse 4	312
OTCO	OTC day coordinator	294
HOLD1	Holding nurse 1	266
GENS6	General surgeon 6	263
GEAS6	Assistant surgeon 6	260
GENS1	General surgeon 1	251
GEAS9	Assistant surgeon 9	247
GENS7	General surgeon 7	246
ICNUR1	Intensive care nurse 1	220
GENS9	General surgeon 9	218
GENS3	General surgeon 3	213
GENS8	General surgeon 8	211
GENS2	General surgeon 2	209
ICNUR2	Intensive care nurse 2	209

Agent code	Description	Degree
GENS4	General surgeon 4	203
ORTS2	Orthopedic surgeon 2	203
GEAS5	Assistant surgeon 5	202
ICNUR10	Intensive care nurse 10	202
ICNUR11	Intensive care nurse 11	201
ICNUR12	Intensive care nurse 12	198
F2NUR1	Ward F2 nurse 1	194
ICNUR13	Intensive care nurse 13	192
ICNUR14	Intensive care nurse 14	192
ORTS4	Orthopedic surgeon 4	192
ICNUR15	Intensive care nurse 15	190
GENS11	General surgeon 11	189
F2NUR10	Ward F2 nurse 10	188
PLAS1	Plastic surgeon 1	188
ICNUR16	Intensive care nurse 16	187
ICNUR17	Intensive care nurse 17	187
ORTS3	Orthopedic surgeon 3	187
ICNUR18	Intensive care nurse 18	184
F2NUR11	Ward F2 nurse 11	183
ICNUR19	Intensive care nurse 19	183
ICNUR20	Intensive care nurse 20	182
UROS2	Urology surgeon2	176
ORTS1	Orthopedic surgeon 1	173
ENTS3	Ear Nose Throat surgeon 3	170
UROS1	Urology surgeon1	169
UROS3	Urology surgeon3	169
GEAS10	Assistant surgeon 10	164
ENTS1	Ear Nose Throat surgeon 1	163
ICNUR21	Intensive care nurse 21	163
PLAS2	Plastic surgeon 2	161
GEAS11	Assistant surgeon 11	160
ENTS2	Ear Nose Throat surgeon 2	156
F2NUR12	Ward F2 nurse 12	155
F2NUR2	Ward F2 nurse 2	155
F2NUR3	Ward F2 nurse 3	155
F2NUR4	Ward F2 nurse 4	153
GENS5	General surgeon 5	153
F2NUR5	Ward F2 nurse 5	151
DENS2	Dental surgeon 2	149
F2NUR6	Ward F2 nurse 6	149
F2NUR7	Ward F2 nurse 7	149
ICNUR22	Intensive care nurse 22	147
GENS12	General surgeon 12	146
ICNUR23	Intensive care nurse 23	144
GYNS7	Gynecological surgeon 7	143
GYNS2	Gynecological surgeon 2	141
N0NUR1	Ward N0 nurse 1	141
F2NUR13	Ward F2 nurse 13	140
GYNS4	Gynecological surgeon 4	140
A2NUR1	Ward A2 nurse 1	139

Agent code	Description	Degree
A2NUR2	Ward A2 nurse 2	139
F2NUR14	Ward F2 nurse 14	139
GYNS3	Gynecological surgeon 3	137
N0NUR2	Ward N0 nurse 2	137
A2NUR3	Ward A2 nurse 3	136
A2NUR4	Ward A2 nurse 4	136
DENS3	Dental surgeon 3	136
N0NUR3	Ward N0 nurse 3	136
A2NUR5	Ward A2 nurse 5	135
A2NUR6	Ward A2 nurse 6	135
A2NUR7	Ward A2 nurse 7	135
GENS13	General surgeon 13	135
GYNS5	Gynecological surgeon 5	135
ICNUR3	Intensive care nurse 3	135
ORAS17	OR nurse 17	135
GEAS7	Assistant surgeon 7	134
ORAS1	OR nurse 1	134
ICNUR4	Intensive care nurse 4	133
A2NUR8	Ward A2 nurse 8	132
A2NUR10	Ward A2 nurse 10	131
A2NUR11	Ward A2 nurse 11	131
ORAS11	OR nurse 11	131
ORAS40	OR nurse 40	131
GYNS1	Gynecological surgeon 1	130
ICNUR5	Intensive care nurse 5	130
ORAS23	OR nurse 23	130
A2NUR12	Ward A2 nurse 12	129
A2NUR9	Ward A2 nurse 9	129
GYNS8	Gynecological surgeon 8	129
ICNUR6	Intensive care nurse 6	129
ICNUR7	Intensive care nurse 7	129
ORAS27	OR nurse 27	129
ORAS3	OR nurse 3	129
A2NUR13	Ward A2 nurse 13	128
ORAS13	OR nurse 13	128
ORAS29	OR nurse 29	128
A2NUR14	Ward A2 nurse 14	127
A2NUR15	Ward A2 nurse 15	127
A2NUR16	Ward A2 nurse 16	127
ORAS18	OR nurse 18	127
ORAS19	OR nurse 19	127
ORAS21	OR nurse 21	127
ORAS10	OR nurse 10	126
ORAS16	OR nurse 16	126
A2NUR17	Ward A2 nurse 17	125
A2NUR18	Ward A2 nurse 18	125
ICNUR8	Intensive care nurse 8	125
ICNUR9	Intensive care nurse 9	125
ORAS2	OR nurse 2	125
ORAS20	OR nurse 20	125
ORAS28	OR nurse 28	125

Agent code	Description	Degree
ORAS36	OR nurse 36	125
A2NUR19	Ward A2 nurse 19	124
A2NUR20	Ward A2 nurse 20	124
ORAS12	OR nurse 12	124
ORAS14	OR nurse 14	124
ORAS30	OR nurse 30	124
ORAS31	OR nurse 31	124
F2NUR8	Ward F2 nurse 8	123
NEUS1	Neurosurgeon 1	123
ORAS24	OR nurse 24	123
ORAS38	OR nurse 38	123
ORAS47	OR nurse 47	123
A2NUR21	Ward A2 nurse 21	122
B0NUR1	Ward B0 nurse 1	122
A2NUR22	Ward A2 nurse 22	121
GEAS13	Assistant surgeon 13	121
ORAS32	OR nurse 32	121
ORAS34	OR nurse 34	121
A2NUR23	Ward A2 nurse 23	120
A2NUR24	Ward A2 nurse 24	120
A2NUR25	Ward A2 nurse 25	120
ORAS22	OR nurse 22	120
ORAS4	OR nurse 4	120
ORAS42	OR nurse 42	120
A2NUR26	Ward A2 nurse 26	119
A2NUR27	Ward A2 nurse 27	119
A2NUR28	Ward A2 nurse 28	119
A2NUR29	Ward A2 nurse 29	119
A2NUR32	Ward A2 nurse 32	119
A2NUR33	Ward A2 nurse 33	119
A2NUR34	Ward A2 nurse 34	119
A2NUR35	Ward A2 nurse 35	119
A2NUR36	Ward A2 nurse 36	119
A2NUR37	Ward A2 nurse 37	119
A2NUR38	Ward A2 nurse 38	119
ORAS26	OR nurse 26	119
ORAS33	OR nurse 33	119
ORAS37	OR nurse 37	119
ORAS39	OR nurse 39	119
ORAS46	OR nurse 46	119
A2NUR30	Ward A2 nurse 30	118
A2NUR31	Ward A2 nurse 31	118
ORAS51	OR nurse 51	118
A2NUR39	Ward A2 nurse 39	117
N0NUR10	Ward N0 nurse 10	117
ORAS25	OR nurse 25	117
ORAS35	OR nurse 35	117
ORAS45	OR nurse 45	117
ORAS48	OR nurse 48	117
ORAS49	OR nurse 49	117
ORAS7	OR nurse 7	117

Agent code	Description	Degree
AN1	Anesthesiologist 1	116
N0NUR11	Ward N0 nurse 11	116
AN11	Anesthesiologist 11	115
B0NUR2	Ward B0 nurse 2	115
GEAS15	Assistant surgeon 15	114
N0NUR12	Ward N0 nurse 12	114
N2NUR1	Ward N2 nurse 1	113
ORAS41	OR nurse 41	113
AN10	Anesthesiologist 10	112
AN2	Anesthesiologist 2	112
AN4	Anesthesiologist 4	112
AN7	Anesthesiologist 7	112
AN8	Anesthesiologist 8	112
ORAS43	OR nurse 43	112
AN3	Anesthesiologist 3	111
AN6	Anesthesiologist 6	111
GEAS8	Assistant surgeon 8	111
ORAS44	OR nurse 44	111
ORAS6	OR nurse 6	111
AN5	Anesthesiologist 5	110
AN9	Anesthesiologist 9	110
B0NUR3	Ward B0 nurse 3	110
N0NUR13	Ward N0 nurse 13	110
N0NUR14	Ward N0 nurse 14	110
N0NUR15	Ward N0 nurse 15	110
N0NUR16	Ward N0 nurse 16	109
F2NUR9	Ward F2 nurse 9	108
N0NUR17	Ward N0 nurse 17	108
OTPLAN	OTC capacity planner	108
N0NUR18	Ward N0 nurse 18	107
N0NUR19	Ward N0 nurse 19	107
N0NUR20	Ward N0 nurse 20	107
N0NUR21	Ward N0 nurse 21	107
N0NUR22	Ward N0 nurse 22	107
ORAS50	OR nurse 50	107
ICNUR24	Intensive care nurse 24	106
ICNUR25	Intensive care nurse 25	106
N0NUR23	Ward N0 nurse 23	106
N2NUR2	Ward N2 nurse 2	106
ICNUR26	Intensive care nurse 26	105
ICNUR27	Intensive care nurse 27	105
ICNUR28	Intensive care nurse 28	105
ICNUR29	Intensive care nurse 29	105
ICNUR30	Intensive care nurse 30	105
N0NUR24	Ward N0 nurse 24	105
N0NUR25	Ward N0 nurse 25	105
N0NUR26	Ward N0 nurse 26	105
N0NUR27	Ward N0 nurse 27	105
N0NUR28	Ward N0 nurse 28	105
N0NUR29	Ward N0 nurse 29	105
N0NUR30	Ward N0 nurse 30	105

Agent code	Description	Degree
N0NUR31	Ward N0 nurse 31	105
B0NUR4	Ward B0 nurse 4	104
N2NUR3	Ward N2 nurse 3	104
B0NUR5	Ward B0 nurse 5	103
N0NUR32	Ward N0 nurse 32	103
N0NUR33	Ward N0 nurse 33	103
ORAS5	OR nurse 5	103
N2NUR4	Ward N2 nurse 4	102
N2NUR5	Ward N2 nurse 5	102
B0NUR6	Ward B0 nurse 6	101
N2NUR6	Ward N2 nurse 6	101
N2NUR7	Ward N2 nurse 7	100
B2NUR1	Ward B2 nurse 1	99
DENS1	Dental surgeon 1	98
GEAS4	Assistant surgeon 4	98
N2NUR10	Ward N2 nurse 10	98
N2NUR8	Ward N2 nurse 8	97
N2NUR9	Ward N2 nurse 9	97
B0NUR7	Ward B0 nurse 7	95
N0NUR4	Ward N0 nurse 4	94
B0NUR8	Ward B0 nurse 8	93
N0NUR5	Ward N0 nurse 5	93
N2NUR11	Ward N2 nurse 11	93
N2NUR12	Ward N2 nurse 12	93
N2NUR13	Ward N2 nurse 13	93
B0NUR9	Ward B0 nurse 9	92
N2NUR14	Ward N2 nurse 14	92
N2NUR15	Ward N2 nurse 15	92
N2NUR16	Ward N2 nurse 16	91
N2NUR17	Ward N2 nurse 17	91
N2NUR18	Ward N2 nurse 18	91
N2NUR19	Ward N2 nurse 19	91
B0NUR10	Ward B0 nurse 10	89
B2NUR2	Ward B2 nurse 2	89
ENTS4	Ear Nose Throat surgeon 4	89
ICNUR31	Intensive care nurse 31	89
ICNUR32	Intensive care nurse 32	89
ICNUR33	Intensive care nurse 33	89
ICNUR34	Intensive care nurse 34	89
N0NUR6	Ward N0 nurse 6	89
N2NUR20	Ward N2 nurse 20	89
N2NUR21	Ward N2 nurse 21	89
ICNUR36	Intensive care nurse 36	88
N2NUR22	Ward N2 nurse 22	88
B0NUR11	Ward B0 nurse 11	87
B0NUR12	Ward B0 nurse 12	87
DENS4	Dental surgeon 4	87
ICNUR35	Intensive care nurse 35	87
ICNUR37	Intensive care nurse 37	87
N0NUR7	Ward N0 nurse 7	87
N2NUR23	Ward N2 nurse 23	87

Agent code	Description	Degree
N2NUR24	Ward N2 nurse 24	87
N2NUR25	Ward N2 nurse 25	87
B0NUR13	Ward B0 nurse 13	86
ICNUR38	Intensive care nurse 38	86
N2NUR26	Ward N2 nurse 26	86
N2NUR27	Ward N2 nurse 27	86
N2NUR28	Ward N2 nurse 28	86
N2NUR29	Ward N2 nurse 29	86
N2NUR30	Ward N2 nurse 30	86
N2NUR31	Ward N2 nurse 31	86
N2NUR32	Ward N2 nurse 32	86
N2NUR33	Ward N2 nurse 33	86
ICNUR39	Intensive care nurse 39	85
N1NUR1	Ward N1 nurse 1	85
ORAS15	OR nurse 15	85
B2NUR3	Ward B2 nurse 3	84
ICNUR40	Intensive care nurse 40	84
N0NUR8	Ward N0 nurse 8	84
B0NUR14	Ward B0 nurse 14	83
ICNUR41	Intensive care nurse 41	83
ICNUR42	Intensive care nurse 42	83
ICNUR43	Intensive care nurse 43	83
N0NUR9	Ward N0 nurse 9	83
B2NUR10	Ward B2 nurse 10	82
B2NUR11	Ward B2 nurse 11	82
B2NUR12	Ward B2 nurse 12	82
B2NUR13	Ward B2 nurse 13	82
B2NUR14	Ward B2 nurse 14	82
B2NUR15	Ward B2 nurse 15	82
B2NUR16	Ward B2 nurse 16	82
B2NUR17	Ward B2 nurse 17	82
B2NUR18	Ward B2 nurse 18	82
B2NUR19	Ward B2 nurse 19	82
B2NUR20	Ward B2 nurse 20	82
B2NUR21	Ward B2 nurse 21	82
B2NUR22	Ward B2 nurse 22	82
B2NUR23	Ward B2 nurse 23	82
B2NUR24	Ward B2 nurse 24	82
B2NUR25	Ward B2 nurse 25	82
B2NUR26	Ward B2 nurse 26	82
B2NUR27	Ward B2 nurse 27	82
ICNUR44	Intensive care nurse 44	82
N1NUR2	Ward N1 nurse 2	82
B0NUR15	Ward B0 nurse 15	81
B2NUR28	Ward B2 nurse 28	81
B2NUR29	Ward B2 nurse 29	81
B2NUR9	Ward B2 nurse 9	81
ICNUR45	Intensive care nurse 45	81
ICNUR46	Intensive care nurse 46	81
ICNUR47	Intensive care nurse 47	81
ICNUR48	Intensive care nurse 48	81

Agent code	Description	Degree
B2NUR30	Ward B2 nurse 30	80
B2NUR31	Ward B2 nurse 31	80
B2NUR32	Ward B2 nurse 32	80
B2NUR33	Ward B2 nurse 33	80
B2NUR4	Ward B2 nurse 4	80
B2NUR8	Ward B2 nurse 8	80
ERPHYS1	ER physician 1	80
ERPHYS4	ER physician 4	80
ERPHYS5	ER physician 5	80
ERPHYS6	ER physician 6	80
ICNUR49	Intensive care nurse 49	80
N1NUR10	Ward N1 nurse 10	80
N1NUR11	Ward N1 nurse 11	80
N1NUR12	Ward N1 nurse 12	80
N1NUR13	Ward N1 nurse 13	80
N1NUR14	Ward N1 nurse 14	80
N1NUR15	Ward N1 nurse 15	80
N1NUR16	Ward N1 nurse 16	80
N1NUR17	Ward N1 nurse 17	80
N1NUR18	Ward N1 nurse 18	80
N1NUR19	Ward N1 nurse 19	80
N1NUR20	Ward N1 nurse 20	80
N1NUR21	Ward N1 nurse 21	80
N1NUR22	Ward N1 nurse 22	80
N1NUR23	Ward N1 nurse 23	80
N1NUR24	Ward N1 nurse 24	80
N1NUR25	Ward N1 nurse 25	80
N1NUR26	Ward N1 nurse 26	80
N1NUR27	Ward N1 nurse 27	80
N1NUR28	Ward N1 nurse 28	80
N1NUR29	Ward N1 nurse 29	80
N1NUR3	Ward N1 nurse 3	80
N1NUR30	Ward N1 nurse 30	80
N1NUR31	Ward N1 nurse 31	80
N1NUR32	Ward N1 nurse 32	80
N1NUR33	Ward N1 nurse 33	80
N1NUR34	Ward N1 nurse 34	80
N1NUR35	Ward N1 nurse 35	80
N1NUR36	Ward N1 nurse 36	80
N1NUR37	Ward N1 nurse 37	80
N1NUR38	Ward N1 nurse 38	80
N1NUR39	Ward N1 nurse 39	80
N1NUR4	Ward N1 nurse 4	80
N1NUR40	Ward N1 nurse 40	80
N1NUR41	Ward N1 nurse 41	80
N1NUR42	Ward N1 nurse 42	80
N1NUR43	Ward N1 nurse 43	80
N1NUR5	Ward N1 nurse 5	80
N1NUR6	Ward N1 nurse 6	80
N1NUR7	Ward N1 nurse 7	80
N1NUR8	Ward N1 nurse 8	80

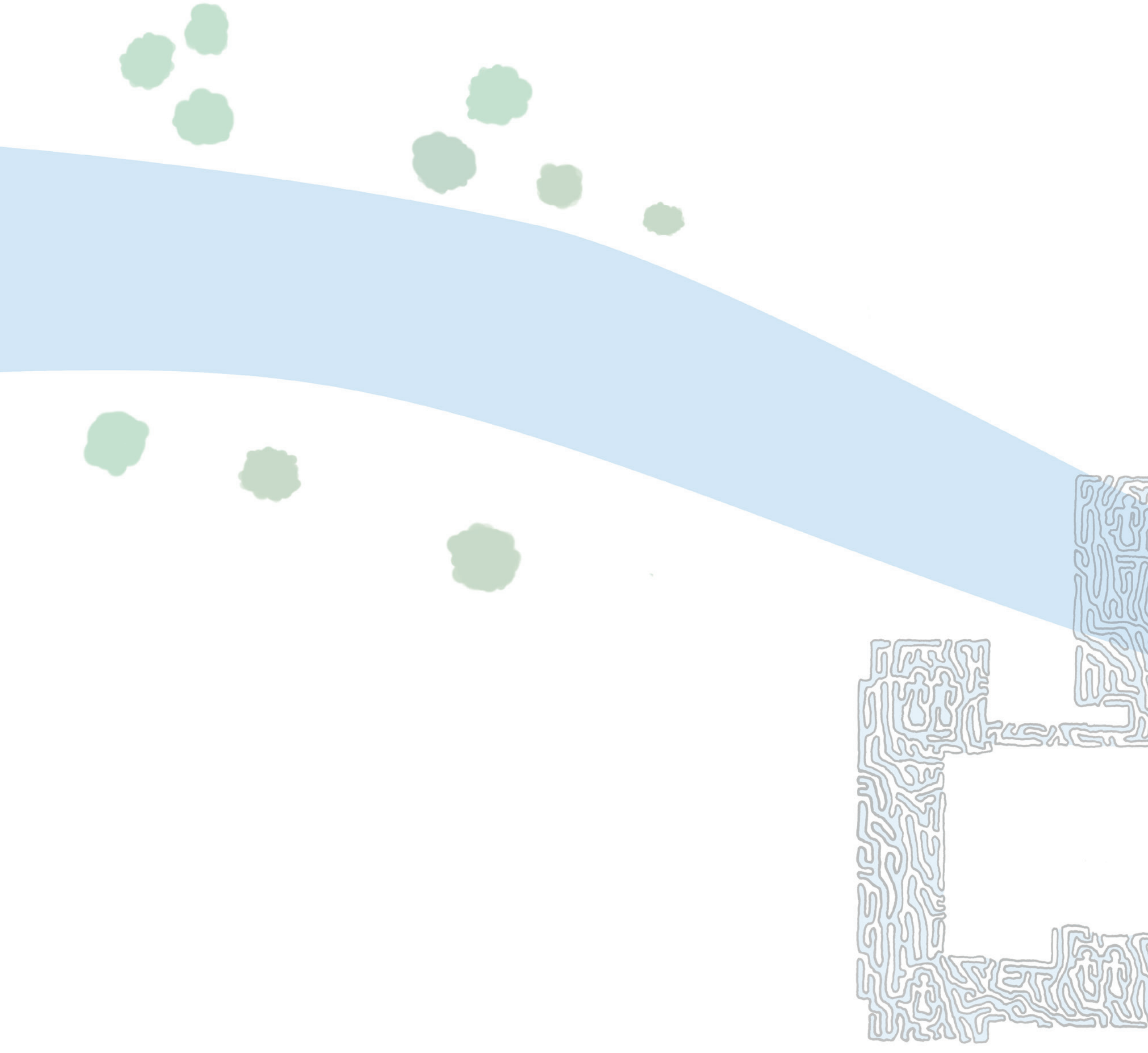
Agent code	Description	Degree
N1NUR9	Ward N1 nurse 9	80
B0NUR16	Ward B0 nurse 16	79
B0NUR17	Ward B0 nurse 17	79
B2NUR5	Ward B2 nurse 5	79
B2NUR6	Ward B2 nurse 6	79
B2NUR7	Ward B2 nurse 7	79
ICNUR50	Intensive care nurse 50	79
ICNUR51	Intensive care nurse 51	79
B0NUR18	Ward B0 nurse 18	78
ICNUR52	Intensive care nurse 52	78
B0NUR19	Ward B0 nurse 19	77
B0NUR20	Ward B0 nurse 20	77
ERPHYS3	ER physician 3	77
B0NUR21	Ward B0 nurse 21	76
B0NUR22	Ward B0 nurse 22	76
B0NUR23	Ward B0 nurse 23	76
B0NUR24	Ward B0 nurse 24	76
ERPHYS2	ER physician 2	76
B0NUR25	Ward B0 nurse 25	75
B0NUR26	Ward B0 nurse 26	75
B0NUR27	Ward B0 nurse 27	75
B0NUR28	Ward B0 nurse 28	75
B0NUR29	Ward B0 nurse 29	74
B0NUR30	Ward B0 nurse 30	74
B0NUR31	Ward B0 nurse 31	74
B0NUR32	Ward B0 nurse 32	74
B0NUR33	Ward B0 nurse 33	74
B0NUR34	Ward B0 nurse 34	74
B0NUR35	Ward B0 nurse 35	74
B2NUR34	Ward B2 nurse 34	74
B2NUR35	Ward B2 nurse 35	74
ORAS8	OR nurse 8	74
ERNUR1	ER nurse 1	68
ERNUR10	ER nurse 10	68
ERNUR11	ER nurse 11	68
ERNUR12	ER nurse 12	68
ERNUR13	ER nurse 13	68
ERNUR14	ER nurse 14	68
ERNUR15	ER nurse 15	68
ERNUR16	ER nurse 16	68
ERNUR17	ER nurse 17	68
ERNUR18	ER nurse 18	68
ERNUR19	ER nurse 19	68
ERNUR2	ER nurse 2	68
ERNUR20	ER nurse 20	68
ERNUR21	ER nurse 21	68
ERNUR22	ER nurse 22	68
ERNUR23	ER nurse 23	68
ERNUR24	ER nurse 24	68
ERNUR25	ER nurse 25	68
ERNUR26	ER nurse 26	68

Agent code	Description	Degree
ERNUR27	ER nurse 27	68
ERNUR28	ER nurse 28	68
ERNUR29	ER nurse 29	68
ERNUR3	ER nurse 3	68
ERNUR30	ER nurse 30	68
ERNUR31	ER nurse 31	68
ERNUR32	ER nurse 32	68
ERNUR33	ER nurse 33	68
ERNUR34	ER nurse 34	68
ERNUR35	ER nurse 35	68
ERNUR4	ER nurse 4	68
ERNUR5	ER nurse 5	68
ERNUR6	ER nurse 6	68
ERNUR7	ER nurse 7	68
ERNUR8	ER nurse 8	68
ERNUR9	ER nurse 9	68
EYES1	Eye surgeon1	68
ORAS9	OR nurse 9	67
SECANE1	Secretary1 Anesthesia	67
SECANE2	Secretary2 Anesthesia	67
SECANE3	Secretary3 Anesthesia	67
SECANE4	Secretary4 Anesthesia	67
GEAS14	Assistant surgeon 14	65
WTEAMA2	Ward team leader A2	65
UROS7	Urology surgeon7	63
WTEAMNF2	Ward team leader F2	63
KDVNUR1	Pediatric ward nurse 1	60
URAS	Urology assistant surgeon	60
GEAS2	Assistant surgeon 2	59
KDVNUR2	Pediatric ward nurse 2	57
OTTEAM1	Team leader Surgery	57
KDVNUR3	Pediatric ward nurse 3	54
KDVNUR4	Pediatric ward nurse 4	54
OTLOG1	OTC logistical staff member 1	54
OTLOG2	OTC logistical staff member 1	54
CLEAN1	Cleaning staff member 1	51
CLEAN2	Cleaning staff member 2	51
WTEAMIC	Ward team leader Intensive Care	50
EYES3	Eye surgeon 3	49
GYNS6	Gynecology surgeon 6	47
AN12	Anesthesiologist 12	46
GENS10	General surgeon 10	46
SASS4	Physician assistant 4	44
UROS5	Urology surgeon5	44
WTEAMN1	Ward team leader N1	43
OTSEC	OTC secretary	42
GEAS1	Assistant surgeon 1	39
SECNEUR	Secretary of Neurology outpatient department	39
UROS6	Urology surgeon 6	39
WTEAMB0	Ward team leader B0	39
SECCAR	Secretary of Cardiology outpatient department	38

Agent code	Description	Degree
GEAS12	Assistant surgeon 12	37
GEAS3	Assistant surgeon 3	36
WTEAMB2	Ward team leader B2	35
UROS4	Urology surgeon4	34
WTEAMN0	Ward team leader N0	33
SASS1	Physician assistant 1	32
UROS8	Urology surgeon 8	31
SECGEN1	Secretary 1 General surgery	28
SECGEN2	Secretary 2 General surgery	28
SECGEN3	Secretary 3 General surgery	28
SECGEN4	Secretary 4 General surgery	25
SECGEN5	Secretary 5 General surgery	25
SECURO1	Secretary 1 Urology outpatient department	25
EYES2	Eye surgeon 2	24
OTTEAM2	Team leader Anesthesia	24
SECGEN6	Secretary 6 General surgery	24
SECGYN1	Secretary 1 Gynecology	24
SECGYN2	Secretary 2 Gynecology	24
SECGYN3	Secretary 3 Gynecology	24
SECORT1	Secretary 1 Orthopedics outpatient department	24
SASS5	Physician assistant 5	22
SECURO2	Secretary 2 Urology outpatient department	22
SECURO3	Secretary 3 Urology outpatient department	22
SECURO4	Secretary 4 Urology outpatient department	22
SECORT2	Secretary 2 Orthopedics outpatient department	21
SECORT3	Secretary 3 Orthopedics outpatient department	21
SECORT4	Secretary 4 Orthopedics outpatient department	21
SECORT5	Secretary 5 Orthopedics outpatient department	21
SECENT1	Secretary1 ENT	20
OTTEAM3	Team leader Recovery/holding	19
SECEYE1	Secretary 1 Ophthalmology	19
CM1	Cluster manager OTC and Services	18
SECDEN1	Secretary1 Dental Surgery	18
SECPLA1	Secretary1 Plastic surgery outpatient department	18
SECENT2	Secretary2 ENT	17
SECENT3	Secretary3 ENT	17
SECENT4	Secretary4 ENT	17
SECENT5	Secretary5 ENT	17
EYES4	Eye surgeon4	16
SECEYE2	Secretary2 Ophthalmology	16
SECEYE3	Secretary3 Ophthalmology	16
POSNUR1	Preoperative nurse 1	15
POSNUR2	Preoperative nurse 2	15
POSNUR2	Preoperative nurse 3	15
POSNUR3	Preoperative nurse 4	15
POSNUR4	Preoperative nurse 5	15
POSNUR5	Preoperative nurse 6	15
SECCLB	Clinical plan boss	15
SECDEN2	Secretary2 Dental Surgery	15
SECPLA2	Secretary2 Plastic surgery outpatient department	15
SECPLA3	Secretary3 Plastic surgery outpatient department	15

Agent code	Description	Degree
SECPLA4	Secretary4 Plastic surgery outpatient department	15
SECPLA5	Secretary5 Plastic surgery outpatient department	15
CM2	Cluster manager Surgery	14
WTEAM3	Team leader in training	13
RADI1	Radiology staff member 1	12
RADI10	Radiology staff member 10	12
RADI11	Radiology staff member 11	12
RADI13	Radiology staff member 13	12
RADI14	Radiology staff member 14	12
RADI15	Radiology staff member 15	12
RADI16	Radiology staff member 16	12
RADI17	Radiology staff member 17	12
RADI18	Radiology staff member 18	12
RADI19	Radiology staff member 19	12
RADI2	Radiology staff member 2	12
RADI20	Radiology staff member 20	12
RADI21	Radiology staff member 21	12
RADI22	Radiology staff member 22	12
RADI23	Radiology staff member 23	12
RADI24	Radiology staff member 24	12
RADI25	Radiology staff member 25	12
RADI26	Radiology staff member 26	12
RADI27	Radiology staff member 27	12
RADI28	Radiology staff member 28	12
RADI29	Radiology staff member 29	12
RADI3	Radiology staff member 3	12
RADI30	Radiology staff member 30	12
RADI31	Radiology staff member 31	12
RADI32	Radiology staff member 32	12
RADI33	Radiology staff member 33	12
RADI34	Radiology staff member 34	12
RADI35	Radiology staff member 35	12
RADI36	Radiology staff member 36	12
RADI37	Radiology staff member 37	12
RADI38	Radiology staff member 38	12
RADI39	Radiology staff member 39	12
RADI4	Radiology staff member 4	12
RADI40	Radiology staff member 40	12
RADI41	Radiology staff member 41	12
RADI5	Radiology staff member 5	12
RADI6	Radiology staff member 6	12
RADI7	Radiology staff member 7	12
RADI8	Radiology staff member 8	12
RADI9	Radiology staff member 9	12
RADI12	Radiology staff member 12	11
SECNEU	Secretary Neurosurgery	11
EYES5	Eye surgeon 5	9
NEUS2	Neuro surgeon 2	9
CM3	Cluster manager Women and Child	6
FARM1	Pharmacy assistant 1	4
FARM2	Pharmacy assistant 2	4

Agent code	Description	Degree
FARM3	Pharmacy assistant 3	4
FARM4	Pharmacy assistant 4	4
FARM5	Pharmacy assistant 5	4
FARM6	Pharmacy assistant 6	4
FARM7	Pharmacy assistant 7	4
SECGER	Secretary of Geriatric outpatient department	4
SECINT	Secretary of Internal medicine department	4
SECLAB	Secretary of Laboratory	4
SECLUN	Secretary of Lung disease outpatient department	4
SECRAD	Secretary of Radiology	4
TECH	Technical staff member	3
CSD1	Central Sterilization Department staff member 1	1
CSD10	Central Sterilization Department staff member 10	1
CSD11	Central Sterilization Department staff member 11	1
CSD12	Central Sterilization Department staff member 12	1
CSD13	Central Sterilization Department staff member 13	1
CSD14	Central Sterilization Department staff member 14	1
CSD15	Central Sterilization Department staff member 15	1
CSD16	Central Sterilization Department staff member 16	1
CSD17	Central Sterilization Department staff member 17	1
CSD18	Central Sterilization Department staff member 18	1
CSD2	Central Sterilization Department staff member 2	1
CSD3	Central Sterilization Department staff member 3	1
CSD4	Central Sterilization Department staff member 4	1
CSD5	Central Sterilization Department staff member 5	1
CSD6	Central Sterilization Department staff member 6	1
CSD7	Central Sterilization Department staff member 7	1
CSD8	Central Sterilization Department staff member 8	1
CSD9	Central Sterilization Department staff member 9	1
SASS3	Physician assistant 3	1
SECWIN	Secretary Winterswijk Surgery outpatient department	1



CHAPTER 4

EXPLAINING INTEGRATION AND DIFFERENTIATION BY IDENTIFYING THE RULES AND COORDINATION MECHANISMS IN A HOSPITAL'S LOGISTICAL SYSTEM

Annelies van der Ham, Arno van Raak, Dirk Ruwaard, Frits van Merode

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ABSTRACT

Purpose

Integration, i.e. the coordination and alignment of tasks, is widely promoted as a means to improve hospital performance. A previous study examined integration and differentiation, i.e. the extent to which tasks are segmented into subsystems, in a hospital's social network. The current study carries this research further, aiming to explain integration and differentiation by studying the rules and coordination mechanisms that agents in a hospital network use.

Design/methodology/approach

The current case study deepens the analysis of the social network in a hospital. All planning tasks and tasks for surgery performance were studied, using a naturalistic inquiry approach and a mixed method.

Findings

Of the 314 rules found, 85% predominantly exist in people's minds, 31% are in documents and 7% are in the information system. In the early planning stages for a surgery procedure, mutual adjustment based on hospital-wide rules is dominant. Closer to the day of surgery, local rules are used and open loops are closed through mutual adjustment, thus achieving integration. On the day of surgery, there is mainly standardization of work and output, based on hospital-wide rules. We propose topics for future research, focusing on increasing the hospital's robustness and stability.

Originality

This exploratory case study provides an overview of the rules and coordination mechanisms that are used for organizing hospital-wide logistics for surgery patients. The findings are important for future research on how integration and differentiation are effectively achieved in hospitals.

INTRODUCTION

Literature in the field of health care calls for a more integrative approach to the logistical or operational system of hospitals[1-3]. There is wide consensus that an integrated perspective in hospitals, which is a central concept in supply chain management, lean strategies and in other operations management theories, can contribute to the improvement of hospital performance[4-10]. This approach includes aligning activities and planning resources from the perspective of the total system, taking hospital-wide processes and resources into account[4]. This is considered important in addressing the widely felt need to improve the quality, accessibility and affordability of healthcare systems[5] and of hospitals in particular, given the fact that hospitals are a major cost item in the healthcare system[11].

There are few studies that focus on the impact of adapting integrative practices with regard to improving system-wide performance[5]. In a previous scoping study[12] we found that research on logistics in hospitals typically focuses on one specific logistical flow (patients, material or staff) or on specific departments, but not on the system as a whole. Furthermore, De Vries and Huijsman[6] point out that little is known on how integration can be achieved in healthcare settings.

Ludwig et al.[8] found evidence that more efficient hospitals score high on cooperation, while efficient departments within a hospital do not necessarily contribute to the hospital’s overall efficiency. Lawrence and Lorsch[13] state that not only is integration important, but also that differentiation is essential in order for integration to be effective. They define integration as ‘achieving unity of effort among the various subsystems in the accomplishment of the organization's task’[13]. Differentiation refers to ‘the state of segmentation of the organizational system into subsystems’[13]. Based on these definitions, hospitals that perform well and in which departments cooperate well may have the right degree of integration as well as differentiation in place.

Research in the field of social network analysis (SNA) also addresses integration[14-16]. In a previous SNA case study of Slingeland Hospital in the Netherlands, we described the network structure of the logistical system, which includes both integration and differentiation[17]. This SNA showed that the hospital’s network structure differs from its formal organizational structure, with tasks being performed mainly across functional silos, and that nurses, physicians and coordinators perform integrative tasks.
However, we agree with Beuving and De Vries[18], that by reducing human action to structural positions in the network, little is revealed about what actually happens between

the agents in the network. We should look specifically at what rules and mechanisms agents use, in order to understand the social network structure, i.e. the integration and differentiation observed in the SNA.

Literature pertaining to social networks and integration often refers to coordination between people, groups or organizations as a core activity in organizations[14-16]. According to Mintzberg[19], there are different types of coordination that connect differentiated activities, which themselves result from the division of labor. Each type of coordination mechanism requires different interactions between agents. Coordination mechanisms are based on rules. Beuving and De Vries[18] use the metaphor of dancing to explain that dancers follow the rules of dancing that have been set by previous dancers, while at the same time dancers still respond to each other, thereby varying within these rules. Accordingly, the structure of the hospital's social network may be explained by describing the rules that the agents use, and by studying the coordination mechanisms that determine the interactions between these agents.

This study deepens the previous SNA study; it aims to explain the integration and differentiation in a hospital by studying the rules and coordination mechanisms that agents use. This topic is important because, despite the fact that there are several promising SNA studies that address the issue of integration[14-16,20-22], Kilduff & Tsai[15] state that little is known on how coordinating mechanisms facilitate differentiation and integration.
The main research questions are: what are the rules and coordination mechanisms that are used in the hospital's operational system and how do these explain the social network structure, i.e. the integration and differentiation?

METHODS

Setting

The study design is based on the case study research method devised by Yin[23]. Slingeland Hospital was selected for this case study because it is a relatively small Dutch hospital with a highly rated performance and no large transformations took place during the time of research. Additional selection criteria were good access to people and data. Slingeland Hospital has around 1,600 staff members and 120 physicians. It services around 200,000 people in the area, and has 350 beds, which is below the average number of 450 beds for Dutch hospitals[24]. Slingeland Hospital performs higher on most logistical indicators than the average Dutch hospital, according to a Dutch benchmark[25]. With an average of 89% operating room (OR) utilization in 2016, Slingeland has higher OR utilization than the 82% average of Dutch hospitals that participate in the national benchmark. For other parameters such as lateness and average surgery time, Slingeland performs better than the average hospital that participates in the Dutch benchmark.

Study design

This study was designed to determine what rules and coordination mechanisms are used for the coordination of tasks and why and how this takes place. A naturalistic inquiry approach was followed, aiming to develop a deeper understanding of how the hospital's network functions[18]. Data were collected from multiple sources and then analyzed through data triangulation, following a mixed method approach.

The study includes all departments that contribute to either the intake, diagnosis, preparations for or performance of the surgery or the aftercare of surgery patients. Figure 4.1 shows all the tasks performed which relate either to the planning or performing of surgeries, including all activities that take place between patient intake and discharge. In this study we focus on planning tasks 1, 2, 3, 6, and 11, and tasks directly related to performing surgery, including preparations and aftercare, being tasks 14, 15, 17, 20, 21 and 22. The main reason for this selection is that these tasks involve coordination, as illustrated by the central position of these tasks in Figure 4.1. These tasks are performed by agents of outpatient departments, the nursing departments, the Operating Theatre Complex (OTC) and the holding and recovery areas.

The Ethics Committee of Maastricht University reviewed the study design and the data protection aspects of the work that was undertaken. The Committee stated that according to Dutch law this study did not need a full review of the Ethics Committee, because no humans, i.e. patients were involved. Nevertheless, the Committee stated that the work was undertaken in a manner that conformed to the ethics and data protections standards of Maastricht University.

Collected data

Data were collected from four different sources: the Hospital Information System (HIS), documentation, observations and interviews. The collection and analysis of data from the HIS and documentation took place in January 2018 and March 2019. Observations and interviews took place between March 2018 and June 2019.

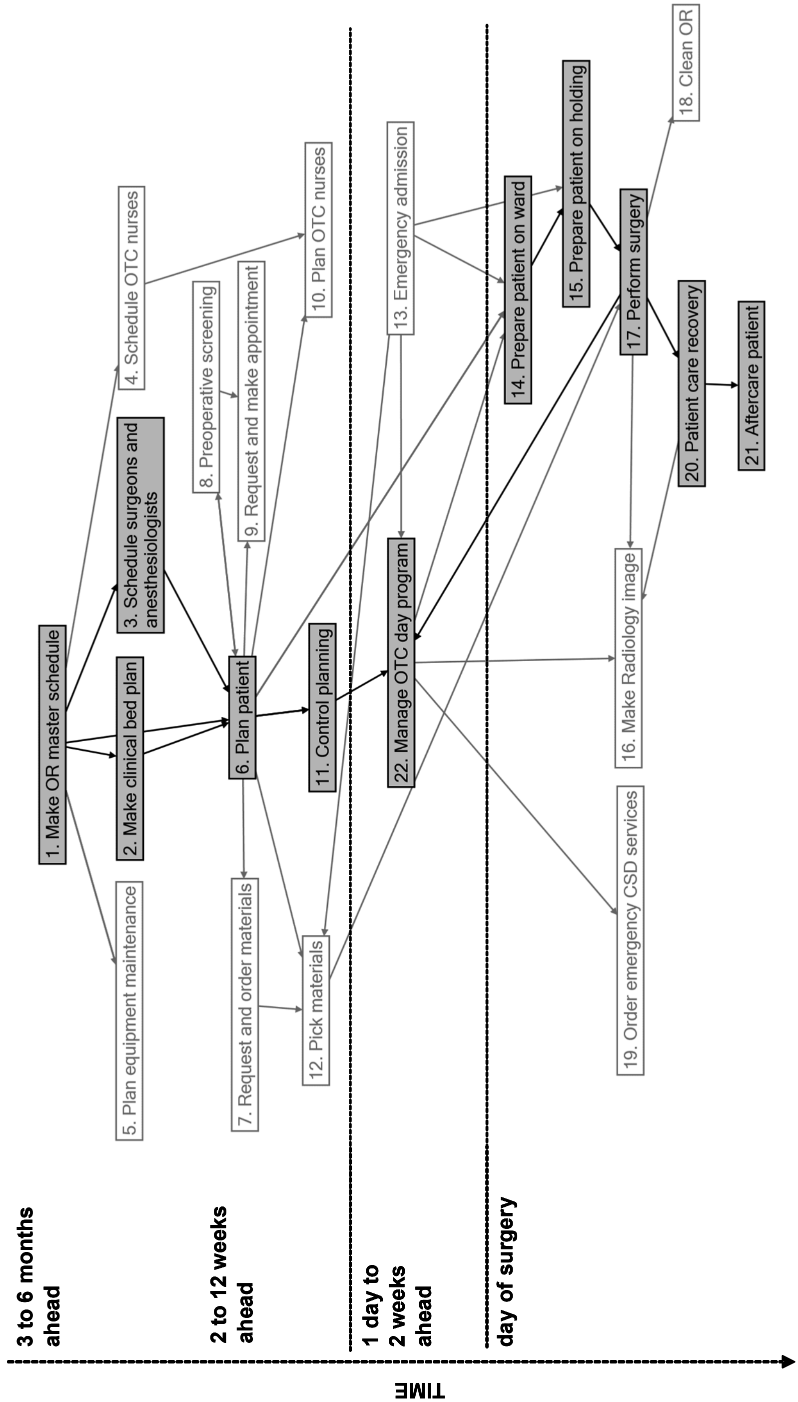

Figure 4.1 Tasks in scope.

HIS data were collected in order to determine the system's output, to observe the system's rhythm and what resources were used for surgery patients. The HIS data include registrations of surgeries performed in 2018, including date of surgery, resources involved, and timestamps of different stages in the surgery patient's process, and in which nursing wards patients stayed before and after surgery.
Documentation was collected in order to find rules that are written down. In total 55 documents were collected, including management reports, planning schemes, working procedures, emails and internal presentations. In addition, planning rules were listed between February and May 2019 by one outpatient secretary and the clinical bed planner. This activity was part of the preparations for the implementation of a central planning department in which surgeries are planned, as of June 2019, by central planners.

Planning and controlling activities were observed over 18 observation days in order to find additional local documents on working procedures and any unwritten rules. The 18 observations took place at three outpatient departments, three nursing departments, the holding area, three surgeries in the OR, the recovery area, with the OTC day coordinator, at the preoperative screening department, two planning meetings and twice at the workplace of the clinical bed planner. During each observation the activities of the hospital staff were observed and several unplanned informal conversations with staff took place, as they explained what tasks they performed. The sequence of events for each observation, together with relevant parts of the conversations, were reported in an observation report.

All collected data were then further explored in 25 interviews, looking specifically for unwritten rules. For the interviews we selected people who are involved in planning activities, including the application controller of the OR, the OTC capacity planner, eleven secretaries of the various outpatient departments, the OTC day coordinator and one cluster manager. For each interview a topic list was prepared, including questions on rules, rhythm, interaction and performance. In addition, a data dashboard was prepared for the interviews with the outpatient secretaries. The dashboard includes HIS data on the number of surgeries and surgeons, planned and emergency surgery percentages, the yearly and weekly pattern of sessions and surgeries, the waiting list development, the percentage of types of surgeries that are performed by one or multiple surgeons and variations in surgery time. In addition, a table was prepared including the average age of patients, utilization rates of OR sessions, the deviation percentage between planned surgery time and actual surgery time, the number of surgeries with particular planning rules, how many patients stayed on each nursing ward and which anesthesiology techniques were used. These data were used in the interviews in order to find unwritten rules and deeper explanations for how agents act. All interviews were recorded and transcribed ad verbatim.

Data analysis

All 94 qualitative data sources, i.e. documents, observations and interviews were structured in five data matrices that include the three main topics of rules, rhythm and interaction. One data matrix was constructed for each of tasks 1, 2 and 3. One data matrix was made for tasks 6 and 11 and another for tasks 14, 15, 17, 20, 21 and 22, because with regard to coordination activities, these tasks are strongly connected.

The rules that are used for each task, i.e. from each data matrix, were then listed. First of all, for each rule the sources in which the rule was found were registered. Rules were then labelled as hospital-wide or local. A hospital-wide rule is used throughout the entire hospital system and a local rule exists for one particular department, group of people or person. In order to assess whether rules are written or unwritten, we indicated whether the rule itself is registered (R) or the output of applying the rule is registered (O) in a document or in the HIS, or if it exists in the mind of hospital staff.
Furthermore, one or multiple coordination mechanisms through which each rule in the hospital is applied was registered. Coordination mechanisms include (1) mutual adjustment, (2) direct supervision, and standardization of (3) work processes, (4) output, (5) skills and (6) norms[19]. A rule is applied through 'mutual adjustment' if an agent interacts with other agents regarding what a rule entails or if the rule is applied through communication in a specific situation. There is 'direct supervision' if a rule is set and monitored by people with formal authority. Rules are the result of 'standardization of work' when they result from specified or programmed working processes. They are related to 'standardization of output' when rules include specified output in terms of predetermined standards for services or performance. When coordination results from rules regarding specified skills and knowledge, this is labelled as 'standardization of skills'. Finally, when rules result from a common culture or ideology, they relate to standardization of norms, in which case rules related to behaviour are set.

The classification of the rules and coordination mechanisms were validated by a second researcher. He reviewed all rules and the associated coordination mechanisms, based on Mintzberg[26] and an agreed set of criteria for operationalization of those mechanisms. Rules that were classified differently by the reviewer were then discussed by the prime researcher and the reviewer. During the discussion the differences in interpretations of Mintzberg's definitions of coordination mechanisms were corrected or the classification was substantiated with the collected data. Consensus was reached on all rules with regard to the coordination mechanism that is used for a rule.

RESULTS

Output of the network

In 2018, a total of 9,846 patients who required surgery were diagnosed in one of nine outpatient departments. In total 344 different types of surgery procedures were performed, by 48 different surgeons and 14 assistant surgeons in nine different operating rooms. Patients were cared for in 12 different nursing departments. Of all surgeries, 82% were planned beforehand, i.e. they were not emergency surgeries. Patients flowed through a series of locations, as shown in Figure 4.2.

There is a variable rhythm in the system, as shown by Figures A4.1.1 and A4.1.2 in Appendix 4.1. In 2018, the number of surgeries varied from a minimum of 20 to a maximum of 242 surgeries a week, as shown in Figure A4.1.1 in Appendix 4.1. The number of surgeries per week varies by 25% on average. Per medical discipline, variability is larger with an average relative standard deviation of 41% (parameter 12 in Table 4.1). Types of surgery procedures were performed between 1 and 729 times per year in 2018, with an average of 23 times. Of all types of surgeries, 5% were performed once a week or more on average.

Tasks and flows

The main task of the logistical system is to get the right patient, surgeon, anesthesiologist, nurses, materials and infrastructure together at the right time and in the right place. In order to succeed in this, planning and scheduling of resources in relation to patient demand takes place, as presented by tasks 1, 2, 3, 6 and 11. Everything that has been planned is performed on the day of surgery through tasks 14, 15, 17, 20, 21 and 22. All tasks are described in more detail in Appendix 4.2.

In the OR master schedule (task 1) and clinical bed plan (task 2) operating time, space and beds are allocated to medical disciplines. After the OR master schedule is set, surgeons and anesthesiologists schedule when they will work in the outpatient department and in the OR (task 3). The patient is planned for in task 6, along with the surgeon who will perform the surgery. In task 11 the final OTC planning is checked and revised. After that, the patient enters the hospital for the surgery, and a series of tasks are performed from the intake of the patient (task 14) until aftercare (task 21).

Table 4.1 Key output figures per medical discipline.

Parameter#	Parameter	Dental surgery	Ear Nose Troat	Eye surgery	General surgery	Gynecology	Neuro-surgery	Orthopedic surgery	Plastic surgery	Urology
	Sessions									
1	Number of sessions per week (even/odd weeks)	2/4	4/5	4/4	21/23	4/3	2/2	14/13	4/3	6/6
2	Average percentage of sessions planned of OR master schedule	90%	79%	72%	93%	80%	100%	83%	89%	79%
3	Average session utilization	100%	94%	94%	88%	89%	85%	93%	83%	83%
4	Number of weeks deviated from OT master schedule	9	22	23	40	22	20	31	17	22
5	Number of weeks without sessions	2	2	6	0	1	18	0	1	1
6	Number of weeks with returned sessions	1	8	12	12	18	3	8	9	6
7	Number of weeks with extra sessions	4	2	0	27	6	5	2	3	7
	Surgeries									
8	Number of surgeries performed in 2018	357	1,069	941	3,299	884	162	1,742	515	876
9	Percentage planned surgeries	97%	97%	99,7%	68%	77%	99%	88%	86%	91%
10	Number of surgery types	21	22	11	130	30	10	69	31	44
11	Average number of surgeries per week	7	20	18	13	17	3	33	10	17
12	Variation number of surgeries per week (relative standard deviation)	43%	41%	49%	21%	35%	79%	30%	35%	38%
13	Average surgery time (min)	88	34	28	90	53	85	76	65	62
14	Variation surgery time (relative standard deviation)	26%	32%	29%	43%	32%	21%	28%	38%	29%

Tasks are differentiated on the basis of multiple rules. First of all, tasks throughout the patient process are allocated to different departments. In outpatient departments the patient is diagnosed and planned for. The intake, preparations and aftercare take place in nursing wards, and actual surgeries are performed in the OTC. Second, the care for patients is differentiated according to medical disciplines. This is most visible at the start of the process, when the patient enters the hospital in one of the outpatient departments, each of which is associated with a medical discipline. For nursing wards, the medical discipline, the expected the length of stay (e.g., the Daycare Department), the age (e.g., the Pediatric Department) and the acuity (e.g., the Intensive Care Unit) of the patients are differentiation criteria.

As a result of differentiation, in 2018 patients flowed past the locations shown in Figure 4.2, using 122 different routes. Each route is a unique combination of either an outpatient department or the Emergency Department to a ward, the OTC, and a ward for aftercare. Table A4.1.1 in Appendix 4.1 shows how many patients from each medical discipline flowed past each location.

Figure 4.2 shows that planning tasks 1, 2, 3, 6 and 11 are performed in parallel. The OR master schedule provides input to the planning for beds (task 2), to the schedule for surgeons and anesthesiologists (task 3) and to the planning of patients (task 6). Patients enter the hospital an unknown number of weeks before the surgery takes place and are registered in the surgery planning between two to twelve weeks ahead of the surgery day, with an average of 45 days. So, the OR master schedule, the clinical bed plan and surgeon's schedules are set before the patient demand is known. In addition, because surgeon's schedules are not shared with agents outside the medical disciplines, information on when surgeons operate emerges from task 6. As a result the OR master schedule and clinical bed plan are adapted and there is feedback between tasks 1, 2 and 6, as illustrated by the dotted lines in Figure 4.2. On the day of surgery tasks are performed in a fixed order, which is based on how patients flow from one location to the other, as shown in Figure 4.2. Controlling this chain of events is done largely in the OTC (task 22) by the OTC day coordinator, who receives feedback from tasks 14, 15, 17 and 20.

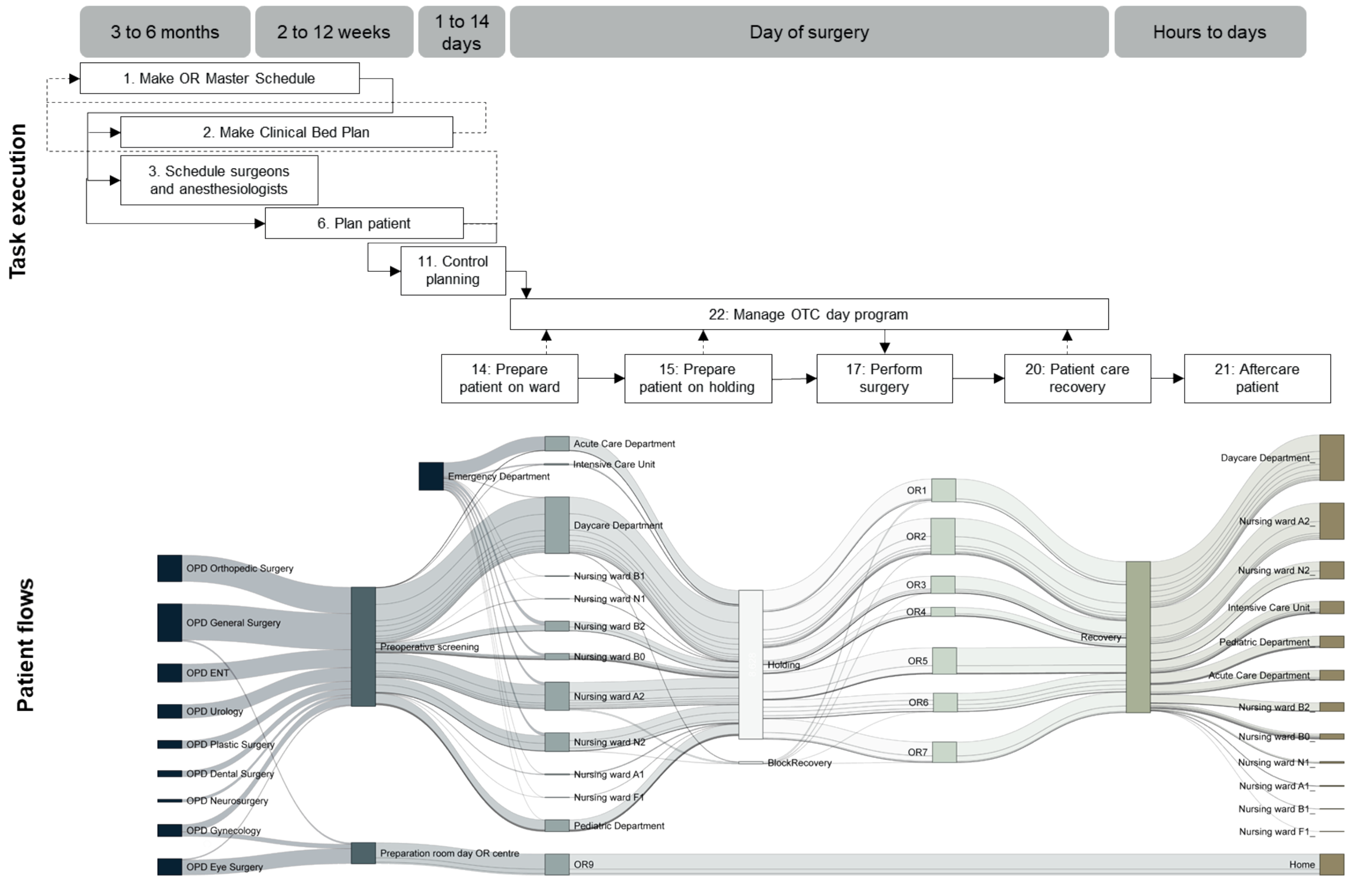

Figure 4.2 Performed tasks and patient flows over time. OPD = outpatient department; OR = operating room; ENT = Ear Nose Throat.

Rules and coordination mechanisms

In Appendix 4.2 the rules, coordination mechanisms and interactions that are used for performing the tasks are listed. Table 4.2 shows that 31% of the total 314 rules are captured in documents; 7% are in the HIS, but most rules (85%) predominantly exist in the minds of the agents in the network. Rules can be both written down and reside in people's minds, in which case they are written down in an often local document, and shared throughout the hospital through social interaction. In total 82% of the documents are not generally known, as these are local or personal documents such as checklists, emails, memos or delivered in internal presentations. Besides being in documents, 16% of all rules are more or less written down because the consequence of applying a rule is registered in the HIS, as for example the OR master schedule.

Table 4.2 Rules and coordination mechanisms per task.

Task	Task description	Number of rules	Hospital-wide or local		Number of rules per information carrier				Coordination mechanism					
			Hospital-wide	Local	Document	HIS rule	HIS output	People's knowledge	Mutual adjustment	Direct supervision	Standardization of work	Standardization of output	Standardization of skills	Standardization of norms
1	Make OR Master Schedule	53	48	5	26	0	16	48	36	0	26	3	0	2
2	Make clinical bed plan	51	51	0	12	0	10	46	35	0	35	0	1	3
3	Schedule surgeons and anesthesiologists	34	5	29	15	0	0	38	20	0	31	0	0	0
6 and 11	Plan patient and control planning	106	64	42	39	4	20	87	37	0	72	18	8	1
14-22	Prepare patient on ward, prepare patient on holding, perform surgery, aftercare on recovery, aftercare on nursing ward, control OTC program	70	51	19	5	19	3	47	26	0	45	35	4	0
Total %		314	219 70%	95 30%	97 31%	23 7%	49 16%	266 85%	154 49%	0 0%	209 67%	56 18%	13 4%	6 2%

Tasks are mainly coordinated through standardization of work (67%) and mutual adjustment (49%) as shown by Table 4.2. Other rules refer to output (18%), and a minority of rules relate to skills (4%) or norms (2%). There is no direct supervision. For 38% of rules, more than one coordination mechanism is used and this explains why the

total percentages do not add up to 100%. In particular, on the day of surgery (tasks 14 to 22), standardization of both working procedures and output go hand in hand with mutual adjustment. For example, rule 285 states that the nurse anesthetist takes the patient to the recovery area and executes the Time Out Procedure (TOP) with a recovery nurse. The TOP is coordinated by standardization of work and output, because both the process as well as required output are specified. The TOP has to be performed through mutual adjustment between the nurse anesthetist and the recovery nurse, because they perform the TOP together, thereby responding to each other.
In the early stages of planning (tasks 1 and 2), mutual adjustment using hospital-wide rules is the dominant coordination mechanism, whereas closer to the day of surgery there is more standardization of work, based on both hospital-wide and local rules. On the day of surgery, there is also standardization of output, which includes hospital-wide rules that need to be met in order for the patient to be operated on.

Coordination and interaction per task

Tasks 1 and 2 are performed using mainly hospital-wide rules in a highly connected social network structure in which almost all agents interact with one another, as shown by the interaction matrices in Appendix 4.2. Hospital-wide rules are largely based on space and time structures that are largely taken for granted by all agents in the hospital. The time structures relate to universal and national time structures, such as the distinction between weekdays and weekends, public holidays and annual national conferences for physicians. In addition, time is structured by defining working hours and by allocating operating time on the basis of historically acquired rights to operating time by medical disciplines. Space structures result from the infrastructure, i.e. the physical building and the presence or absence of specific equipment in operating rooms. As a result the OR master schedule remained largely unchanged throughout 2017 and 2018; 82% of the allocated OR sessions in the first quarter of 2017 are identical to those in the last quarter of 2018.

In addition, hospital-wide rules define how to negotiate through mutual adjustment on allocated operating time, which is defined in OR sessions, and on beds. Both of these have to be requested or returned via the OTC capacity planner and the clinical bed planner. There are norms and output measures as to how and how often a medical discipline may or may not request or return OR sessions or beds, but these are discussed or put aside under certain circumstances, through mutual adjustment. Table 4.1 shows that most medical disciplines request and return OR sessions. As a result, in 50 weeks in 2018 the OR master schedule was different from the initial schedule. The initial OR master schedule and clinical bed plan, which are recorded in Excel and printed on paper, deviate from the allocated OR sessions and beds that are registered in the HIS.

Surgeons and anesthesiologists are scheduled within each medical discipline (task 3), thereby predominantly following local rules. These rules are not set in the HIS, but in local documents, computer systems or through oral agreements between agents. Documents or systems are not shared hospital-wide nor are they easily accessible to agents outside the outpatient department. There is a multitude of locally defined scheduling methods, e.g. surgeons are either scheduled on fixed days or not, perform surgery part of the day or all day, distribute shifts in different ways et cetera. These rules are set and applied within each medical discipline through mutual adjustment.

When surgeries for patients are actually scheduled (task 6), the overview of the inflow of patients and what resources are needed starts to build up. Hospital-wide rules state that medical disciplines plan patients using their own methods (e.g. rules 158 and 165), using standard surgery coding and surgery times set in the HIS. Within the outpatient departments the secretaries match the patient's wishes and the surgeon's orders, thereby following a multitude of local rules with regard to demand management, resource allocation to surgeries and national regulations and norms. For 80% of the 344 types of surgery procedures one or more specific rules are used; this includes 52% of all performed surgeries. Rules relate to individual patients as well as individual surgeons, as illustrated by rules 147 to 157 in Appendix 4.2. Secretaries often use a preliminary planning schedule, which is mostly kept in personal paper notebooks, on whiteboards or in the secretaries' minds, before registering the surgery in the HIS. By looking at the HIS and by interacting with the outpatient secretaries and surgeons, the OTC capacity planner and the clinical bed planner monitor the planned patients and try to control the overall planning in order to prevent any possible instability, e.g. shortages of beds, cancellations of surgeries or lateness in the OTC. In the two weeks before the surgery date, the preoperative secretaries, the outpatient secretaries and the OTC capacity planner and ward team leaders meet up to check whether all rules have been met in order to proceed with the surgeries as planned (task 11).

Tasks that are performed on the day of surgery include mainly hospital-wide rules that result from the Time Out Procedure (TOP), which is a series of standard checklists that is used in every step of the patient process, from intake until discharge, and which is laid down in the HIS. What needs to be done for patient transfer is standardized and registered in the HIS, but exactly when and by whom activities are performed is determined during task performance, through mutual adjustment. In order to maintain stability, the OTC day coordinator monitors the progress of surgeries, both by looking at the HIS and by observing the holding area, the recovery area and ORs. He uses several local rules for detecting any potential factors that may endanger a smooth patient flow in the OTC.

Rules, coordination and interaction over time

In the planning process, initially drafted hospital-wide schedules are adjusted as time passes and reality unfolds. Table 4.3 shows that three to six months ahead, coordination is mainly based on hospital-wide rules (75%), through standardization of work (67%) and mutual adjustment (66%). Then, from three months to one week before surgery, 40% of the rules applied are local rules and 68% are part of standard working procedures. In this phase the OTC capacity planner and the clinical bed planner coordinate local planning through mutual adjustment. On the day itself there is predominantly hospital-wide standardization of work and output (see Table 4.3).

Table 4.3 Rules and coordination mechanisms over time.

Time horizon	Tasks	% of rules		Coordination mechanism					
		Hospital wide	**Local**	**Mutual adjustment**	**Direct supervision**	**Standarization of work**	**Standarization of output**	**Standarization of skils**	**Standarization of norms**
3-6 months	1,2,3	75%	25%	66%	0%	67%	2%	1%	4%
1 day to 12 weeks	6,11	60%	40%	35%	0%	68%	17%	8%	1%
Day of surgery	14,15,17,20,21,22	73%	27%	37%	0%	64%	50%	6%	0%

Figure 4.3 shows that more agents become involved in the interaction as the surgery date approaches. Twelve agents are involved from the start (tasks 1 and 2), six months ahead, and 373 agents interact only on, or about, the day of surgery. Besides a time horizon of one day, these 373 agents have a space horizon of one department or they go one step up- or downstream, like for example a ward nurse who takes the patient to the holding area. Surgeons and one anesthesiologist are involved from months before until the day of surgery and they work in multiple locations in the hospital. As shown in Figure 4.3, over the long term (task 1) nine surgeons and one anesthesiologist are involved in coordination. In the short term, they coordinate on the day of surgery (tasks 14, 15, 17, 20, 21, 22). In between those two time horizons (tasks 3 and 6) surgeons and anesthesiologists coordinate locally.

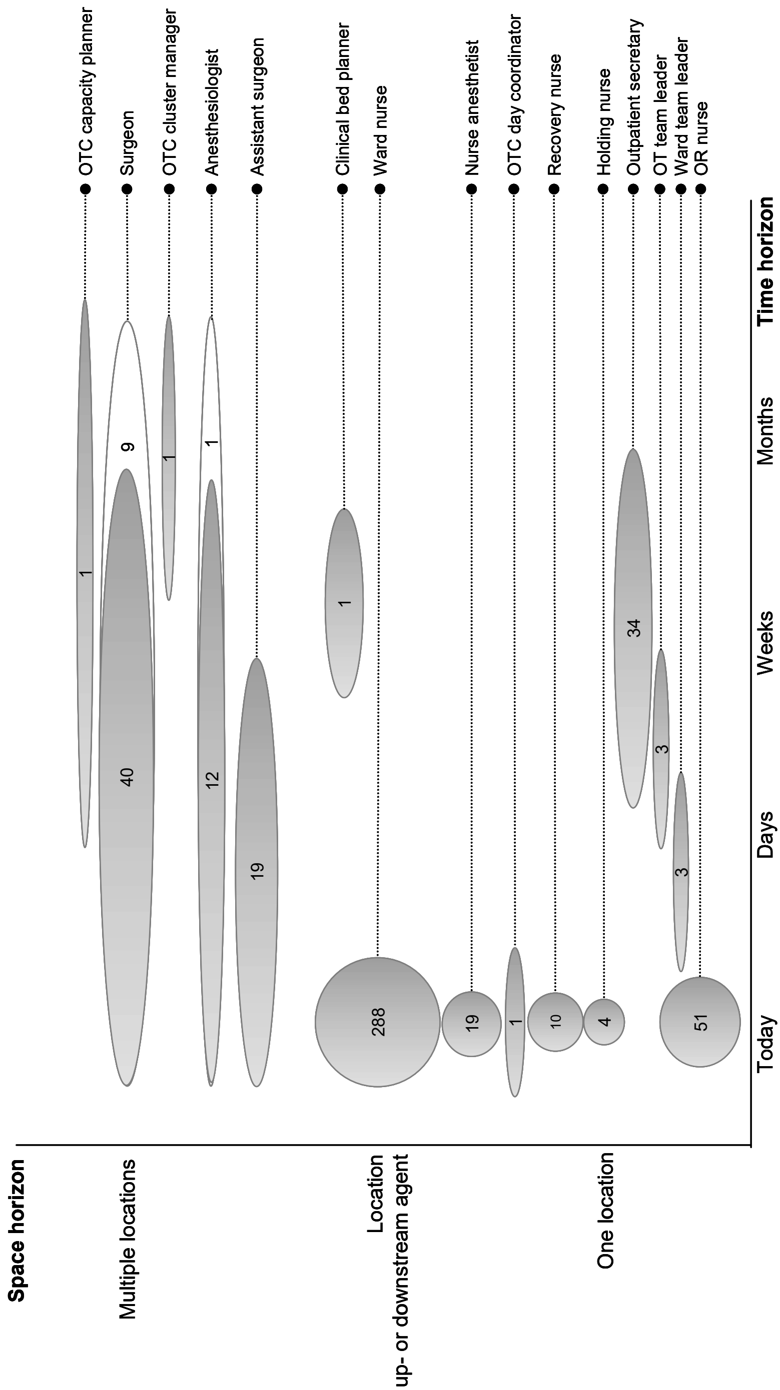

Figure 4.3 Time and space horizon of the agents.

DISCUSSION

In a previous SNA study[17] we described the Slingeland Hospital's social network structure, i.e. the integration and differentiation that shape the network. In the current study the social network structure of Slingeland Hospital was further explored by studying the rules and coordination mechanisms that explain the interactions observed in the social network analysis.

In order to coordinate the patients' process from hospital admission to discharge, and to schedule the use of all necessary resources, 314 rules were found. Long-term schedules and plans are the result of applying hospital-wide rules, which were set in the past and by time and space structures. In the shorter term, these schedules are subsequently adapted to the circumstances through negotiation by agents in the social network. Circumstances unfold when the local schedules for surgeons are made and when patients are planned for surgery in the OTC. Standardized ways of working are adapted to the circumstances as they present themselves, thus requiring mutual adjustment. There is continuous interaction between agents to observe the expected future and current state of the system, which often changes given the variable rhythm of the system. In addition there is no reliable central view of all local rules and schedules, as these reside mostly in people's minds. Most agents interact shortly before or on the day of surgery.

The OR master schedule, the clinical bed plan and the surgeon's schedules create open loops, because they are not based on future patient demand. As time passes the loops are closed through mutual adjustment, by adapting these schedules to the reality of the actual demand and availability of resources. The OTC capacity planner and the clinical bed planner continuously monitor the current situation and raise issues that may endanger the stability of the system with other agents, i.e. outpatient secretaries and surgeons. Any remaining open loops on the day of surgery are closed by the OTC day coordinator, nurses, nurse anesthetists, surgeons and anesthesiologists.

Central to literature pertaining to surgery planning is the idea of being able to structure time, space, demand, resource availability and uncertainty[27-29]. Many studies use formal and mathematical methods to create a controllable future state of the system. In contrast, in this case agents work in a negotiated order[30], in particular for planning tasks. Copp et al.[31] state that in negotiated orders there are 'ongoing processes of negotiation' and agents 'alternately create, maintain, transform, and are constrained by social structures'. There is coordination between autonomously acting parts, and people coordinate themselves and each other in their social network rather than through 'managers' who coordinate from the top, or by a fixed and formalized set of rules.

In this study, Mintzberg's[26] notion that standardization of skills is the dominant coordination mechanism for professional organizations such as hospitals, is much less observed for organizing hospital-wide logistics. Interestingly, in his later work Mintzberg[19] advocates for more coordination through mutual adjustment and standardization of norms. Following Mintzberg's line of thinking, this raises the question of on what idea, belief or to what ends mutual adjustment is based. Perhaps there is expansive learning, a concept introduced by Engeström[32], in which engaged agents with differentiated tasks produce new patterns of activity, driven by their shared responsibility for patients. In addition, stabilizing the system appears to be an important motive for integration, especially because this is mainly done by agents with no formal responsibility for (large parts of) the system as a whole. This apparent need for stabilization may have to do with the absence of the concept of Takt time as a coordination mechanism. Takt time is the desired time between units of output, to be synchronized to the customers' demand, as described by Munavalli et al.[33]. Takt time is considered important for the synchronization and integration of activities and for stabilizing the system[33]. From this perspective, interactions in the social network could be there to respond to patient demand in the second instance, because the initial hospital-wide schedules are not based on patient demand. When surgeons plan patients, the open loop character of the system emerges and agents who observe this try to close these loops.

Perhaps this self-organizing, adaptive and learning organization is a good thing, as stated both in literature and given the highly rated performance of Slingeland Hospital. There could, however, be a downside. The hospital's performance may be vulnerable and potentially unstable, leading to critical events, as mentioned by Ren et al.[34]. The multitude of very detailed, conflicting or specific rules may hinder the overview of the system and hide possible open loops. In the SNA[17] it was observed that the OTC capacity planner and the OTC day coordinator have a very central position in the network. This study shows that, together with the clinical bed planner, their integrative actions result from mutual adjustment and not from direct supervision. This can be a very challenging task for which extraordinary skills or even a certain personality are required. When these agents are absent or leave the hospital, the network may not only fall apart, but their knowledge of hospital-wide and local rules may disappear from the hospital, as most of those rules are unwritten. In addition, the lack of direct supervision by management may lead to a disconnection between the strategic and operational parts of the hospital. Relevant bottom-up feedback could be missed by top management, and operational agents may not respond to top-down management input, thus creating more open loops. This may hinder, for example, effective cost control of the hospital.

This exploratory case study provides an overview of the rules, coordination mechanisms and variables that are used for organizing the hospital-wide logistics for surgery patients. The main contribution of this study is that it reveals the rules and the coordination mechanisms that are used in a hospital, and it shows that the combination of these create open loops, for which integration is achieved. In line with Yin[23], the findings should be used for 'analytic generalization'[23] and the lessons learned provide input to working hypotheses for future research. Clearly, the limitations of this study should be taken into account when drawing up hypotheses. The rules as described here may be temporary, and not universal, both in time as well as given the environment of this particular hospital. Furthermore, from this study we cannot conclude how the coordination mechanisms relate to the hospital's performance.

Given the findings of this exploratory study, there are several issues we propose to explore further. First of all, we observe that the variability and uncertainty which are inextricably characteristic of hospital logistics[3,4,9,10,27-29,33] are managed through local rules and standards and by mutual adjustment processes. Integration is the result of actions of agents who try to stabilize the hospital system through mutual adjustment. We should further explore how integration and differentiation can be organized in hospitals in a more structural way. It is the question of what degree of integration and differentiation works and accordingly, how a closed loop system can be achieved within a certain network structure.

Further, we have to learn more about whether variability is the cause or the effect of the current way of working, or both. We need to understand how and when to close the loops - in other words, how to use and facilitate mutual adjustment in these uncertain circumstances. In relation to this it would be interesting to further explore which network structure and what rules and coordination mechanisms could facilitate Takt time management and thus facilitate stabilizing the hospital system. In addition, we need to explore how all this contributes to the hospital's performance.

We believe it is important to further develop Slingeland Hospital's logistical system in order to make it more robust, for example by creating redundancy in the network, and possibly even improve its stability and performance. We should not leave the logistical organization of hospitals entirely up to the personal initiatives of some individuals nor discard informal mutual adjustment processes as a whole, for their apparent chaotic character. We propose three different approaches for future research.

First of all, if mutual adjustment is to be combined with standardization of norms[19], we need to understand what the norms of agents in hospitals are with regard to logistics. Mintzberg's norms[19] refer to engagement in health care as a calling, but what this means for hospital logistics has to be specified further. A second approach is to study how the interplay between rules, coordination mechanisms, social network structures and hospital performance evolve over time. When circumstances change, both externally and internally, new rules may emerge and old ones be abolished, possibly as the result of a learning process. A third approach is to develop a multi-agent system model in which the role of the OTC capacity planner is supported or even performed by an intelligent real-time scheduler, as proposed for outpatient clinics by Munavalli et al.[35]. In this approach the relation between coordination and performance is explored by developing formal negotiation processes and studying the effects of Takt time management in computer simulation models.

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APPENDIX 4.1

Table A4.1.1 Number of surgery patients per location

Medical discipline	Emergency Department	Outpatient Department	Preoperative screening	Nursing Department - admission														Holding	Block on Recovery
				Daycare Department	Nursing ward A2	Nursing ward B0	Nursing ward A1	Pediatric Department	Nursing ward N0	Nursing ward F1	Nursing ward N1	Nursing ward B1	Nursing ward B2	Nursing ward N2	Intensive Care Unit	CCU	Unknown		
General Surgery	1122	2177	2091	950	695	158	48	18	615	7	6	12	24	582	57	2	125	3149	25
Orthopedic Surgery	213	1529	1528	966	498	40	2	3	131	0	1	0	4	5	4	1	87	1544	111
Ear Nose Throat	27	1042	1042	319	106	39	0	570	13	0	1	0	3	7	1	0	10	1058	1
Eye Surgery	3	938	63	29	1	7	0	22	1	0	0	0	0	0	0	0	1	60	0
Urology	82	794	794	291	9	23	3	24	35	0	0	1	7	455	7	0	21	855	0
Gynecology	201	683	429	87	0	5	0	0	0	0	1	0	523	2	1	0	145	619	0
Plastic Surgery	70	445	445	313	99	24	0	16	29	0	0	1	2	11	3	0	17	497	1
Dental Surgery	10	347	347	124	135	64	0	22	4	0	0	0	0	2	1	0	5	352	0
Neurosurgery	2	160	160	151	0	0	0	0	1	0	2	0	0	0	0	0	8	154	0

Table A4.1.1 (continued)

Medical discipline	Preparation room OR 9	Operating Room								Recovery	Nursing Department - aftercare														
		OR 1	**OR 2**	**OR 3**	**OR 4**	**OR 5**	**OR 6**	**OR 7**	**OR 9**		**Daycare Department**	**Nursing ward A2**	**Nursing ward B0**	**Nursing ward A1**	**Pediatric Department**	**Nursing ward N0**	**Nursing ward F1**	**Nursing ward N1**	**Nursing ward B1**	**Nursing ward B2**	**Nursing ward N2**	**Intensive Care Unit**	**CCU**	**Unknown**
General Surgery	86	74	1050	752	362	427	243	305	86	2542	966	690	116	33	19	424	6	5	9	20	535	457	1	18
Orthopedic Surgery	1	1157	534	10	4	17	16	3	1	1594	428	1071	31	2	3	86	0	1	0	3	4	100	2	11
Ear Nose Throat	0	1	16	3	12	1035	1	1	0	1058	321	99	38	0	570	12	0	0	0	3	7	18	0	1
Eye Surgery	875	0	64	1	0	0	0	0	876	63	30	1	7	0	22	0	0	0	0	0	0	1	0	0
Urology	0	2	40	9	2	8	10	805	0	826	304	9	22	2	24	23	0	0	0	5	436	45	1	5
Gynecology	254	2	178	98	28	15	247	62	254	480	89	0	5	0	0	0	0	1	0	475	1	56	0	70
Plastic Surgery	0	0	40	20	13	21	416	5	0	482	317	98	22	0	16	25	0	0	1	2	12	19	0	3
Dental Surgery	0	0	9	101	99	3	145	0	0	350	123	129	64	0	21	3	0	0	0	0	2	13	0	2
Neurosurgery	0	1	153	1	0	0	4	3	0	162	77	0	0	0	0	1	0	79	0	0	0	3	0	2

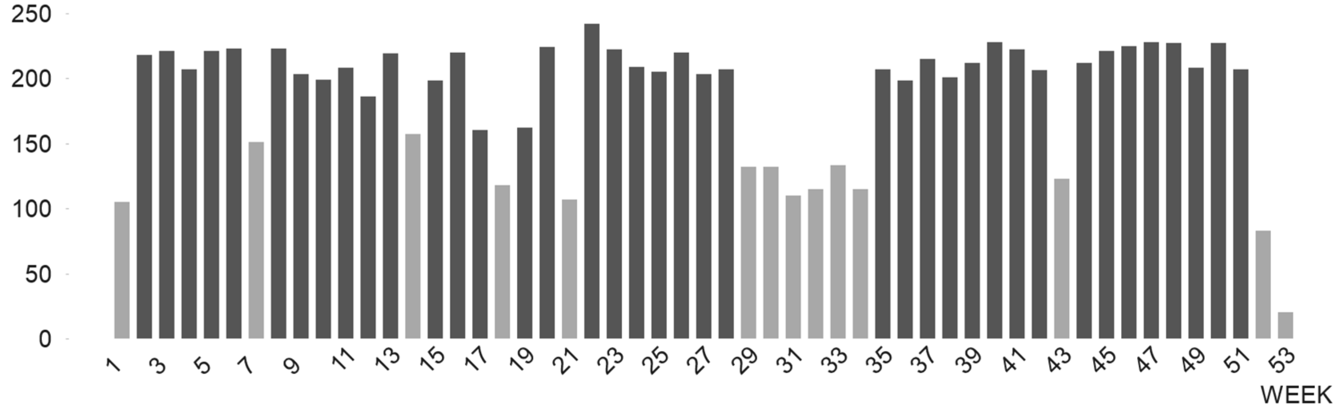

Figure A4.1.1 Number of surgeries per week.

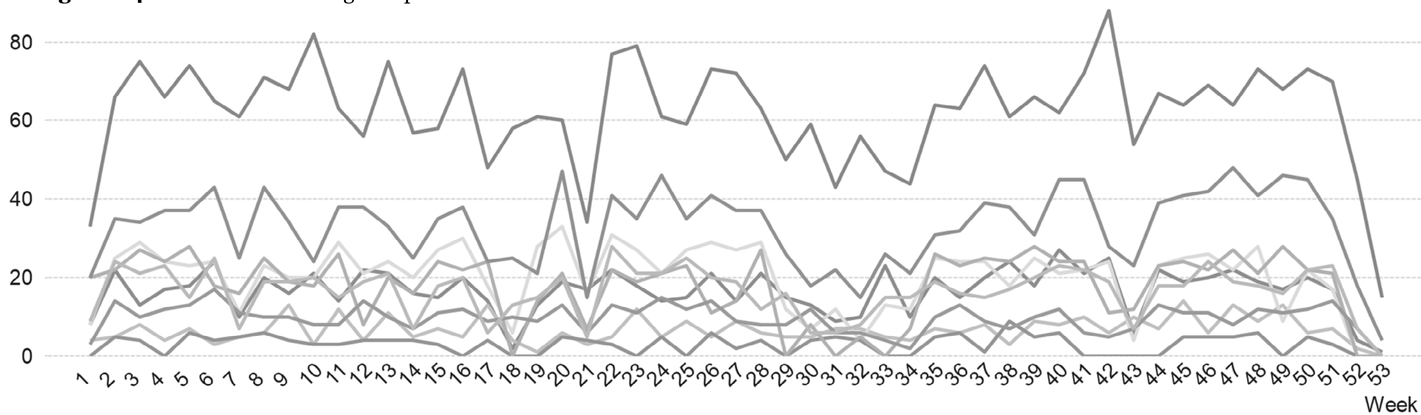

Figure A4.1.2 Number of surgeries per week per medical discipline.

APPENDIX 4.2

The tasks, agents, interactions and coordination mechanisms in the social network

Task 1: Make OR Master Schedule

Task description

The Operating Room (OR) master schedule is made in the Tactical Planning Meeting (TPM). Three cluster managers, who are responsible, respectively, for outpatient, inpatient departments and the Operating Theatre Complex (OTC), nine surgeons, one anesthesiologist and the OTC capacity planner participate in this meeting. The OR master schedule is prepared by four participants of the TPM, who then propose the scheme to the entire TPM. The OR master schedule is then presented to the OTC commission. The OTC commission discusses and advises OTC management on planning, staff and budget issues. The OTC commission includes one surgeon from every surgical discipline, the cluster manager responsible for the OTC and the OTC capacity planner. When the OR master schedule is final, the OTC capacity planner informs all outpatient secretaries on the changes made.

Time horizon

12 to 20 weeks ahead

Frequency

4 times a year

Interactions

	Number of agents	Anesthesiologist	Cluster manager	OTC capacity planner	Outpatient secretary	Surgeon
Anesthesiologist	1		X	X		X
Cluster manager	3		X	X		X
OTC capacity planner	1				X	
Outpatient secretary	13					
Surgeon	9					X

Rules for task performance

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Structuring time and space																					
1	In the OR master schedule sessions are allocated to medical specialties for even and odd weeks in one quarter of the year.	X											R/O	O				X			
2	The OR master schedule is set for 38 'regular weeks'. The other 14 weeks are reduction weeks and these are in national school holiday weeks.	X											O	O	R			X			
3	The OR master schedule is different on national holidays outside reduction weeks and on anesthesiology conference days.	X											O	O	R			X			
4	The OR master schedule is set quarterly, two quarters ahead.	X											R					X			
5	Each of nine operating rooms has 2 sessions - a morning and afternoon session - on week days and there are 90 sessions in one week.	X											O	O	R			X			
6	In the OR master schedule 70 to 72 sessions are allocated to either a medical specialty, a treatment type or labelled as flexible or as an emergency session.	X											O	O	R			X			
7	One session is allocated to one medical specialty, or labelled as flexible or as an emergency session.	X											O	O	R			X			
8	Every day there is an emergency session from 12 to 16 pm.	X											R					X			
9	If all sessions are required by medical specialties, then there is no flexible session.	X												O	R	X					
10	Flexible sessions or sessions in reduction weeks are used for medical specialties with a high waiting list, for which no structural increase of session allocation is required.	X													R	X					
11	Session duration is 4 hours, from 8:00 to 12:00 and 12:00 to 16:00. Session times are different for Eye surgery, ENT, specific surgeries performed by General Surgery, Urology, Neurosurgery and Orthopedics.	X												O	R			X			
12	Operating rooms 1 and 2 are used for defined surgeries for which a plenum is required. In addition a number of surgery types are defined for which OR 1 and 2 are to be used with strong preference.	X											R		R	X		X			
13	Operating rooms 8 and 9 are used for defined surgeries or treatments for which no complete anesthesia is required.	X													R			X			
14	Urology surgeries preferably take place in OR 7.	X											O	O	R	X		X			
15	Ear Nose Throat surgeries preferably take place in OR 5.	X											O	O	R	X		X			
16	OR 4 and 6 are preferably used by medical specialties that do surgery only in these ORs because the physical layout differs from the standard OR.	X											O	O	R	X		X			
17	On Wednesdays two sessions in OR 2 are used by either Orthopedics or Neurosurgery.	X											O	O	R			X			
18	Sessions are registered in the Hospital Information System (HIS).	X											R	O	R			X			
19	The OTC capacity planner, OTC day coordinator, OTC application controller, OTC secretary and the clinical bed planner are authorized to change sessions in the HIS.	X												O	R			X			
Making the OR master schedule																					
20	The number of sessions a medical specialty gets, matches the number of sessions they need in order to be able to operate on patients.	X													R	X					
21	The number of sessions a medical specialty needs is based on past session utilization, current and expected waiting list and resource availability.	X											R		R	X					
22	The OR master schedule is based on past OR session allocation and is an adapted version of the previous OR master schedule.	X											O		R	X					
23	Structural changes to the OR master schedule are made only when the changes are expected to last for the long term, based on expected demand and available staff resources (surgeons and OTC staff).	X													R	X					
24	Production figures of last year's same quarter are used to determine whether structurally changing the OR master schedule is necessary or not.	X											R		R	X					
25	In reduction weeks medical specialties are entitled to 50% of the sessions they get during regular weeks.	X													R			X			
26	On request, medical specialties can get more sessions during reduction weeks.	X												O	R	X					
27	Medical specialties are allowed to decide to do less than 50% or no sessions during reduction weeks.	X													R	X					
28	When sessions are taken away, it is guaranteed to the medical specialty that sessions are returned when the medical specialty needs these sessions.	X													R	X					
29	When sessions are taken away, this is discussed outside the TPM first, before deciding on the OR master schedule in the TPM.	X													R	X					
30	Although this is not considered desirable by the OTC, medical specialties are free to return more than 50% of sessions during reduction weeks.	X											O		R	X					X
31	The OTC capacity planner proposes the OR master schedule in the pre-Tactical Planning Meeting, which involves the cluster manager of the OTC and Services and the cluster manager Surgery Care.	X											R/O		R	X					
32	The OR master schedule is agreed upon in the Tactical Planning Meeting (TPM), which includes the cluster manager of OTC and Services, surgeons from medical specialties, and one anesthesiologist.	X											O		R	X					
33	OR sessions are released in the HIS after the TPM has taken place.	X													R			X			

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Session allocation and use																					
34	Allocated OR sessions can be returned or additional OR sessions can be requested by medical specialties. Requests are made to the OTC capacity planner.	X											O		R	X		X			
35	If the waiting list of a medical specialty is above a certain number of weeks and the session utilization is high, additional sessions are allocated in regular weeks or in reduction weeks.	X													R	X					
36	The waiting list has to be perceived as 'real' in order to act on it, meaning that this includes actual patients waiting, and not, for example, patients who wait at their own request.	X													R	X					
37	Extra sessions can be requested and are granted if session utilization meets utilization standards, if previously offered sessions were accepted, if the waiting list increases, and the resources are expected to be available.	X												O	R	X					
38	A minimum of 95% of the inititally allocated sessions in the OR master schedule should be used.	X											R			X			X		
39	A minimum of 85% of the sessions should be used for surgeries; for eye surgery this is 75%.	X											R			X			X		
40	When session utilization is expected to be 40% or below, sessions are to be returned or taken from the medical specialty.	X													R	X			X		
41	Sessions are taken from medical specialties through mutual agreement between the OTC capacity planner and the medical specialty.	X													R	X					
42	Returning OR sessions is considered to be unacceptable behaviour if there are no circumstances that justify this.	X											R		R	X					X
43	Sessions should be returned preferably 10 weeks beforehand and no later than 6 weeks beforehand.	X											R		R	X		X			
44	When the waiting list exceeds 4 weeks, allocating more sessions is considered.	X													R	X		X			
45	If there is an overall shortage of session time, sessions may be returned later than 6 weeks beforehand.	X													R	X		X			
46	Under specific incidental circumstances such as illness of surgeons or shortage of OTC staff, sessions may be returned later than 6 weeks beforehand.	X											R		R	X		X			
47	Changes in session allocation are made by the OTC capacity planner up until 2 weeks beforehand and by the day coordinator from 2 weeks beforehand.	X													R			X			
48	Changes in session allocation are discussed between the OTC capacity planner and the OTC day coordinator in order to make sure that the right OTC staff are available for the sessions.	X													R	X					
49	General Surgery requests all sessions that are returned by other medical specialties.			X											R	X					
50	Dental Surgery intends to use the sessions as allocated in the initial OR master schedule.		X												R	X					
51	Neurosurgery intends to use the sessions as allocated in the initial OR master schedule, except for when the neurosurgeon is absent.							X							R	X					
52	Eye surgery uses extra sessions preferably for 'one eye' surgery and not for 'two eye' surgeries.						X								R			X			
53	Outpatient secretaries monitor the waiting list development and advise the surgeons on returning or requesting sessions.		X	X	X	X	X	X	X	X	X				R	X					

Task 2: Make Clinical Bed Plan

Task description In the clinical bed plan, beds are assigned to a medical discipline for each nursing department. The clinical bed plan is established in consultation between the OTC capacity planner, one secretary from the nursing department and the two team leaders of the three nursing wards who host most surgery patients. The team leaders of these nursing wards are also involved in making the clinical bed plan, but one nurse ward secretary has the informal role of 'clinical bed plan boss'.

Time horizon 12 to 20 weeks ahead

Frequency 4 times a year

Interactions

	Number of agents	OTC capacity planner	Clinical bed planner	Ward team leader
OTC capacity planner	1		X	X
Clinical bed planner	1			X
Ward team leader	2			X

Rules for task performance

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Structuring time and space																					
54	The clinical bed plan has the same time structure as the OR master schedule.	X											R/O					X			
55	There is a fixed number of beds allocated to defined nursing departments.	X											R/O	O	R			X			
56	Specific beds, identified by a bed number, are allocated to a medical specialty or surgery type on each weekday.	X											O	O				X			
57	Patients under 18 years old are cared for in the Pediatric Department.	X													R			X			
58	Patients that go home after surgery on the same day are prepped and recover in the Daycare Department.	X													R			X			
59	The Daycare Department closes at 9:30 pm.	X											R		R			X			
60	Patients under 18 years of age who go home after surgery on the same day are prepped and recover in the Pediatric Daycare. Department.	X													R			X			
61	General surgery patients are primarily in the Daycare Department and in nursing departments A2 and N2.	X													R	X		X			
62	Orthopedic patients are primarily in the Daycare Department and in nursing department A2.	X													R	X		X			
63	Neurosurgery patients are primarily in the Daycare Department before surgery and in nursing department N1 after surgery.	X													R	X		X			
64	Gynecology patients are primarily in nursing department B2.	X											R		R	X		X			
65	Plastic surgery patients are primarily in the Daycare Department and on nursing department A2.	X													R	X		X			
66	Ear Nose and Throat patients are in the Daycare Department and on nursing department A2.	X													R	X		X			
67	Dental surgery patients are primarily in the Daycare Department and in nursing department A2.	X													R	X		X			
68	Urology patients are primarily in the Daycare Department and in nursing department N2.	X													R	X		X			
69	Patients who require surgery and who entered the hospital through the Emergency Department are in the Acute Intake Department.	X													R			X			
70	Patients who require surgery and who enter the hospital through the Emergency Department but who are diagnosed in the outpatient department, are not admitted to the Acute Intake Department.	X													R	X		X			
71	Patients who have a trauma that has existed for more than one week, are not admitted to the Acute Intake Department.	X													R			X			
72	Patients admitted to the Acute Intake Department should leave the department within 48 hours.	X											R					X			
Setting the clinical bed plan																					
73	For each OR session a number of beds is allocated to a medical specialty operating in the OR session per nursing department.	X											O	O	R	X		X			
74	Final bed allocation to medical specialties is based on the surgeon allocated to the OR session and/or the type of surgery taking place.	X												O	R	X					

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Bed allocation and use																					
75	In principle medical specialties are only allowed to reserve beds that have been allocated to them according to the clinical bed plan.	X											R			X		X			
76	Bed allocation is tailored as much as possible to each medical specialty's demand for beds.	X													R	X					
77	Outpatient secretaries can request additional beds from the clinical bed planner.	X													R	X					
78	Based on the final OTC program and how many patients require a bed specific beds are allocated to specific patients, on the basis of practical experience and knowledge.	X												O	R	X					
79	The medical specialty, as represented by the outpatient department, is responsible for reserving beds for patients six weeks ahead.	X													R			X			
80	The medical specialty, as represented by the outpatient department, is responsible for a good ratio between day care and clinical bed patients.	X													R	X					
81	The allocated beds in the clinical bed plan can be reserved for patients by outpatient secretaries without consultation with the clinical bed planner.	X													R			X			
82	Beds may be exchanged between sub-specialties within General Surgery (Vascular Surgery, Oncology and Trauma surgery) without consulting the clinical bed planner.	X													R	X					
83	A standard number of beds are reserved for as yet unknown emergency patients in nursing departments.	X												O	R			X			
84	A bed that is required for a small number of hours per day is not reserved for one patient.	X												O	R			X			
85	Deviations from the allocated number of beds in the clinical bed plan have to be discussed with the clinical bed planner.	X													R	X					
86	The clinical bed planner monitors the planning of OR sessions and bed reservations and takes proactive action if there is a risk of a possible mismatch between the number of patients and the number of available beds on specific days.	X													R	X					
87	The clinical bed planner takes action two weeks ahead of planned surgeries.	X													R	X		X			
88	Requesting beds on short notice or reserving beds that are not allocated to your department according to the clinical bed plan, is not considered as be acceptable behaviour.	X													R	X					X
89	The more outpatient secretaries share the need for beds on time and consult with the clinical bed planner on bed requirements the more she is willing to find a solution for any bed shortages. This is a give and take process.	X													R	X					X
90	If a medical specialty does not behave as expected, the clinical bed planner waits with communication on a possible solution, in order to enforce improved planning behaviour for the future.	X													R	X					X
91	If no beds are available in the nursing department where a patient of a medical specialty should be, then the patient is allocated to another nursing department.	X											R	O	R	X					
92	Shifting patients to a different nursing department is possible when the required level of care of the patient and the knowledge and skills of nurses, which are acquired in training, in the other nursing department matches.	X											R		R	X				X	
93	If OR sessions are planned 100% for a specific medical specialty, then the allocation of beds in the clinical bed plan for that day is not applicable.	X													R	X		X			
94	If beds are not reserved two weeks ahead, the allocated beds in the clinical bed plan for that week are cancelled.	X											R			X		X			
95	If all allocated beds are reserved for a specific medical specialty, but the OR session is not, then the clinical bed planner contacts the outpatient department in order to discuss a possible need for	X													R	X					
96	Patients for whom no bed is available yet or for which no allocated bed is yet required, are placed in the 'ball box'. This is a registry of all patients in the HIS, which includes all patients who are planned for surgery and allocated to a nursing department, but who do not yet have a reserved bed.	X												O	R	X		X			
97	The final bed allocation is made by the team leader of the nursing department, on the day before patient admission.	X												O	R			X			
98	In case of conflicts between the clinical bed planner and a medical specialty on bed requests, the clinical bed planner consults with the nursing departments team leaders and/or the OTC capacity planner in order to determine a common policy.	X													R	X					
99	Patients with sleeping apnea or lung surgery are cared for in the Intensive Care Department after surgery.	X											R		R			X			
100	If there are only daycare patients on the waiting list of a medical specialty, it is allowed to request additional beds two weeks beforehand.	X													R	X		X			
101	Specific requests of patients, e.g. to stay in a single room, are taken into account and granted if possible.	X													R	X					
102	If the expected length of stay of a patient is expected to be high or the patient is infected with MRSA, the outpatient secretary discusses the bed reservation with the clinical bed planner.	X													R	X		X			
103	Oncology patients have priority over all other patients when allocating beds to specific patients.	X													R	X		X			
104	Specific combinations of patients that are being cared for in nursing departments are averted, based on past experience. For example, one rule is that when a bed is required for a patient in nursing department N0, no vascular surgeries, which can have a heavy impact on the patient, should be planned for at the same time.	X													R	X		X			

Task 3: Schedule surgeons and anesthesiologists

Task description

The surgeons of each outpatient department and anesthesiologists make schedules for themselves and allocate surgeons to the time slots in the OR master schedule. The scheduler of each medical discipline group proposes the schedule and discusses it with the surgeons. In some outpatient departments the secretary of the outpatient department is involved in this.

Time horizon

10 weeks ahead

Frequency

Variable

Interactions

	Number of agents involved	Anesthesiologist	Surgeon General Surgery	Outpatient secretary General Surgery	Surgeon Orthopedic Surgery	Outpatient secretary Orthopedic Surgery	Surgeon Dental Surgery	Outpatient nurse Dental Surgery	Surgeon Eye Surgery	Outpatient secretary Eye Surgery	Surgeon Gynecology	Outpatient secretary Gynecology	Surgeon Plastic Surgery	Outpatient secretary Plastic Surgery	Surgeon ENT	Outpatient secretary ENT	Surgeon Urology	Outpatient secretary Urology	Surgeon Neurosurgery	Outpatient secretary Neurosurgery
Anesthesiologist	12	X																		
Surgeon General Surgery	14		X	X																
Outpatient secretary General Surgery	3																			
Surgeon Orthopedic Surgery	4				X	X														
Outpatient secretary Orthopedic Surger	1																			
Surgeon Dental Surgery	5						X	X												
Outpatient nurse Dental Surgery	1																			
Surgeon Eye Surgery	5								X	X										
Outpatient secretary Eye Surgery	1																			
Surgeon Gynecology	9										X	X								
Outpatient secretary Gynecology	1																			
Surgeon Plastic Surgery	2												X	X						
Outpatient secretary Plastic Surgery	1																			
Surgeon ENT	4														X	X				
Outpatient secretary ENT	1																			
Surgeon Urology	3																X	X		
Outpatient secretary Urology	1																			
Surgeon Neurosurgery	1																		X	X
Outpatient secretary Neurosurgery	1																			

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Structuring time and space																					
105	The surgeons' and anesthesiologists' schedules have the same time structure as the OR master schedule as far as surgery time is concerned.	X											O		R			X			
106	The surgeons' and anesthesiologists' schedules use their own scheduling method for scheduling OTC, outpatient and clinical activities.		X	X	X	X	X	X	X	X	X	X	O		R	X		X			
107	Each year there are predefined Anesthesiology and General Surgery meetings, during which surgeons are scheduled from 9 am at the earliest.	X											O		R			X			
Setting the surgeon's and anesthesiologist schedules																					
108	Each medical specialty schedules its own surgeons or anesthesiologists, based on sessions allocated in the OR master schedule.	X											O		R			X			
109	The individual surgeon's schedule is tailormade and depends on the number and type of surgeries, the outpatient activities he or she does, on what days he or she works at Slingeland Hospital and on the surgeons' personal preferences.	X											R		R	X					
110	Medical specialties are expected to allocate surgeons to specific OR sessions no later than 10 weeks ahead.	X											R		R	X		X			
111	The surgeons' or anesthesiologists' considerations are in the lead regarding how the schedule is made within the medical specialty.		X	X	X	X	X	X		X	X	X			R			X			
	Each medical specialty follows its own scheduling policies, e.g.:														R						
112	The scheduling horizon varies per medical specialty, from three to six months ahead.		X	X	X	X	X	X	X	X	X	X			R			X			
	Surgeons are scheduled per week either on:														R						
113	- fixed weekdays		X			X	X	X		X	X	X	O		R			X			
114	- on different weekdays			X	X				X				O		R			X			
	The following principles are agreed upon between surgeons and used for allocating OR sessions to specific surgeons:														R						
115	- waiting list per surgeon		X		X				X						R	X		X			
116	- proportionate allocation based on the number of working hours per surgeon					X									R	X		X			
117	- an agreed distribution of outpatient, treatment and surgery activities among the surgeons within one medical discpline				X										R	X		X			
118	- even distribution accross sub-specialties			X											R	X		X			
119	- the way night and weekend shifts are allocated to surgeons.				X										R	X		X			
120	If a surgeon operates extra hours, the extra time is returned to the surgeon.						X								R			X			
121	After a night shift the surgeon has a day off work.				X										R			X			
	Surgeons are scheduled for:																				
122	- a full day (two OR sessions)		X					X	X	X	X	X	O		R			X			
123	- half a day (one OR session)		X		X	X	X						O		R			X			
124	- both full and half days.			X					X				O		R			X			
125	In reduction weeks, sessions are either distributed accross available surgeons or all surgery activities are put on hold, if all surgeons are on leave at the same time.		X	X	X	X	X	X	X	X	X	X	O		R	X					
126	Each medical specialty has its own agreements on who is allowed to take leave when.		X	X	X	X	X	X	X	X	X	X	O		R	X					
	The schedule is made by an agent who is part of an outpatient department and who is the point of contact for discussion on the schedule. This can be:														R						
127	- one surgeon			X	X	X	X	X		X	X	X			R	X		X			
128	- the outpatient secretary								X						R	X		X			
129	- an outpatient nurse.		X												R	X		X			
130	For trauma patients, surgeons are scheduled on fixed days: every Tuesday afternoon and one weekend per month.			X					X						R			X			
131	Orthopedic surgeons who work quickly, are not scheduled on Mondays because of the number of available beds on Monday.								X						R	X		X			
132	Shifts are evenly distributed accross all surgeons, independent of the number of working hours.				X								O		R	X		X			
133	In case surgeons perform surgeries together with another surgeon, dentist or orthodontist, the schedule is set in consultation between these practitioners.		X	X			X			X					R	X		X			
134	Every day there has to be at least one surgeon available for doing breast cancer surgery; therefore they can never all take leave at the same time.			X											R	X		X			
135	Schedules for assistant surgeons are not made by the scheduler; they make their own schedule for participating in surgeries.			X											R	X		X			
136	Complex lung surgeries are performed by two surgeons and therefore these surgeons never take leave at the same time.			X											R	X		X			
137	Every day at least one surgeon from every sub-specialty - Vascular Surgery, Trauma Surgery or Oncology - must be available.			X									O		R	X		X			
138	The surgeon looks one week ahead to see what he is going to do.			X											R			X			

Tasks 6 and 11: Plan patient and control planning

Task description

6) The planning for surgeries takes place at one of the nine outpatient clinics. The secretary puts the patient on the waiting list or sets a surgery date right away. There can be interaction between secretaries and the OTC capacity planner on specific surgery requirements or when the OR master schedule is almost filled. Surgeons also email or phone the OTC capacity planner for specific patient cases that require tuning.

11) The planning is checked and revised in the process leading to surgery. The preoperative secretaries interact with all outpatient secretaries on whether everything is arranged for the surgery. In the weekly 'Tuesday morning' meeting, the planning for the upcoming week is discussed among the outpatient secretaries, the ward team leaders and the OTC capacity planner. Also, a weekly bed meeting takes place between ward team leaders, a nurse and the OTC capacity planner. All checks for the next day's OR program are made in this meeting. The OTC capacity planner views the daily OTC schedule the day before to determine the exact sequence of the operations. When everything is checked, she informs the OTC day coordinator regarding any specific details in the next day's OTC program.

Time horizon

6) 6 days to 20 weeks ahead
11) 1 day to 2 weeks ahead

Frequency

6) Daily
11) Daily

Interactions

	Number of agents involved	OTC capacity planner	Preoperative secretary	Clinical bed planner	Ward team leader	Surgeon General Surgery	Outpatient secretary General Surgery	Surgeon Orthopedic Surgery	Outpatient secretary Orthopedic Surgery	Surgeon Dental Surgery	Outpatient nurse Dental Surgery	Surgeon Eye Surgery	Outpatient secretary Eye Surgery	Surgeon Gynecology	Outpatient secretary Gynecology	Surgeon Plastic Surgery	Outpatient secretary Plastic Surgery	Surgeon ENT	Outpatient secretary ENT	Surgeon Urology	Outpatient secretary Urology	Surgeon Neurosurgery	Outpatient secretary Neurosurgery	Daycare nurse
OTC capacity planner	1		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Preoperative secretary	4						X		X		X		X		X		X		X		X		X	
Clinical bed planner	1				X		X		X		X		X		X		X		X		X		X	
Ward team leader	3				X																			X
Surgeon General Surgery	15					X	X																	
Outpatient secretary General Surgery	6						X																	
Surgeon Orthopedic Surgery	4							X	X															
Outpatient secretary Orthopedic Surger	5								X															
Surgeon Dental Surgery	5									X	X													
Outpatient nurse Dental Surgery	2										X													
Surgeon Eye Surgery	4											X	X											
Outpatient secretary Eye Surgery	3												X											
Surgeon Gynecology	8													X	X									
Outpatient secretary Gynecology	3														X									
Surgeon Plastic Surgery	2															X	X							
Outpatient secretary Plastic Surgery	5																X							
Surgeon ENT	4																	X	X					
Outpatient secretary ENT	5																		X					
Surgeon Urology	5																			X	X			
Outpatient secretary Urology	4																				X			
Surgeon Neurosurgery	1																					X	X	
Outpatient secretary Neurosurgery	1																						X	
Daycare nurse	10																							

Rules for task performance

Rule #	Rule	Hospital-wide or local											Information carrier (R = Rule/O = Output)			Coordination mechanism					
		Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Definition of surgeries																					
139	A surgery type is defined by a surgery code and surgery name.	X											R	O	R				X		
140	Each surgery type is allocated to one of nine medical specialties, with the exception of trauma surgeries.	X											R	O	R				X		
141	Surgery codes of a medical specialty can only be registered in the HIS in sessions allocated to that medical specialty.	X												O	R			X			
142	For surgeries that are not defined in a surgery code, the code 'Miscellaneous' is used.	X												O	R				X		
143	The use of the code 'Miscellaneous' is not accepted by the OTC capacity planner.	X													R						X
144	Emergency surgeries are scheduled in HIS without a surgery code.	X													R			X			
145	No elective surgeries are allowed to be scheduled in the emergency OR sessions, although in the HIS this is possible. Elective surgeries can be scheduled in emergency OR sessions when this is agreed upon.	X											R		R	X		X			
146	Emergency surgeries are registered into the emergency OR sessions, even when the time of surgery does not lie within the time frame of the OR session.	X												O	R			X			
Required resources																					
147	Specified surgery types can only performed by specific surgeons, based on what skills are required.		X	X	X	X	X	X	X	X	X		R		R					X	
148	Surgery types are performed by specific surgeons based on their personal preference.		X	X	X	X	X	X	X	X	X				R	X					
149	Specified surgery types can only performed by two surgeons within the same medical specialty, which is based on what skills are required.		X	X	X	X	X	X	X	X	X		R		R					X	
150	Specified surgery types can only performed by two surgeons of two different medical specialties, based what skills are required.		X	X						X			R		R					X	
151	Specified surgery types require specific medical instruments, equipment, accessories and/or materials with limited availability.		X	X		X		X	X	X	X		R	R	R			X			
152	Specified surgery types require experts with specific skills or knowledge, either from another hospital department (e.g. Radiology) or from an external firm (e.g. for assisting with medical instruments).			X					X	X			R	R	R					X	
153	Resource related rules are registerered in the HIS per surgery code and are shown when a patient is planned for that surgery type.	X											R	O	R			X			
154	The HIS provides a signal in case more medical instruments of one sort are required than what is available.	X												O	R			X			
155	For surgeries a 'first responsible' OR nurse, who is specialized in a medical specialty through training, is required.	X											R		R					X	
156	For specified surgeries the required equipment is operated by a Radiology staff member, except when a surgeon is capable of doing this himself, as a result of trained skills.			X										O	R					X	
157	For surgeries two OR nurses are required from the OR nurses cluster to which a medical specialty belongs. A nurse cluster is based on trained skills of nurses.	X											O		R					X	
Demand management																					
158	Each medical specialty has its own way of managing demand.	X													R	X					
159	Surgeries and resources are scheduled in relation to the first available surgeon.		X	X		X			X	X	X			O	R	X		X			
160	Surgeries and resources are scheduled with the intention of filling OR sessions.			X	X		X	X	X						R			X	X		
161	The maximum number of weeks on the waiting list is defined and used for planning.										X				R			X	X		
162	The maximum number of weeks on the waiting list is not defined nor used for planning.		X		X	X		X			X				R	X		X			
163	Resources are mostly fixed and determine how many surgeries are performed, independent of demand.		X					X							R	X			X		
164	If there is a population screening for breast cancer in the region, then OR sessions are reserved for these patients.			X											R	X					

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Schedule surgeries																					
165	Each medical specialty has its own way of scheduling surgeries.	X													R	X					
166	The surgeon or outpatient secretary schedules the surgery.	X												O	R	X					
167	The outpatient secretary initially schedules the surgery on paper, e.g. in a book, diary or ticket folder, and at a later stage, in the OR sessions in the HIS.		X	X	X	X	X	X	X	X	X		O	O	R			X			
168	Surgeries can be scheduled until the OR session is filled to a maximum of 105%.	X												O	R			X			
169	Each OR session consists of surgery time and turnover time.	X												O	R				X		
170	Standard turnover time is 10 minutes.	X												O	R				X		
171	For Eye Surgery turnover time is 5 minutes.						X							O	R				X		
172	For ENT sessions in which children are operated turnover time is 6 minutes.					X								O	R				X		
173	A predefined number of surgeries per surgeon can be performed within one session.						X							O	R				X		
174	Specified surgery types can be performed only at a maximum of specified times per OR session, based on either the surgeon's capacity or preference, the number of available medical instruments, the available number of beds or as a result of hospital policy with regard to children (a maximum number of children in surgery per day).						X		X		X		R	R	R			X			
175	A surgery date is set after the preoperative screening has taken place and the anesthesiologist has approved of the surgery.	X											R		R			X			
176	A surgery date is set when the surgeon and patient decide upon the surgery, before the preoperative screening takes place.					X				X	X		O		R			X			
177	A surgery date is set when the insurance company or patient has given an approval.									X								X			
178	Emergency surgeries are planned in elective OR sessions, when the surgery needs to be performed within two weeks.			X										O	R			X			
179	OR sessions labelled as emergency sessions are intended for emergency patients who entered the hospital on the same day.	X													R			X			
180	Emergency patients are allowed to be scheduled only by consultation with the OTC day coordinator.	X													R	X		X			
181	Elective surgeries are planned at the last possible moment, when no (more) emergency patients are expected to arrive. Elective surgeries fill any gaps in the available OR sessions.			X											R	X		X			
182	Surgeries can be planned in the HIS 2 quarters ahead at the latest. Surgeries that are planned later are planned outside the HIS, i.e. in a book, paper diary or on a whiteboard.		X				X			X					R			X			
183	The patient is operated on by the surgeon who has set the diagnosis, except in cases where the timing of the surgery is essential, for surgeries in OR 8 and 9 and when the surgeon indicates otherwise and the patient agrees.		X	X	X	X	X	X	X	X	X				R	X		X			
184	The assistant surgeon performs the surgery after consultation with the patient and/or the surgeon involved.			X											R	X		X			
185	MRSA-infected patients are planned in consultation with the OTC capacity planner.	X													R	X					
186	A maximum of one MRSA-infected patient is allowed in the OTC on one day.	X													R			X			
187	Patients who weigh over 150 kilograms who are operated on OR 8 or 9 require an OR table, instead of a chair.	X													R			X			
188	Orthopedics schedules 20 prosthesis surgeries every week, 4 per day.								X						R				X		
189	Three gallbladder surgeries are planned for each Friday.			X											R				X		
190	Four sentinel node surgeries are peformed on Mondays, after scintygraphy has taken place.			X											R				X		
191	For revisions, surgery is planned as soon as the delivery date of the required materials is known.								X						R	X		X			
192	Eye surgeries for two eyes need to be performed using one and the same surgical technique and by the same surgeon.						X								R			X			
193	A maximum of three patients who require intensive care in the ICU are allowed in one day on the OTC program. During reduction weeks, the maximum is two patients.	X													R			X	X		
194	If the anesthesiologist has not approved the surgery two days before surgery, the surgery date needs to be rescheduled.	X													R	X		X			
195	For prosthesis surgery no staff replacement is allowed during surgery.								X	X					R			X			
196	Each anesthesiologist serves two ORs on one day.	X													R			X			
197	For surgeries on children one anesthesiologist serves one OR.	X													R			X			
198	Surgeries taking place in OR 8 and in OR 9 each require the supervision of one anesthesiologist.	X													R			X			
199	The X-ray equipment is available primarily for Neurosurgery on Wednesdays.	X													R	X		X			
200	When a surgeon is unexpectedly absent, surgeries are cancelled and outpatient activities are prioritized.						X				X				R	X		X			

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Surgery timing																					
201	The surgery date is planned in accordance with the patient's preference.		X	X	X	X	X	X	X	X	X				R	X					
202	Patients who use blood thinners have to be planned for a specific day at least five days ahead.	X													R			X			
203	Specified surgery types need to be performed within days after the diagnosis is set, according to guidelines.		X	X	X	X				X	X		R		R				X		
204	A patient surgery is planned on the first date that any surgeon is available.			X	X	X		X		X	X				R	X		X			
205	The patient's surgery is planned for the first date that the surgeon who made the diagnosis is available.			X	X	X		X		X	X				R	X		X			
206	Surgeries are performed as soon as possible in one of three hospitals within a regional network collaborative.			X											R	X		X			
207	The timing of specified surgery types depends on the menstrual cycle of the patient.				X								R		R	X		X			
208	Surgeries, for which specific equipment with limited availability is required (e.g. gammaprobe, lonestar, saw, drill) cannot be performed at the same time and/or at a specified maximum number of times a day.	X											R		R			X	X		
209	The surgery for patients who have had a miscarriage are planned as soon as possible.				X										R	X		X			
210	Patients in a dental treatment process are operated as soon as the braces are removed.		X												R	X		X			
211	When surgery on two eyes must be performed at different times, there must be four weeks between the first and the second surgery.						X						R		R			X			
212	Surgeries for which Radiology is required are not planned before 8:30 am because the Radiology Department starts working at 8:30 am.	X											R		R			X			
213	When a different medical specialty uses the afternoon OR session, the medical specialty using the morning session has to be finished strictly at 12:30 pm.	X													R			X			
214	Patients undergoing specified surgery types need be researched or prepared before surgery can take place (e.g. dental imprints, scintigraphy, urine or blood tests etc.). This has to be accounted for when scheduling the surgery.		X	X			X				X		R		R			X			
215	Patients should be admitted to the hospital at least two hours before surgery.	X											R		R			X			
216	Patients receiving a block should be admitted to the hospital at least two and a half hours before surgery.	X													R			X			
217	Children should be admitted to the hospital at least 1 hour before surgery.	X													R			X			
Surgery time																					
218	The surgery time is proposed by the HIS and is based on the last 25 times that the specific surgeon has performed this surgery type.	X												R					X		
219	The proposed surgery time may be changed by the surgeon or outpatient secretary.	X												O	R	X					
220	The surgery time depends on the surgical technique, anesthesia method, what is to be done in the surgery (e.g. one eye/two eyes, one finger/multiple fingers etc.) and the condition of the patient, the work pace of the surgeon.	X													R	X					
221	The surgical technique of individual surgeons may vary for one surgery type and this has to be accounted for when registering the surgery time.	X													R	X				X	
222	The anesthesia method impacts the surgery time.	X													R	X					
223	Anesthesia method depends on the surgeon who performs the surgery, the patient's preference and/or the anesthesiologist's orders.	X													R	X					
Order of surgeries																					
224	The order in which surgeries are planned is determined by the OTC capacity planner.	X													R			X			
225	For children, the order in which surgeries are planned is determined by the Pediatric Daycare.	X													R			X			
226	Surgeries of patients with diabetes are scheduled for early in the day.	X											R					X			
227	Patients who receive a block as anesthesia, are scheduled preferably after 9:30 am.	X											R			X		X			
228	Surgeries of children are scheduled for early in the day.	X											R					X			
229	MRSA-infected patients are scheduled for the end of the day.	X											R					X			
230	Lengthy surgeries are preferably scheduled for the start of the day and shorter surgeries at the end.	X											R			X		X			
231	Surgeries for which the patient's body is marked are not scheduled for early in the day.	X											R					X			
232	Patients who require intensive care are not scheduled as the first patients in the OTC program.	X											R					X			
233	Patients with a latex allergy are preferable scheduled for early in the day.	X											R			X		X			
234	Patients who require an INR value test are preferably not scheduled for early in the day.	X											R			X		X			
235	Oral diabetes patients are preferably scheduled for early in the day.	X											R			X		X			
236	Insuline diabetes patients have to be admitted before 8:30 am, not scheduled as a first patient, but later in the morning.	X											R					X			
237	Ureterorenoscopy surgeries should be scheduled from 9:30 am, in case an X-ray has to be made.	X											R					X			
238	Sentinel node procedures are scheduled in the morning, apart from the sentinel node surgeries in OR 8 and 9.	X											R					X			
239	Patients with contact isolation are preferably scheduled for the end of the day.	X											R			X		X			
240	Carotis procedures are not scheduled for the start of the day.	X											R					X			
241	Small standard surgeries are scheduled between the morning and afternoon session in order to control variation for the entire day program.	X													R			X			

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Finalise OTC program																					
242	There is a weekly meeting between the OTC capacity planner, the outpatient secretaries and the nursing ward team leaders on the planning for the upcoming week.	X											R			X		X			
243	OR sessions are closed on Thursdays before 9:30 am for the upcoming week, which means that after that no surgeries can be scheduled for that week.	X												O	R			X			
244	When the OTC program is closed the following checks are made by the OTC capacity planner: Are surgery times well planned and realistic? Is the OR session filled sufficiently? How many IC patients are on the program? Did the anesthesiologist approve the surgery in the preoperative screening? Is Radiology required for the surgeries and can this be handled by one Radiology staff member? Are there enough available medical instruments for all surgeries planned? Are there enough available Storz endoscope for all surgeries planned? Are surgeries planned in the right OR? Are there any patient specifics indicated by anesthesiologists that need to be accounted for the order of surgeries? Are patients planned at the right time of day? Is the patient admission time correct? Is there a bed reservation?	X											R					X			

Tasks 14,15,17,20,21 and 22: Prepare patient on ward, holding, perform surgery and aftercare on recovery and nursing ward, control OTC program

Task description	14)	The patient is admitted to one of the nursing wards. The nurse anesthetist then calls the nurse to indicate that premedication should be given to the patient, mostly two hours before the expected starting time of the surgery. The nurse anesthetist makes a second call to the nurse to say that the patient is to be taken to holding area.
	15)	The ward nurse hands the patient over to one of the holding nurses. The holding nurse prepares the patient for surgery. When it is time to go to the OR, the nurse anesthetist enters the holding area and the holding nurse hands the patient over to the nurse anesthetist.
	17)	The nurse anesthetist mentions any relevant details about the patient to the rest of the OR team. The anesthesiologist administers anesthetics prior to the surgery and leaves once the patient is asleep. The surgery is performed by the surgeon, assisted by the OR nurses. The nurse anesthetist monitors the patient and calls the anesthesiologist if necessary.
	20)	After surgery the patient is transferred to recovery by the nurse anesthetist. The transfer is performed between the nurse anesthetist and the recovery nurse. The recovery nurses interact with the anesthesiologists regarding the medication policy if necessary.
	22)	There are several tasks, performed at various moments in time, making sure that the surgeries that are scheduled for one day are performed well and on time. There is daily start of day meeting between the OTC day coordinator and the three OTC team leaders, in which expectations and special surgeries are discussed. During the course of the day the OTC day coordinator monitors the progress of each OR. The OTC day coordinator communicates with the anesthesiologist or surgeons about any alterations required in the OR scheme.
Time horizon	All tasks)	Day of surgery
Frequency	All tasks)	Daily

Interactions

	Number of agents involved	Anesthesiologist	Nurse anesthetist	Assistant surgeon	Holding nurse	OTC capacity planner	OTC day coordinator	OR nurse	OTC secretary	OTC team leader	Outpatient secretary	Recovery nurse	Surgeon	Ward nurse	Ward team leader
Anesthesiologist	12	X	X	X			X	X				X	X		
Nurse anesthetist	19		X	X	X		X	X				X	X	X	
Assistant surgeon	14							X					X		
Holding nurse	4				X									X	
OTC capacity planner	1						X								X
OTC day coordinator	1							X	X	X	X	X	X		
OR nurse	51							X					X		
OTC secretary	1														
OTC team leader	3									X					
Outpatient secretary	34														
Recovery nurse	10											X		X	
Surgeon	48													X	
Ward nurse	288													X	X
Ward team leader	3														X

Rules for task performance

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Time Out Procedure																					
245	Each step in the patient process is performed according to the Time Out Procedure (TOP). In the TOP standard procedures and required outcomes are specified in order for the patient to proceed to the next (sub)process.	X												R				X	X		
246	Approval of surgeon	X												R				X	X		
247	Nurse intake	X												R				X	X		
248	Approval of anesthesiologist	X												R				X	X		
249	Release OTC planning	X												R				X	X		
250	Admission to nursing department	X												R				X	X		
251	Sign in part 1	X												R				X	X		
252	Sign in part 2	X												R				X	X		
253	Pre-time out procedure in recovery	X												R				X	X		
254	Time out in the Operating Room	X												R				X	X		
255	Sign out in the Operating Room	X												R				X	X		
256	Sign in at recovery	X												R				X	X		
257	Check out of recovery	X												R				X	X		
258	Checklist in nursing department by surgeon	X												R				X	X		
259	Checklist in nursing department by nurse.	X												R				X	X		
260	In the TOP for each step, all requirements that need to be met and checks that need to be performed are specified.	X												R				X	X		
Prepare the patient on the ward																					
261	The ward nurse prepares the patient for the holding area and makes sure that the patient is ready on time.	X													R			X	X		
262	Ward nurses are allocated to specific rooms of patients.		X												R			X			
263	Patients who receive a block go to the recovery area and not to holding.	X											R					X			
264	The ward nurse who takes the patient to the holding performs the TOP procedure with a holding nurse.	X												O	R			X			
265	Emergency patients are admitted to the Acute Admissions Department.	X													R			X			
266	If a patient in the Emergency Department is operated on within half an hour, then the patient goes directly from the Emergency Department to the OTC.	X													R	X		X			
267	The nurse anesthetist tells the ward nurse when to administer premedication with the patient.	X													R	X		X			
268	The nurse anesthetist tells the ward nurse when to take the patient to the OTC.	X													R	X		X			
269	Ward nurses serve each other's patients when this supports the flow of patients.		X												R	X					
270	Ward nurses ask another ward nurse to check the medication that they administer to the patient.	X													R	X		X			
271	If blood needs to be taken from the patient before surgery, the patient is sent to the lab. When the patient is not in a well enough state, the lab technician is asked to come to the nursing ward.		X												R	X		X			
Prepare the patient in the holding																					
272	The holding nurse prepares the patient for surgery and makes sure that the patient is ready on time.	X													R				X		
273	Holding nurses insert patients with puncture drips, except when it is busy. Then this is done by the nurse anesthetist.			X											R	X			X		
274	Nursing staff from outside the holding assist holding nurses at the start of the day, when it is busy.			X											R	X					
275	There are standard procedures for preparing equipment, materials and medication.			X									R					X			
276	There are standard procedures per anesthesia method on what patients are allowed to wear, e.g. glasses, make-up etc.	X											R						X		
277	The nurse anesthetist who takes the patient from the holding area to the OR performs the TOP procedure with a holding nurse.	X													R			X			
278	The nurse anesthetist stays with the patient from holding to recovery.	X													R			X			
Perform surgery																					
279	The surgeon is responsible for the surgery and determines when to start and end with the surgery.	X													R					X	
280	The anesthesiologist is responsible for the anesthesia and determines when to start and end anesthesia and any medication during the surgery.	X													R					X	
281	The OR nurse assists the surgeon.	X													R					X	
282	The nurse anesthetist assists the anesthesiologist and is responsible for monitoring the patient during surgery, informing the anesthesiologist on this.	X													R	X				X	
283	All checks of the TOP are performed with all members of the operating team and the patient.	X												R		X		X	X		
284	In case x-ray photos are taken during surgery, the OTC day coordinator or OTC secretary asks the Radiology Department to send someone to the OTC.					X									R	X					

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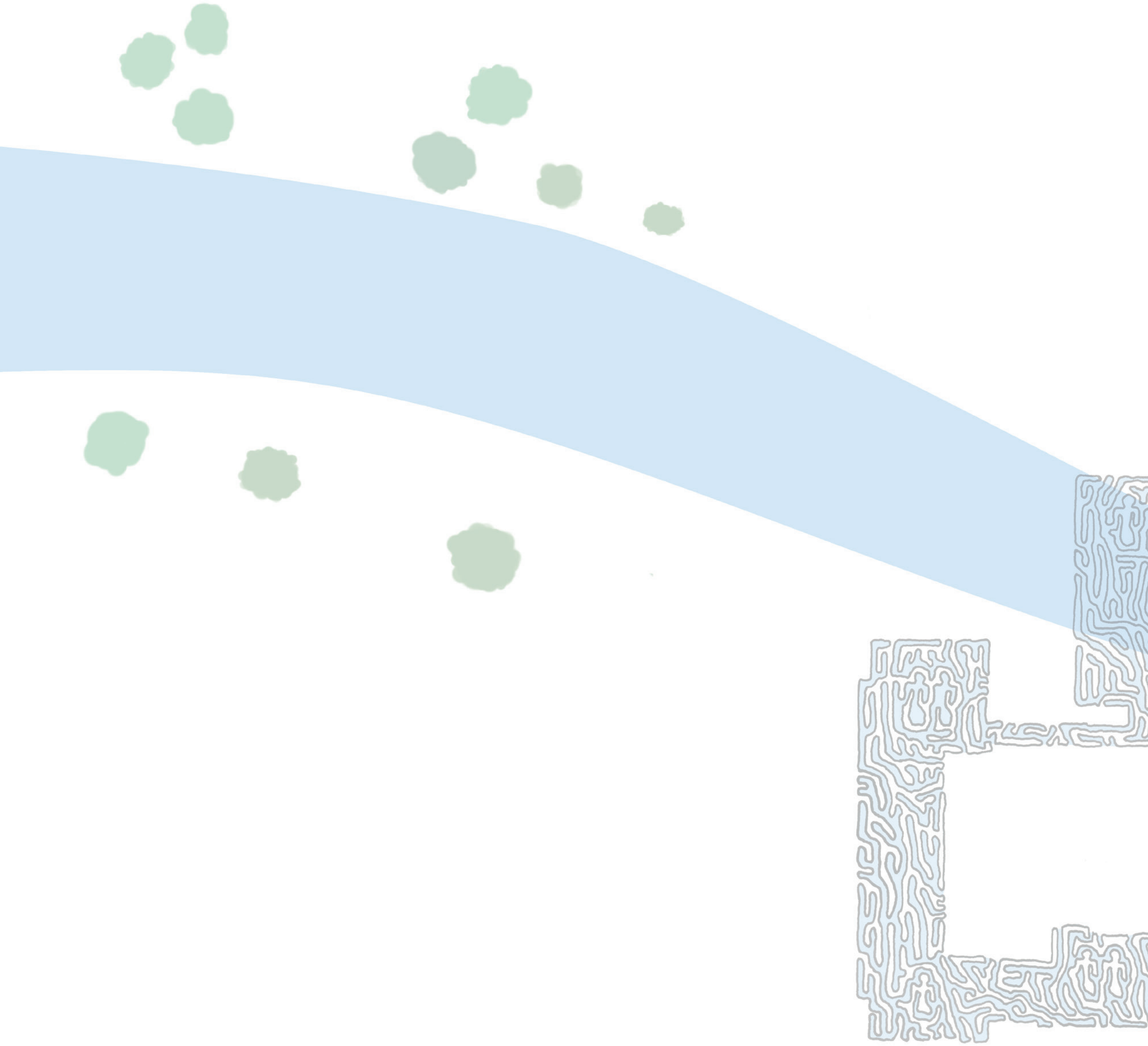
Patient care recovery																					
285	The nurse anesthetist who takes the patient to recovery performs the TOP procedure with a recovery nu	X												R		X		X	X		
286	The recovery nurse prepares the patient for transfer to the nursing department and makes sure that the recovery area does not get crowded.	X													R	X		X	X		
287	The ward nurse that takes the patient to the nursing department performs the TOP procedure with a recovery nurse.	X												R		X		X	X		
288	The patient is transferred to the nursing ward when all required PAR-scores are met.	X												O	R	X		X	X		
289	Two recovery beds are allocated to specific recovery nurses for the day.						X								R			X			
290	If a recovery nurse has few patients to care for, then the first entering patient is allocated to that nurse, if she desires. Patients are distributed equally.						X								R	X					
291	In case PAR scores suggest that more medication is required, the recovery nurse consults with an anesthesiologist.	X											R		R	X			X		
292	Recovery nurses have to ask another recovery nurse to check the medication that they administer with the patient.	X													R	X		X			
293	The recovery area closes at 6:00 pm.	X													R			X			
294	In case surgeries run late, patients go directly to the Intensive Care Department.	X													R	X		X			
295	In case x-ray photos are taken during surgery, a recovery nurse asks the Radiology Department to send someone to come to the recovery.	X													R	X					
Aftercare patient																					
296	The ward nurse prepares the patient for going home.	X													R			X	X		
297	The surgeon visits the patient and checks his or her condition, thereby informed by a ward nurse.	X													R	X					
298	The patient is discharged based on the checks as specified in the TOP procedure.	X												O	R			X	X		
Manage OTC day program																					
299	All surgeries have to be finished at 4 pm.	X													R			X			
300	No more than two operating rooms are allowed to finish late.	X													R				X		
301	If the OTC program is (possibly) running late, the OTC day coordinator consults with the anesthesiologist on changing the OTC program, e.g. regarding shifting or cancelling surgeries.	X													R	X					
302	If the OTC program is (possibly) running late, the anesthesiologist consults with the involved surgeon(s).	X													R	X					
303	On one day one anesthesiologist acts as point of contact for the OTC day coordinator.	X													R	X					
304	If the OTC program is (possibly) running late, the surgeon may decide to skip breaks.					X									R	X					
305	The OTC capacity planner monitors real time course of the OTC program and estimates whether any delays in surgeries impact the course of the OTC program as a whole.					X									R			X			
306	The OTC capacity planner monitors all potential factors that cause the OTC day program to run late, using rules such as:					X									R			X			
307	- OR sessions that are filled 105% may run late					X									R				X		
308	- Estimated surgery time is (un)reliable depending on the medical discipline or surgeon who scheduled the surgery					X									R				X		
309	- Large complex surgeries that are on the OTC program in the afternoon increase probability of lateness					X									R				X		
310	- Surgery time of 31 minutes is unreliable because this is the default surgery time as set by the HIS					X									R				X		
311	- If the time planned for anesthesia with blocks is too low, there is possible delay					X									R				X		
312	- If preoperative screening has not been performed, then the surgery may have to be postponed					X									R			X			
313	- Specific issues related to the condition of the patient may cause surgeries to take more time than the scheduled surgery time.					X									R				X		
314	Every day there is a clinical bed meeting with the OTC capacity planner and the team leaders of the nursing wards to discuss today's bed allocation.	X											R			X		X			



CHAPTER 5

EVALUATING CHANGES IN INTEGRATION, DIFFERENTIATION, RULES, COORDINATION AND PERFORMANCE FOLLOWING THE INTRODUCTION OF A HOSPITAL PLANNING CENTRE: A CASE STUDY

Annelies van der Ham, Arno van Raak, Dirk Ruwaard, Frits van Merode

Submitted

ABSTRACT

Purpose

This study evaluates changes in a hospital with regard to integration, i.e. the coordination and alignment of tasks - and differentiation, i.e. the extent to which tasks are segmented into subsystems, rules and coordination mechanisms - and hospital performance following the introduction of a Hospital Planning Centre (HPC).

Design/methodology/approach

A case study was conducted in which a hospital's social network, rules, coordination mechanisms and performance were studied both before and after the HPC was introduced. All planning and execution tasks for surgery patients were studied, using a naturalistic inquiry and mixed method approach.

Findings

Following the introduction of the HPC, bed utilization increased with peak utilization of beds and operating rooms decreasing, increases in the waiting list, in cancellations and in variability. More integration was observed for specific planning tasks, but not for the hospital network as a whole. Differentiation based on medical discipline remained. More hospital-wide and fewer local rules exist and these have remained largely undocumented, i.e. in people's minds. Coordination mechanisms both before and after the introduction of the HPC are mainly mutual adjustment and standardization of work. For performance enhancement, the authors propose system-wide horizontal coordination that includes collective learning and information sharing.

Originality

This exploratory study describes how a hospital network's structure, rules, coordination mechanisms and performance change following the introduction of a HPC. The findings are important for future research on enhancing hospital performance.

INTRODUCTION

Integration in organizations, i.e. the coordination and alignment of tasks, is widely promoted in order to improve hospital performance[1-3]. There is consensus that concepts such as supply chain management, lean strategies and other operations management theories can contribute to the improvement of hospital performance[4-10]. This is considered important to meet a broadly felt need to improve the quality, accessibility and affordability of healthcare systems[5] and of hospitals in particular, given the fact that hospitals are a major cost item in the healthcare system[11].

A previous scoping study[12] showed that research on logistics and operations in hospitals is fragmented. Studies typically focus on one or two logistical parameters, specific logistical flows (patients, material or staff) or on specific departments, but not on the hospital as a whole. This may be problematic, as Ludwig et al.[8] found evidence that in well-performing hospitals, departments cooperate for the benefit of the hospital's efficiency, while efficient departments by themselves do not necessarily contribute to the overall efficiency of the hospital.

Lawrence and Lorsch[13] state that not only is integration important, but also that differentiation is essential in order for integration to be effective. They define integration as 'achieving unity of effort among the various subsystems in the accomplishment of the organization's task'[13]. Differentiation refers to 'the state of segmentation of the organizational system into subsystems'[13]. From this perspective, well-performing hospitals in which departments cooperate well are likely to have the right degree of integration as well as differentiation in place.

In previous case studies integration and differentiation were investigated in a hospital[14-15]. These case studies showed that tasks are performed mainly across functional silos and that nurses, physicians and coordinators perform integrative tasks. In addition, rules that are used by agents exist predominantly in people's minds. Coordination mainly takes place through mutual adjustment and local standardization of work, as defined by Mintzberg[16]. Long-term schedules for surgeries create open loops[17], as resources and patients are not scheduled based on actual or future patient demand, potentially causing the system to become unstable. As the surgery date approaches, several agents in the hospital try to close these loops through mutual adjustment, thereby stabilizing the hospital system.

In our case studies, the observed ways of working seem to have emerged as a result of an individual agent's action rather than from an explicit organizational design. Central agents coordinate tasks without having a formal hierarchical position towards others and their actions are based mostly on undocumented working procedures. In line with Ren et al.[18], the way of working observed may result in vulnerability and potential instability in the hospital's performance, leading to critical events. The hospital where our case studies took place, Slingeland Hospital in the Netherlands, had similar concerns, and decided in 2019 to change the way in which surgeries are planned. Since 1 June 2019 a Hospital Planning Centre (HPC) has been responsible for planning surgeries and beds for surgery patients. Before 1 June 2019 surgeries were planned by secretaries in outpatient departments, which are differentiated according to medical disciplines.

Understanding how a hospital's logistical system works in practice is a first and necessary step towards improving the way hospitals function. This organizational change provides us with the opportunity to explore further how integration, differentiation and coordination mechanisms relate to hospital performance. A most obvious and highly relevant question is whether the introduction of the HPC improved the hospital's performance. As suggested by Van der Ham et al.[15], creating redundancy in the network may increase the robustness of the hospital, in which case interaction patterns and the related information processing will have changed. In line with Galbraith[19], who relates integration to the information processing capacity of an organization, the introduction of the HPC may have changed the degree of integration, differentiation, and the performance of the hospital. On the other hand, as stated by Van der Ham et al.[15], any intervention may also destabilize the hospital, in which case the performance also changes, but not for the better.

Accordingly, our aim is to evaluate whether the hospital's social network structure, coordination mechanisms and performance have changed following introduction of the HPC. There are three research questions:

1. Did the hospital's network structure, i.e. integration and differentiation, change following the introduction of the HPC and if so, in what way?
2. Did the rules and coordination mechanisms that explain the network structure change following the introduction of the HPC and if so, in what way?
3. Can changes in the system's performance be observed following the introduction of the HPC?

METHODS

Setting

This study is the third case study in Slingeland Hospital, which is situated in Doetinchem in the Netherlands. Slingeland Hospital was selected for the previous two case studies because of its relatively small size, highly rated performance[20] and stable environment. Slingeland Hospital has around 1,600 staff members and 120 physicians. It services around 200,000 people in the area and has 350 beds, which is below the average number of 450 beds for Dutch hospitals[21].

In 2018 Slingeland Hospital set up the 'Integral Capacity Management' (ICM) program. This program envisages the integral design, planning, management and safeguarding of all care-related critical capacities, i.e. time, people, space, and resources, in order to achieve the desired quality, efficiency and service levels[22]. In accord with this program the HPC started on 1 June 2019, and is ongoing. The HPC was a new department, with six central planners who are responsible for planning surgeries and beds for surgery patients. Five planners were former outpatient secretaries and one planner who had not previously worked for Slingeland Hospital was hired. Since July 2020 the ICM program has been converted to a more permanent form, the ICM department. The HPC is part of this department.

Not all surgeries are planned by the HPC. The HPC plans all elective and semi-urgent surgeries that are performed under general anesthesia. This excludes all eye surgeries and a part of the gynaecology surgeries, because these are often performed under local anesthesia. Urgent surgeries, which take place the same day, are planned by surgeons and secretaries of the outpatient departments, in direct contact with the Operating Theatre Complex (OTC).

Design

This study was designed to compare the network structure, the rules, coordination mechanisms and performance before and after the HPC was introduced. The before period was defined from 1 June 2018 to 13 March 2019 and the after period from 1 June 2019 to 13 March 2020. The date of 13 March was selected because from 13 March 2020 all but the most urgent surgeries were cancelled due to the Covid-19 pandemic. By choosing that date we exclude any potential impact of the pandemic from this study. In this paper we will refer to the two periods as the before period and the after period.

In order to be able to compare the before period with the after period, the study design for the third case study is largely the same as for the previous two case studies. The main methods and concepts of the two previous case studies[14-15] are summarized below.

The study design for both previous case studies was based on the case study research method devised by Yin[23] and a naturalistic inquiry approach as described by Beuving and De Vries[24] was followed. Data were collected from multiple sources and then analysed through data triangulation following a mixed method approach. The study included all departments that contribute to either the intake, diagnosis, preparations, the surgery or the aftercare of surgery patients. In the second case study[15] there was a particular focus on planning tasks 1, 2, 3, 6, and 11, and tasks related to coordinating the execution of surgery and the preparations and aftercare that surgery involves, these being tasks 14, 15, 17, 20, 21 and 22 (Figure 5.1).

Integration and differentiation were described using social network analysis to analyse the network structure in the first case study[14]. All interactions that agents have for performing tasks (Figure 5.1) were identified, registered in an Excel database per task and then inserted in NodeXL[25]. Specific measures of the social network that are related to integration and differentiation were analysed, both for the entire network and per task. Density, degree, betweenness centrality and clique overlap were used as indications for integration. A clique exists when all agents in a group are connected. There is clique overlap when agents are part of more than one clique, thereby connecting different cliques. Cliques were looked at for identifying differentiation, as groups of highly connected agents may indicate a division of labour. These measures are presented in Table 5.1.

The coordination mechanisms and rules that were studied in the second case study[15] refer to the before period. The after period was analysed to determine whether a rule still exists or if any new rules were added, and abolished rules were registered. Coordination mechanisms were registered for each rule, based on Mintzberg[26], as presented in Table 5.1.

In addition the performance of the hospital was analysed for both the before and the after period. In summary, in this third case study all concepts as defined in Table 5.1 were studied for both the before and the after period, in order to evaluate changes following the introduction of the HPC.

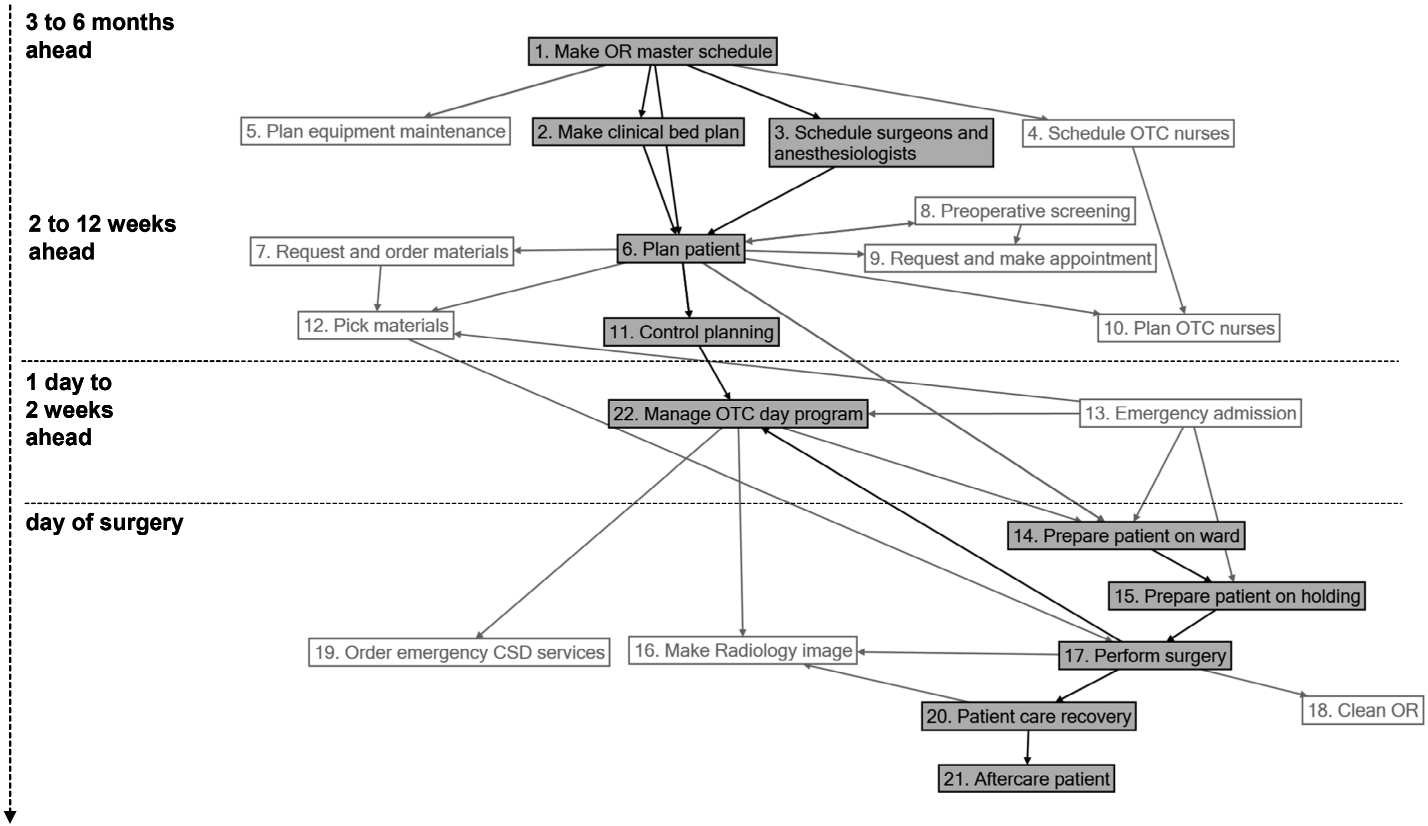


Figure 5.1 Tasks in scope (Van der Ham, 2021).

Table 5.1 Definition of concepts.

Concept	Definition
Integration	The coordination and alignment of tasks, thus achieving 'unity of effort among the various subsystems in the accomplishment of the organization's task'[13]
Differentiation	The 'state of segmentation of the organizational system into subsystems'[13]
Social network analysis	
Node	An agent
Tie	A communication link between two agents via email, text message, telephone or face-to-face.
Clique	A set of agents who are all connected to one another.
Density	The number of ties a set of agents has in relation to the number of possible ties they can have.
Clique overlap	The percentage of agents who are members of more than one clique for a specific task.
Degree	The number of ties of one agent.
Betweenness centrality	The number of times a node (agent) lies on the shortest path between other nodes (agents).
Rules and coordination mechanisms	
Rule	A defined, accepted or agreed way of performing tasks, which includes what is done, how it is done and what is allowed and what is not allowed.
Mutual adjustment	An agent interacts with other agents about a rule, i.e. what it entails or how to apply it in a specific situation or the application of the rule requires interaction.
Direct supervision	A rule is set and monitored by people with formal authority.
Standardization of work processes	Rules result from specified or programmed working processes.
Standardization of output	Rules include specified output in terms of predetermined standards for services or performance.
Standardization of skills	Rules include specified skills and knowledge.
Standardization of norms	Rules result from a common culture or ideology and specify norms for behaviour.
Performance indicators	
Patient inflow	The number of surgery orders within a specified period.
Number of surgeries	The number of surgical cases performed.
Number of elective/non-elective surgeries	The number of planned/(semi-)urgent surgeries.
Surgery time	The time between starting a surgery, i.e. when patient positioning and/or skin preparation starts, to when the surgery is completed.
Planned versus realized surgery time	The difference between realized and planned surgery time.
Overutilization operating room (OR)	The total number of operating room days that finished after 4 pm divided by the total number of regular operating room days on which elective surgeries took place.
Number of late operating rooms	The number of operating rooms that finish after 4 pm.
Cancellations	The number of cancelled surgeries.
Waiting list length	Average number of weeks necessary for operating on all patients on the waiting list, given the number of OR sessions allocated to a medical discipline.

Table 5.1 (continued)

Concept	Definition
OR session utilization	The total amount of time surgical patients are present in the OR, divided by the amount of allocated OR session time. An OR session is a time slot that is allocated to a specific medical discipline on a specific weekday and OR.
OR utilization	The total amount of time surgical patients are present in the OR during regular working hours between 8 am - 4 pm, divided by the total amount of OR time during these working hours (8 hours).
Bed utilization	The average number of beds used for a patient in a nursing department divided by the number of available beds.
Number of beds	The number of beds in the nursing departments.
Variability OR utilization	The degree to which OR utilization deviates from the average OR utilization.
Variability OR session utilization	The degree to which OR session utilization deviates from the average OR session utilization.
Variability bed utilization	The degree to which bed utilization deviates from the average bed utilization.
Variability waiting list length	The degree to which waiting list length deviates from the average waiting list length.

Data collection

Data were collected from four different sources: the Hospital Information System (HIS), documentation, observations and interviews. For the before period data were collected as described in the previous two case studies[14-15]. For the after period between June 2020 and October 2020 HIS data and documentation were collected specifically for this study. Observations and interviews took place between August 2020 and October 2020. Staff who were interviewed in the before period were also interviewed in the after period, as far as possible.

For the total study period between 1 June 2018 and 13 March 2020, HIS data include registrations of surgeries performed in 2018, 2019 and 2020, including date of surgery, resources involved, timestamps of different stages in the surgery patient's process, and in which nursing wards patients stayed before and after surgery. In total 72 documents were collected between 2018 and 2020, including project plans, management reports, planning schemes, working procedures, emails and internal presentations. Of 72 documents, 64 are dated in the before period and eight documents were made in the after period.

Planning and controlling activities were observed between 2018 and 2020 over 19 observation days. One observation day was in the after period and 18 in the before period, which includes four observation days between March 2019 and June 2019, when preparations for the HPC were made. The 19 observations took place, variously, in three outpatient departments, three nursing departments, the holding area, during three surgeries in the operating room (OR), in the recovery area, with the OTC day coordinator, in the preoperative screening department, during two planning meetings and twice at the workplace of two, at that moment in time, future central planners and at the HPC. During each observation, the activities of the hospital staff were observed and several unplanned informal conversations with staff took place, as they explained what tasks they performed. The sequence of events for each observation, together with relevant parts of the conversations, was reported in an observation report.

In the before period, between March 2018 and June 2019, 25 interviews were held with 23 different people. In the after period, between August 2020 and January 2021, 19 interviews were held with 19 different people. In total 14 people were interviewed in both the before and after periods. Two people were observed in the before period and interviewed in the after period. People who were interviewed only in the before period, were involved in tasks that are outside the scope of this study, but who were relevant to our earlier case study (Figure 5.1). People who were interviewed only in the after period were new to a function that was performed by another person in the before period. For each interview, a topic list was prepared, including questions on agents, interactions, rules, coordination and performance. All interviews were recorded and transcribed ad verbatim with the consent of the respondents.

Data analysis

The network structure, i.e. the agents and interactions between them, was constructed per task (Figure 5.1) in the same way as in the first case study[14]. The social network analysis that was based on data from 2017 and 2018[14] was updated to reflect the entire before period. For example, the number of agents involved in the tasks was updated. Then the social network was constructed for the after period. Measures for integration and differentiation were analysed for both the before and after period.

All 44 data sources for rules and coordination mechanisms for the after period, that is all documents, observations and interviews, were structured in five data matrices. One data matrix was constructed for each of tasks 1, 2 and 3; one data matrix was made for tasks 6 and 11, and another for tasks 14, 15, 17, 20, 21 and 22. For the before period, these five data matrices were constructed in the second case study, based on 94 qualitative sources.

We then analysed whether a rule still exists in the after period, whether it is applied hospital-wide or locally, i.e. within one particular department, group of people or by one person. Any new rules were added and abolished rules were registered. In addition, we analysed whether rules are registered (R) or the output of applying the rule is registered (O) in a document or in the HIS, and/or if this exists only in the mind of hospital staff. The coordination mechanisms[26] were registered for all rules in the after period, based on the definition of the coordination mechanisms as presented in Table 5.1.

The performance indicators that are mentioned in the 138 data sources of the before and after periods were then listed. Performance indicators that could be calculated on the basis of available HIS data were included in this study, as presented in Table 5.1. It was registered in which and how many sources each performance indicator was mentioned before the introduction of the HPC. In addition it was registered whether the indicator or desired changes were mentioned qualitatively or quantitatively. The value of these performance indicators was calculated for the before and after period.

A focus group session was held for validating the quantified performance indicators. The manager of the ICM Department, who was the OTC capacity planner in the before and the after period, and one central planner participated. In this session all performance indicators were validated, i.e. it was discussed whether the performance indicators reflect the performance in reality. The manager and central planner considered all performance indicators to be valid.

RESULTS

Network structure

The evaluation of the network structure following the introduction of the HPC shows that there is a decrease in the number of agents who are involved in the network. The number of agents went down from 526 to 514, as shown in Table 5.2. Table 5.3 shows that in the after period fewer OR nurses, secretaries and ward nurses participate in the network, and there is one less manager involved. On the other hand, the number of surgeons and/or surgeon assistants increased and six central planners were added.

Table 5.2 Network parameters overall network in the before and after period

Network Parameter	Before 1 June 2019			After 1 June 2019			Change		
Number of agents		526			514			-2%	
Number of ties		32,002			31,703			-1%	
Density		0.23			0.24			4%	
Number of cliques		7,692			6,909			-10%	
Agent parameter	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest
Degree	1	122	411	2	124	402	100%	2%	-2%
Betweenness centrality	0	240	5,611	0	233	4,728	N/A	-3%	-16%

Further, the number of cliques went down from 7,692 to 6,909, a decrease of 10%. This change is attributed mainly to the fact that in the after period surgeries were performed more frequently by the same OR team. In the after period there were 5,881 unique OR teams, i.e. cliques, while in the before period there were 6,660, as shown in Table 5.4. Network parameters associated with integration, i.e. density, degree and betweenness centrality barely changed, as shown by Table 5.2.

Table 5.3 shows that there has been a change in the network position of managers. In the before period one cluster manager was also manager of the OTC and this latter position was taken over by an OTC team leader. The new OTC manager has a higher degree (25) and betweenness centrality (311) in the after period than the average degree (11) and centrality (4) for the cluster managers in the before period. Table A5.1.1 in Appendix 5.1 shows that the OTC manager has become involved with planning surgeries (task 6) whereas in the before period the cluster manager was not involved.

The position of the OTC capacity planner changed as well. In the after period her degree and centrality decreased by 78% and 88% respectively. Her formal position was OTC capacity planner until July 2020, but her network position and tasks changed earlier, i.e. during the after period. After the HPC was introduced, the OTC capacity planners' tasks shifted to the OTC manager and central planners. In addition, the centrality of the outpatient secretaries, surgeons, OTC team leaders and OTC day coordinator decreased substantially as a result of the HPC.

Central planners have taken a central position in the network with the fourth highest betweenness centrality. The OTC day coordinator is most central, followed by nurse anesthetists and recovery nurses. Their central position is explained mainly by the fact that on the day of surgery they interact with all agents who are involved in performing surgeries, i.e. OR nurses, nurse anesthetists, surgeons, anesthesiologists and ward nurses, who transfer patients from and to the OTC. In addition, the OTC day coordinator interacts with the central planners and outpatient secretaries for planning tasks on the day before a surgery takes place.

The neurosurgeon has the highest betweenness centrality both in the before and in the after period. This is explained by the fact that the neurosurgeon is the only surgeon who visits patients in nursing ward N1, because all other surgery patients stay in other nursing wards. Thus he is the only agent in the entire network who interacts with the nurses of nursing ward N1. As a result his network position is relatively central, as shown by Figure A5.2.1 in Appendix 5.2.

Table 5.3 Network metrics per role in the before and after period.

Role	Number of agents in network			Average degree			Average betweenness centrality		
	Before	After	Change	Before	After	Change	Before	After	Change
Anesthesiologist	12	12	0%	159	152	-4%	147	133	-10%
Central planner	N/A	6	N/A	N/A	90	N/A	N/A	686	N/A
Cluster manager	3	1	-67%	11	2	-82%	4	0	-100%
Holding nurse	4	4	0%	272	268	-2%	601	549	-9%
Nurse anesthetist	31	31	0%	372	372	0%	1,481	1,452	-2%
OR nurse	61	51	-16%	129	135	5%	41	44	7%
OTC capacity planner	1	1	0%	99	22	-78%	2,155	267	-88%
OTC day coordinator	3	3	0%	198	189	-5%	3,507	2,736	-22%
OTC manager	0	1	N/A	N/A	25	N/A	N/A	311	N/A
OTC team leader	11	11	0%	32	33	2%	111	13	-88%
Recovery nurse	10	10	0%	246	245	0%	1,949	1,937	-1%
Secretary	41	34	-17%	17	17	-3%	60	1	-99%
Surgeon or assistant surgeon	58	63	9%	148	132	-11%	432	360	-17%
Ward nurse	291	286	-2%	99	103	4%	44	46	5%

Table 5.4 Network metrics for each task.

Task	Number of agents			Number of ties			Density			Number of cliques			Clique overlap		
	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change
1 Make OR master schedule	28	14	-50%	110	82	-26%	0.3	0.9	209%	2	2	0%	6 21%	2 14%	-67%
2 Make clinical bed plan	4	9	125%	6	33	450%	1	0.9	-8%	1	3	200%	N/A N/A	6 67%	N/A
3 Schedule surgeons and anesthesiologists	65	60	-8%	195	218	12%	0.09	0.12	31%	9	9	0%	0 0%	0 0%	N/A
6 Plan patient	79	88	11%	315	715	127%	0.1	0.2	83%	42	50	19%	1 1%	6 7%	500%
# Control planning	54	15	-72%	224	75	-67%	0.2	0.7	356%	2	5	150%	3 6%	6 40%	100%
# Prepare patient on ward	280	278	-1%	12,109	11,914	-2%	0.3	0.3	0%	248	248	0%	31 11%	31 11%	0%
# Prepare patient in holding	282	277	-2%	1,071	1,054	-2%	0.03	0.03	2%	278	273	-2%	4 1%	4 1%	0%
# Perform surgery	162	157	-3%	8,653	8,183	-5%	0.7	0.7	1%	6,660	5,881	-12%	146 90%	147 94%	1%
# Patient care recovery	290	284	-2%	2,383	2,374	0%	0.06	0.06	4%	278	273	-2%	10 3%	10 4%	0%
# Aftercare of patient	383	386	1%	12,630	12,736	1%	0.2	0.2	-1%	171	176	3%	221 58%	222 58%	0%
# Manage OTC day program	201	187	-7%	600	555	-8%	0.03	0.03	7%	1	1	0%	N/A N/A	N/A N/A	N/A

Network structure per task

From the social networks per task (Appendix 5.2) and Table 5.4 one can see that the network structure for tasks 1, 2, 6 and 11 changed in the after period, with task 1 being performed by a denser network, with a density that increased from 0.3 to 0.9. Fewer agents (50%) are involved in the after period (Figure A5.2.2) because outpatient secretaries and two cluster managers are no longer involved in this task. Clique overlap decreased by 67%, which is explained by the fact that in the after period only two agents participate in multiple cliques instead of six, as in the before period.

For the clinical bed plan (task 2), the central planners take the lead in the after period, and they interact with nursing ward team leaders (Figure A5.2.3) Density decreases by 8% in the after period, as there are now three cliques instead of one.

For patient planning (task 6), density has increased by 83% and clique overlap has increased by 500%. Figure A5.2.5 in Appendix 5.2 shows that now six planners have connections with all surgeons and outpatient secretaries, instead of with one OTC capacity planner who coordinated planned surgeries. In addition, 72% fewer agents are involved in controlling the planning (task 11) in the after period, i.e. 15 instead of 54, increasing the density of the network from 0.2 to 0.7. In addition, the clique overlap increased from 6% to 40% for task 11.

For scheduling surgeons and anesthesiologists (task 3), there are ten networks that are not connected both in the before and in the after period, as shown by Figure A5.2.4 in Appendix 5.2. The density for task 3 increased by 31% because there are more surgeons than in the before period. All tasks performed on the day of surgery barely changed in terms of density and the number of cliques. Any changes were explained by changes in the number of involved agents. The number of cliques for performing surgeries (task 17) decreased by 12%, which means that there are fewer unique OR teams than in the before period.

Rules and coordination

Table 5.5 shows that after the introduction of the HPC the total number of rules decreased by 7%. Although there are 8% more rules that are applied hospital-wide, there are 38% less local rules. The decrease of local rules is largely attributed to tasks 6 and 11, for which local rules have gone down by 83%. Of 314 rules from the before period in total 63 rules (20%) changed in the after period.

Table 5.5 Rules and coordination mechanisms per task in the before and after period.

Task	Task description	Number of rules			Number of changed rules	Hospital-wide or local					
		Before	*After*	*Change*		*Before*		*After*		*Change*	
						Hospital-wide	Local	Hospital-wide	Local	Hospital-wide	Local
1	Make OR Master Schedule	53	51	-6%	23	48	5	47	4	-2%	- 20%
2	Make clinical bed plan	51	37	-27%	19	51	0	38	0	-25%	N/A
3	Schedule surgeons and anesthesiologists	34	34	0%	0	5	29	5	29	0%	0%
6 and 11	Plan patient and control planning	106	101	-5%	20	64	42	95	7	48%	-83%
14-22	Prepare patient on ward, prepare patient on holding, perform surgery, aftercare on recovery, aftercare on nursing ward, control OTC program	70	70	0%	1	51	19	51	19	0%	0%
Total		314	293	-7%	63	219	95	236	59	8%	-38%
%						70%	30%	81%	20%		

Table 5.5 (continued)

Task	Task description	Number of rules per information carrier											
		Before				*After*				*Change*			
		Document	HIS rule	HIS output	People's knowledge	Document	HIS rule	HIS output	People's knowledge	Document	HIS rule	HIS output	People's knowledge
1	Make OR Master Schedule	26	0	16	48	26	0	18	47	0%	N/A	13%	-2%
2	Make clinical bed plan	12	0	10	46	10	0	11	35	-17%	N/A	10%	-26%
3	Schedule surgeons and anesthesiologists	15	0	0	38	15	0	0	38	0%	N/A	N/A	0%
6 and 11	Plan patient and control planning	40	4	20	88	41	4	19	83	3%	0%	-5%	-6%
14-22	Prepare patient on ward, prepare patient on holding, perform surgery, aftercare on recovery, aftercare on nursing ward, control OTC program	5	19	3	47	5	19	3	47	0%	0%	0%	0%
Total		98	23	49	267	97	23	51	250	-1%	0%	4%	-7%
%		31%	7%	16%	85%	33%	8%	17%	85%				

Table 5.5 (continued)

Task	Task description	Coordination mechanism																	
		Before						After						Change					
		Mutual adjustment	Direct supervision	Standardization of work	Standardization of output	Standardization of skills	Standardization of norms	Mutual adjustment	Direct supervision	Standardization of work	Standardization of output	Standardization of skills	Standardization of norms	Mutual adjustment	Direct supervision	Standardization of work	Standardization of output	Standardization of skills	Standardization of norms
1	Make OR Master Schedule	36	0	26	3	0	2	33	0	29	2	0	2	-8%	N/A	12%	-33%	N/A	0%
2	Make clinical bed plan	35	0	35	0	1	3	23	0	29	0	1	0	-34%	N/A	-17%	N/A	0%	N/A
3	Schedule surgeons and anesthesiologists	20	0	31	0	0	0	20	0	31	0	0	0	0%	N/A	0%	N/A	N/A	N/A
6 and 11	Plan patient and control planning	37	0	72	18	8	1	36	0	71	15	8	1	-3%	N/A	-1%	-17%	0%	0%
14-22	Prepare patient on ward, prepare patient on holding, perform surgery, aftercare on recovery, aftercare on nursing ward, control OTC program	26	0	45	35	4	0	26	0	45	35	4	0	0%	N/A	0%	0%	0%	N/A
Total		154	0	209	56	13	6	138	0	205	52	13	3	-10%	N/A	-1%	-7%	0%	-50%
%		49%	0%	67%	18%	4%	2%	47%	0%	70%	18%	4%	1%						

For task 1 the number of rules changed by 6% and 23 of 53 rules were changed. During the after period, as of 1 January 2020, the OR master schedule was restructured, taking bed availability in the nursing wards into account. In addition, the HPC has taken more initiative and control over the process of returning or granting extra sessions, and rules related to this were changed accordingly.
A similar change is observed for task 2, as the number of rules decreased by 27% and 19 of the 51 rules were changed. In the before period the clinical bed plan was informally controlled by the clinical bed planner, who was a nursing ward secretary with no formal position for this task. In the after period the HPC was given planning and control over the beds for nursing wards A2, N2 and for the Short Stay Department.
Nine new rules were introduced and 20 rules changed for patient planning (task 6) and controlling the planning (task 11). A number of local rules that were applied in the before period were standardized into one hospital-wide rule, which has to be applied by the HPC. For example, the HPC does not set a surgery date for the patient at the time of visiting the outpatient department. The HPC sets a date approximately two weeks ahead of surgery, whereas in the before period some outpatient departments set this in an earlier stage while other outpatient departments did not. In addition, semi-urgent surgeries are treated by the HPC as ‘regular’ surgeries, i.e. these are not put in between planned surgeries, but planned as though they are elective surgeries, even though they have to take place on shorter notice. Also the maximum planned utilization of an OR session was decreased from 105% to 100% and is strictly applied by the HPC. Further, the HPC has to plan all patients in the HIS instead of in paper planning documents.

Rules did not change for scheduling surgeons and anesthesiologists (task 3), i.e. the majority of rules have remained local. For tasks 14 to 22 the rules did not change either, with the exception of one, and these remained mostly hospital-wide rules. Both in the before and after period rules are mostly in people’s minds (85%) and to a lesser extent in documents (31% before and 33% after) or in the HIS.

Looking at coordination mechanisms, standardization of work and mutual adjustment have remained the most used mechanisms, whereas direct supervision is absent and standardization of output and standardization of norms are low. For task 1, standardization of output decreased by 33%, mutual adjustment by 8% and there is more standardization of work (12%). This is explained by the restructuring of the OR master schedule, which was done by the OTC manager and OTC capacity planner during the after period. The clinical bed plan was restructured in line with the OR master schedule, and central control of the HPC led to 34% less mutual adjustment and 17% less standardization of work. For planning and control tasks 6 and 11, no large changes were observed with regard to coordination mechanisms. For tasks 3 and 14 to 22, coordination mechanisms and all tasks on the day of surgery remained largely unchanged.

Performance indicators

Before introducing the HPC, Slingeland hospital envisaged changes for 17 performance indicators, as presented in Table 5.1. Table 5.6 shows that before the HPC was introduced, the expected change of the associated performance indicators for each performance area were mostly specified qualitatively. The value of waiting list length and resource utilization are the only performance indicators that are reported quantitively both in the before and the after period. However, for these two indicators the desired or expected change was not specified beforehand. Several improvements were envisaged for performance indicators, related to how well processes were planned. Improved planning of surgery time, less overutilization of ORs, lateness and cancellations, were most frequently mentioned beforehand, in six documents and four interviews. The second most mentioned indicator was a reduction of variability, which was mentioned in six documents and three interviews.

While the number of surgeries performed stayed roughly the same, the average waiting list length increased by 21%, from 5.8 to 7 weeks on average. Figure 5.4.1 in Appendix 5.4 shows that the increase of the waiting list started in week 37 in 2019 (9 September), which is three months after the HPC was introduced. The waiting list length stabilizes at the start of 2020.
The ORs and OR sessions were utilized slightly 3% less and beds were utilized 11% more. Higher bed utilization is related to the fact that the number of beds was reduced by 14% in the after period.

The main change with regard to the area of process quality and control is the increase of 88% in cancellations. Figure 5.4.2 in Appendix 5.4 shows the number cancellations per registered reason. The increase of cancellations is largely attributed to administrative reasons. Surgeries were 'entered incorrectly in the system' 172% times more in the after period and surgeries for which 'the surgery date is unknown' increased by 5250%. This was attributed to the fact that, based on rule 167, planners should plan all surgeries in the HIS, including those for which the surgery date is not final and the patient has not yet been informed of the date. Leaving out these two administrative factors, the number of cancellations has increased by 15%.

Table 5.6 Performance indicators in the before and after period.

Performance indicator	Description	Indicator specification		Number of sources			Value			Unit of measure
		Quantitative	Qualitative	Total	Document	Interview	Before	After	Change	
1. Surgeries performed										
Patient inflow	The average number of surgery orders made per week.		X	3	1	2	192	183	-5%	Number of surgery cases
Number of surgeries	Total number of surgical cases performed.						7,888	7,470	-5%	Number of surgeries
Number of elective and non-elective surgeries	Elective or non-elective/emergency cases performed (%) included are all inpatient surgical cases excluded are cases performed at separate OR locations.						83%	83%	0%	%
Surgery time	The sum of surgery times of all surgeries, with surgery time being the time starting when patient positioning and/or skin preparation can begin to when the surgery is completed.						8,845	8,604	-3%	Hours
2. Process quality and control										
Planned vs realised surgery time	Average % difference between realised and planned surgery time		X	10	6	4	29%	31%	7%	%
Overutilization OR	The total number of operating room days that finished after 4 pm divided by the total number of regular operating room days on which elective surgeries took place.						27%	26%	-4%	%
Number of late ORs	The average number of operating rooms that finish after 4 pm.						2.01	1.96	-2%	Number of ORs
Cancellations	Number of surgeries that were cancelled.						992	1,863	88%	Number of surgeries
3. Variability										
Variability OR utilization	Standard deviation of OR utilization.		X	9	6	3	19%	20%	5%	%
	Minimum OR utilization: the lowest OR utilization for an OR on a weekday.						5%	7%	40%	%
	Maximum OR utilization: the highest OR utilization for an OR on a weekday.						134%	107%	-20%	%
Variability OR session utilization	Standard deviation of OR session utilization.						7%	8%	14%	%
	Minimum OR utilization: the lowest OR session utilization for an OR on a weekday.						66%	57%	-14%	%
	Maximum OR utilization: the highest OR session utilization for an OR on a weekday						111%	100%	-10%	%

Table 5.6 (continued)

Performance indicator	Description	Indicator specification		Number of sources			Value			Unit of measure
		Quantitative	Qualitative	Total	Document	Interview	Before	After	Change	
Variability bed utilization	Average standard deviation of bed utilization divided by the average bed utilization and minimum and maximum OR utilization.						29	29	0%	Number of beds
	Minimum bed utilization.						1	1	0%	Number of beds
	Maximum bed utilization.						172	157	-9%	Number of beds
Variability waiting list	Average standard deviation of waiting list length divided by the average waiting list length.						3.1	3.7	19%	Weeks
	Minimum waiting list length.						1	1.3	30%	Weeks
	Maximum waiting list length.						15.9	19.3	21%	Weeks
4. Waiting list										
Waiting list length	Average number of weeks necessary for operating on all patients on the waiting list, given the number of OR sessions allocated to a medical discipline.	X		7	5	2	5.8	7	21%	Weeks
5. Resource utilization										
OR session utilization	The total amount of time surgical patients are present in the OR, divided by the amount of allocated OR session time x 100%. An OR session is a time slots that is allocated to a specific medical discipline on a specific weekday and OR.	X		5	4	1	87%	84%	-3%	%
OR utilization	The total amount of time surgical patients are present in the OR during regular working hours between 8 am - 4 pm, divided by the total amount of OR time during these working hours (8 hours).						77%	75%	-3%	%
Bed utilization	The average number of beds used for a patient in a nursing department divided by the number of available beds, for nursing departments A2, N2 and the Daycare/Short Stay Department.						76%	84%	11%	%
6. Resource availability										
Number of beds	The number of beds in nursing departments A2, N2 and the Daycare/Short Stay Department.		X	6	4	2	96	83	-14%	Number of beds

Lateness in the OR, i.e. the average number of late ORs and the percentage of days with surgeries running late, decreased slightly by 2% and 4% respectively. The difference between the planned and realized surgery time increased by 7%.

Variability did not change much on average, except for the waiting list variability, as shown by Table 5.6. The waiting list length has become more variable, by 19%. Table 5.6 also shows that the maximum values for OR utilization, OR session utilization and bed utilization have all decreased by 9% to 20%.

DISCUSSION

In this study changes that followed the introduction of a HPC are described in terms of the network structure, i.e. integration and differentiation, rules, coordination and performance of the hospital. With regard to performance, the number of beds has decreased and the related bed utilization has increased. In addition, peak values in resource utilization decreased. However, not all performance indicators that Slingeland Hospital mentioned prior to the introduction of the HPC have improved. A remarkable increase in waiting list length, cancellations and average variability in the waiting list was observed following the introduction of the HPC.

Integration, thereby focusing on density, increased mainly on the task level for planning tasks in which the OR master schedule is set (task 1), surgeries and beds are planned (task 6) and planning is controlled (task 11). Central planners take a central position for the main planning tasks 6 and 11. The OTC manager has taken a more central position than in the before period, thus contributing to integration. Differentiation based on medical discipline remained after the introduction of the HPC and is observed for tasks 3 and 6, through which surgeons and surgeries are planned.

Rules are applied less locally, i.e. rules from the before period have become the hospital-wide standard or new hospital-wide rules were set. Rules remain mostly in people's minds and there is scarcely any increase in documented rules. Coordination mechanisms remained largely the same after the HPC was introduced, and mainly include standardization of work and mutual adjustment.

The fact that the hospital's performance does not seem to have improved substantially and has even decreased in some ways, is remarkable. Even though the relation between the observed changes cannot be established by this study alone and the period of nine months may be too short to assess the hospital-wide impact of the HPC, a number of possible explanations related to integration, differentiation and coordination can be discussed based on this study.

First of all, the HPC plans specific groups of patients, excluding non-surgical patients and certain surgery patients, and it does not control the surgeons' schedules. According to Ludwig et al.[8] the hospital's efficiency will most likely improve when all departments cooperate instead of some departments, as is the case here.

Second, the HPC does not seem to take demands from the environment, i.e. patient demand, into account more than the outpatient departments did in the before period. Long-term schedules, of surgeons in particular, have remained largely unchanged, and waiting list length is determined mainly by the available capacity. With a patient inflow that is similar in the before and after period and a lowered maximum utilization of OR sessions, the waiting list length logically increases. In addition, both surgeons and outpatient secretaries, who have direct and first contact with patients, have a less central position than in the before period. This appears to be in contrast with both Galbraith[19] and Lawrence and Lorsch[13], who state that the organizational structure, i.e. the degree of integration and differentiation, should be tuned to the demands of the environment in order to perform well. In addition, the unchanged long-term schedules still create open loops[17], which are closed by mutual adjustment, as in the before period[15]. Although now six planners close the loops, instead of the one OTC capacity planner, we believe that the potential causes of instability, e.g. the multitude of rules and the open loops, have shifted from the outpatient departments and the OTC capacity planner to the HPC, but have not been reduced. The increased length of the waiting list and number of cancellations suggest that the network has remained unstable or has become even more unstable.

Based on these observations and the literature, we believe that the introduction of HPC should be part of a system redesign from the perspective of the total system, including network structure, rules and coordination mechanisms. The observed ways of working in Slingeland Hospital show some similarities with the horizontal coordination in Japanese companies as described by Aoki[27]. According to Aoki, horizontal coordination involves collective learning and knowledge sharing based on informal and mostly verbal communication and is considered most effective in dynamic environments. This will be effective only when all agents have a good understanding of the whole work process and organizational goals are internalized. In line with both Aoki[28] and Galbraith[19], it appears that with the introduction of the HPC stronger lateral relations have been created, but it is unclear whether there is collective learning, knowledge sharing and full understanding of organization-wide goals.

Starting with organization-wide goals, we therefore first propose that Slingeland Hospital management specifies desired, expected and realized performance indicators more explicitly. Literature pertaining to performance indicators[12] and to hospital planning[29-32] could be used for drawing up expected and desired changes in performance. These goals should then be discussed and shared hospital-wide. By regularly monitoring, evaluating and communicating changes in network structure, rules, coordination mechanisms and performance, expansive learning could be facilitated, a process in which agents produce new forms of work activity[33] based on feedback. Through job rotation[27] the hospital-wide comprehension of processes is likely to be enhanced, and it could prevent a too strong identification with specific subsystems in which agents work. This is in line with Mintzberg[26], who advocates for more mutual adjustment and standardization of norms in hospitals. As stated by Aoki[27] agents could be motivated to act and behave in the interest of the hospital-wide goals by incentives.

Second, the organizational design concepts of integration, differentiation and centralization require further elaboration, first of all in practice. The word 'centre' in HPC implies that centralization of planning was intended. However, according to Mintzberg[16] centralization is related to decision power. At Slingeland Hospital, through lack of direct supervision, planning tasks seem instead to be concentrated without power, meaning that planners were grouped and given the competency to perform planning tasks without having actual decision power. At the same time, following the concept of horizontal coordination as described by Aoki[27], there might not be any need for formal decision power to be assigned to agents for controlling operations. As shown by Van Merode et al.[34] agents are able to influence decision-making processes notwithstanding their formal positions. By concentrating the planners, thus centralizing them further in the network structure by involving them in planning processes from start to end, they might be able to effectively increase their influence further.
In addition, for effective horizontal coordination we believe Slingeland Hospital should pay more attention to differentiation. This means that differentiated tasks are explicitly specified and both central planners, outpatient secretaries, surgeons and anesthesiologists share goals, information and are allowed to 'stop the line' whenever they see issues that might lead to problems. We believe it is important that hospital management explicitly states what organizational model lies behind any further organizational changes.

Similar to the previous two case studies[14-15] this study is exploratory. Because it concerns a single case study the results may not be applicable to other cases. The findings should be used for 'analytic generalization'[23,] providing input for future studies. The above-

mentioned recommendations for practice are relevant input for further research, albeit for the purpose of identifying connections between performance, network structure, integration, differentiation, rules, and coordination mechanisms in general.
More specifically, first the concept of integration as defined in social network and organizational theory needs to be developed further. Based on social network metrics, integration in Slingeland Hospital appears to have increased for some tasks, but according to Lawrence and Lorsch[13] and Mintzberg[16], it could be argued that integration did not change, when taking decision power into account.
Second, some network metric changes seem to be attributed to factors other than the introduction of the HPC, as illustrated by the decreased number of unique OR teams and the position of the one neurosurgeon. There is also the limitation of not taking into account interaction frequency between agents, causing low and high frequency interaction to be valued equally. Nevertheless, in line with Beuving and De Vries[24], we believe that network performance can only be understood when accompanied by an understanding of what happens between the agents in the network.
Third, we believe that the concept of horizontal coordination is worth exploring further, but as mentioned by Aoki[27], the cost of intensive interaction between multiple agents and time consuming learning processes will pay off only in volatile and dynamic environments, for which a more hierarchical model is not effective. Given the limited attention that is paid to the hospital's environment, more research is required on the dynamics of the environment. In addition, Takt Time Management should be considered in relation to horizontal coordination models. Through Takt Time Management the desired time between units of output is synchronized to the customer's demand, in order to stabilize the system[17]. A multi-agent system which includes horizontal coordination was designed by Munavalli et al.[32], for example, and could be used to further develop hospital-wide coordination, integration and differentiation.

In conclusion, this study explores the (un)changeable coherence of a hospital network's structure, rules, coordination mechanisms and performance, which is important input for further studies. Future studies could be performed in hospital settings, but also in other organizations that provide healthcare on a regional or national level, i.e. including other hospitals and the supply chain partners of hospitals. Given the fact that the accessibility and affordability of healthcare systems clearly have been under even more pressure since the Covid-19 pandemic, the relation between integration, differentiation, coordination and the stability of healthcare networks and organizations is highly relevant and demands further research.

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APPENDIX 5.1 INVOLVED AGENTS PER TASK

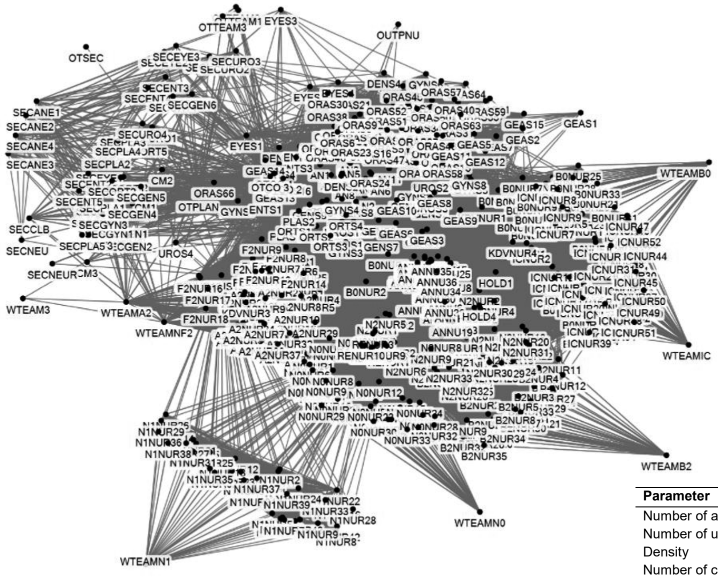
Table A5.1.1 Tasks and agent types involved in these tasks.

	Tasks	**Anesthesiologist**		**Nurse anesthetist**		**Assistant surgeon**		**Central planner**		**Cluster manager**		**Holding nurse**		**OTC capacity planner**		**OTC day coordinator**		**OTC manager**		**OR nurse**		**OTC secretary**		**OTC team leader**		**Outpatient secretary**		**Preoperative secretary**		**Recovery nurse**		**Surgeon**		**Ward nurse**		**Clinical bed plan boss**		**Ward team leader**		**Task description**
		b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	
1	Make OR master schedule	x	x							x				x	x				x							x						x	x							Make the OR master schedule in which operating time for each medical discipline is allocated to the operating rooms.
2	Make clinical bed plan								x					x																						x		x		Make the clinical bed plan in which beds are allocated to medical disciplines per nursing ward.
3	Schedule surgeons and anesthesiologists	x	x																							x	x					x	x							Determine the working hours for every surgeon and anesthesiologist for the upcoming three to six months, including where they are working, i.e. in the outpatient department and the OTC.
6	Plan patient								x					x					x							x	x					x	x			x				Determine the time and date that the patient will be operated on and register this in the OR master schedule.
11	Control planning								x					x		x	x				x	x	x	x		x		x						x		x		x	x	Check all requirements for the surgery to be able take place, determine the final order of the surgeries for each OR and if necessary revise planned surgeries.
14	Prepare patient on ward			x	x																													x	x			x	x	Admit the patient to the nursing ward, administer premedication to the patient and further prepare the patient for surgery.
15	Prepare patient in holding			x	x							x	x																					x	x					Transfer the patient from the nursing ward to holding, further prepare the patient for surgery and transfer the patient to the nurse anesthetist.
17	Perform surgery	x	x	x	x	x	x													x	x											x	x							Perform the surgery with the OR team.
20	Patient care recovery	x	x	x	x																									x	x			x	x					Take care of the patient after surgery, making sure the patient is well enough to be transferred to the nursing ward.
21	Aftercare of patient																															x	x	x	x			x	x	Take care of the patient after surgery, making sure the patient is well enough to go home.
22	Manage OTC day program	x	x	x	x							x	x	x		x	x		x	x	x			x	x	x				x	x	x	x							Coordinate and manage the daily OT program, making sure that all surgeries planned for each day are well-executed and on time, and review this over time.
	Total number of tasks involved	5	5	5	5	1	1	**0**	**3**	**1**	**0**	2	2	**5**	**1**	2	2	**0**	**3**	**2**	**3**	1	1	**2**	**1**	**5**	**2**	**1**	**0**	2	2	6	6	**5**	**4**	**3**	**0**	**4**	**3**	

APPENDIX 5.2: SOCIAL NETWORKS

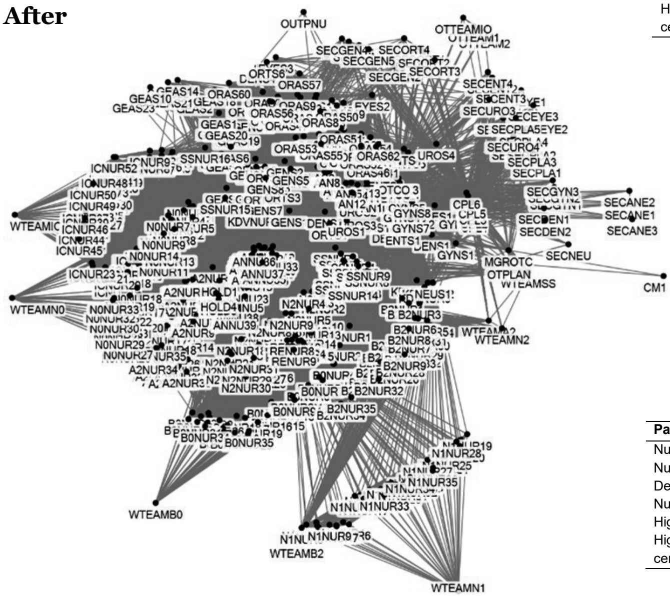
A5.2.1 The entire social network

Before



Parameter	Value
Number of agents	526
Number of unique ties	32,002
Density	0.23
Number of cliques	7692
Highest degree	Nurse anesthetist 10
Highest betweenness centrality	Neurosurgeon

After

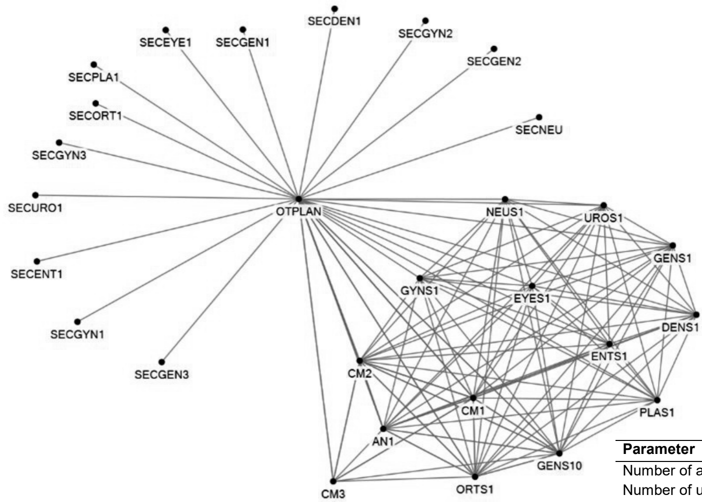


Parameter	Value
Number of agents	514
Number of unique ties	31,703
Density	0.24
Number of cliques	6909
Highest degree	Nurse anesthetist 12
Highest betweenness centrality	Neurosurgeon

Figure A5.2.1 Before and after social networks and metrics for the entire network.

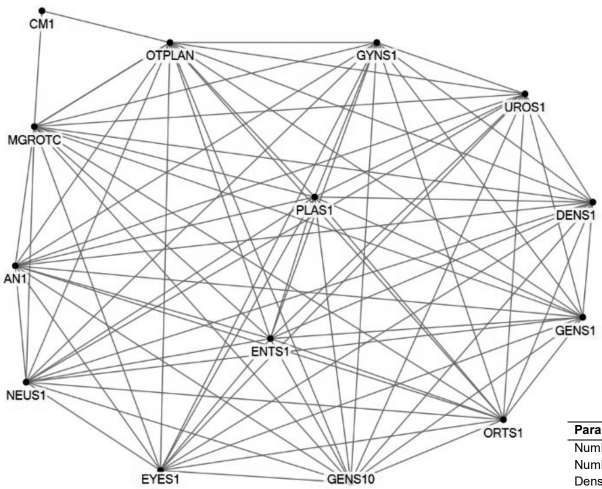
A5.2.2 Task 1: Make OR master schedule

Before



Parameter	Value
Number of agents	28
Number of unique ties	110
Density	0.3
Number of cliques	2
Highest degree	OTC capacity planner
Highest betweenness centrality	OTC capacity planner

After

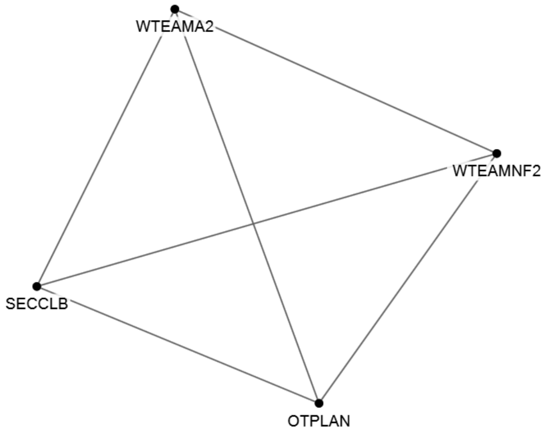


Parameter	Value
Number of agents	14
Number of unique ties	82
Density	0.9
Number of cliques	2
Highest degree	Manager OTC, OTC capacity planner
Highest betweenness centrality	Manager OTC, OTC capacity planner

Figure A5.2.2 Before and after social networks and metrics for task 1.

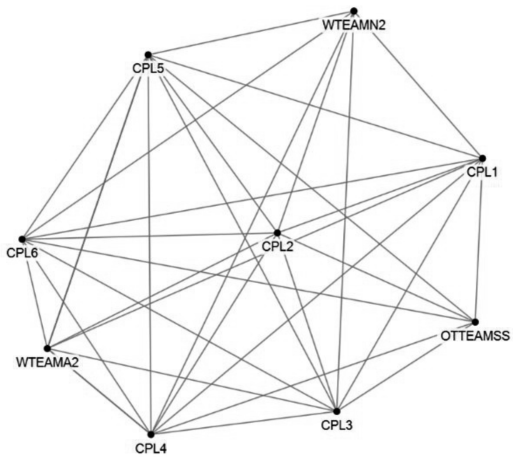
A5.2.3 Task 2: Make clinical bed plan

Before



Parameter	Value
Number of agents	4
Number of unique ties	6
Density	1
Number of cliques	1
Highest degree	N/A
Highest betweenness centrality	N/A

After

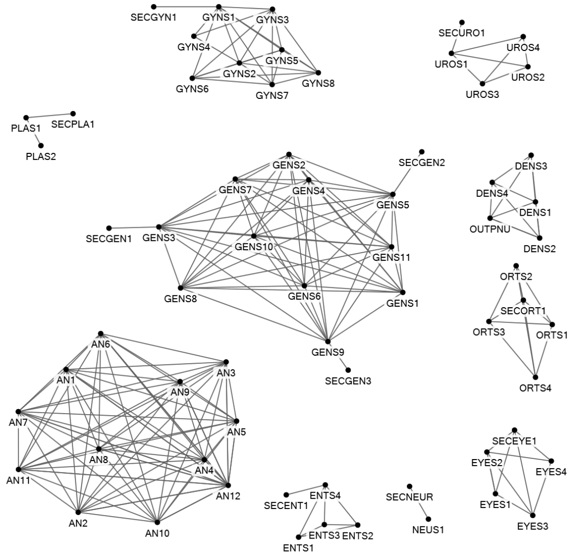


Parameter	Value
Number of agents	9
Number of unique ties	33
Density	0.9
Number of cliques	3
Highest degree	N/A
Highest betweenness centrality	All central planners

Figure A5.2.3 Before and after social networks and metrics for task 2.

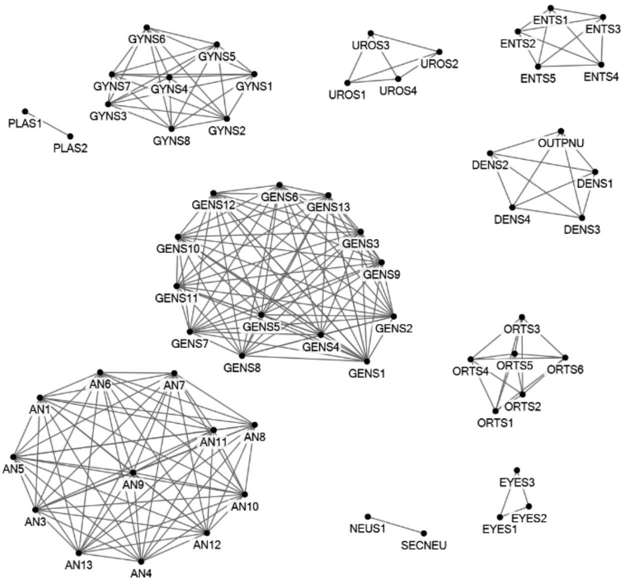
A5.2.4 Task 3: Schedule surgeons and anesthesiologists

Before



Parameter	Value
Number of agents	65
Number of unique ties	195
Density	0,09
Number of cliques	9
Highest degree	All general surgeons
Highest betweenness centrality	N/A

After

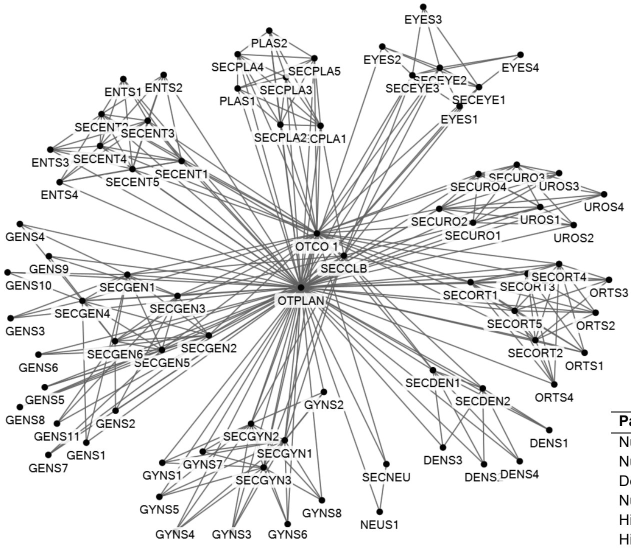


Parameter	Value
Number of agents	60
Number of unique ties	218
Density	0,12
Number of cliques	9
Highest degree	All general surgeons
Highest betweenness centrality	N/A

Figure A5.2.4 Before and after social networks and metrics for task 3.

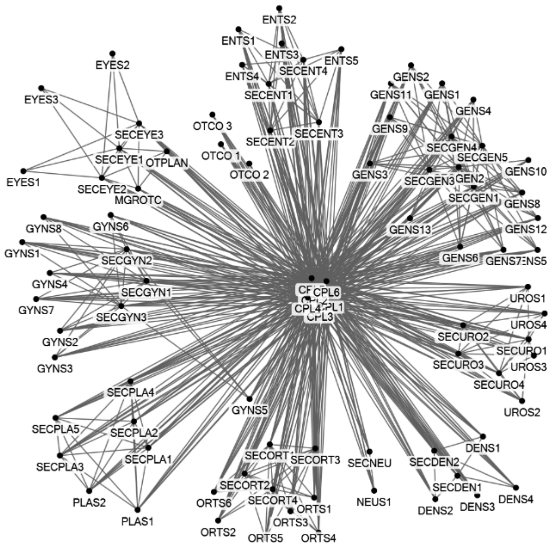
A5.2.5 Task 6: Plan patient

Before



Parameter	Value
Number of agents	79
Number of unique ties	315
Density	0,1
Number of cliques	42
Highest degree	OTC capacity planner
Highest betweenness centrality	OTC capacity planner

After

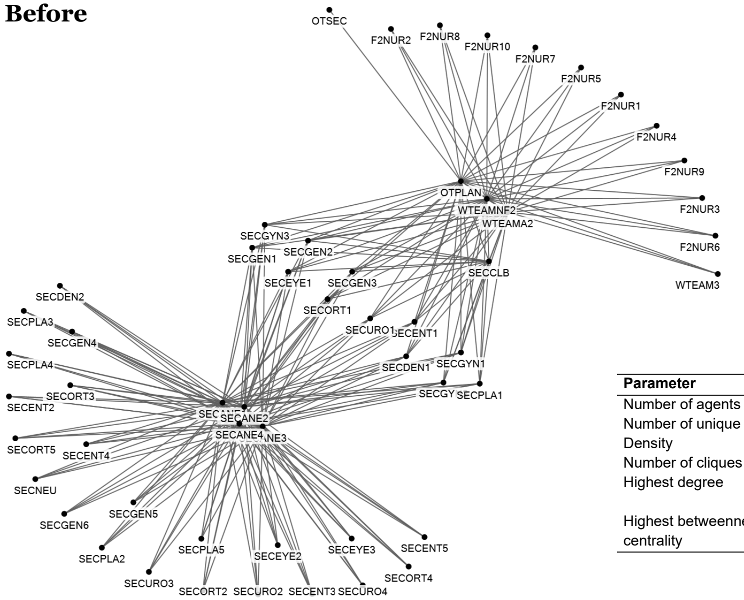


Parameter	Value
Number of agents	88
Number of unique ties	715
Density	0,2
Number of cliques	50
Highest degree	All central planners
Highest betweenness centrality	All central planners

Figure A5.2.5 Before and after social networks and metrics for task 6.

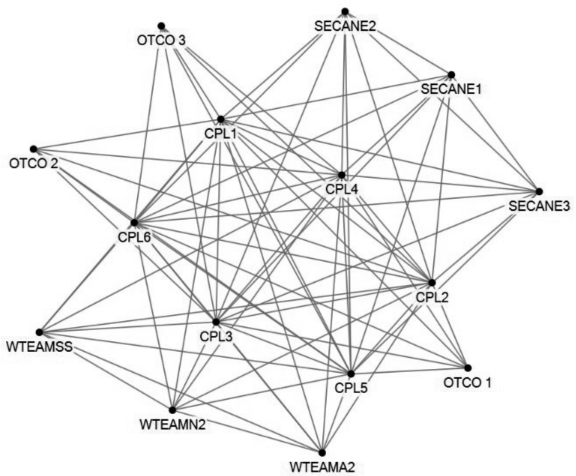
A5.2.6 Task 11: Control planning

Before



Parameter	Value
Number of agents	54
Number of unique ties	224
Density	0,2
Number of cliques	2
Highest degree	All preoperative screening secretaries
Highest betweenness centrality	All preoperative screening secretaries

After

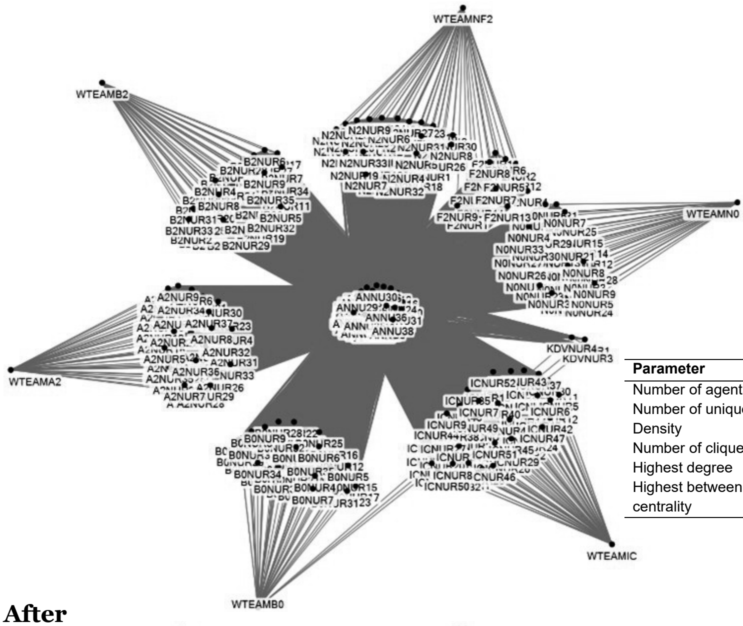


Parameter	Value
Number of agents	15
Number of unique ties	75
Density	0,7
Number of cliques	5
Highest degree	All central planners
Highest betweenness centrality	All central planners

Figure A5.2.6 Before and after social networks and metrics for task 11.

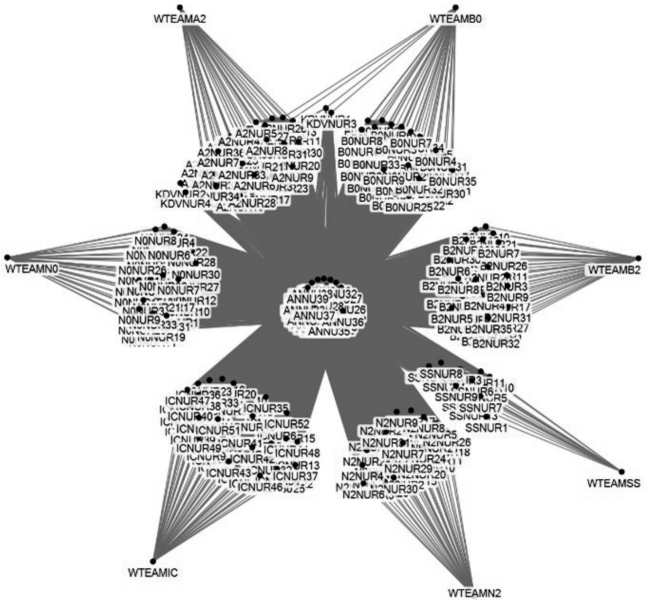
A5.2.7 Task 14: Prepare patient on ward

Before



Parameter	Value
Number of agents	280
Number of unique ties	12.109
Density	0,3
Number of cliques	248
Highest degree	All nurse anesthetists
Highest betweenness centrality	All nurse anesthetists

After

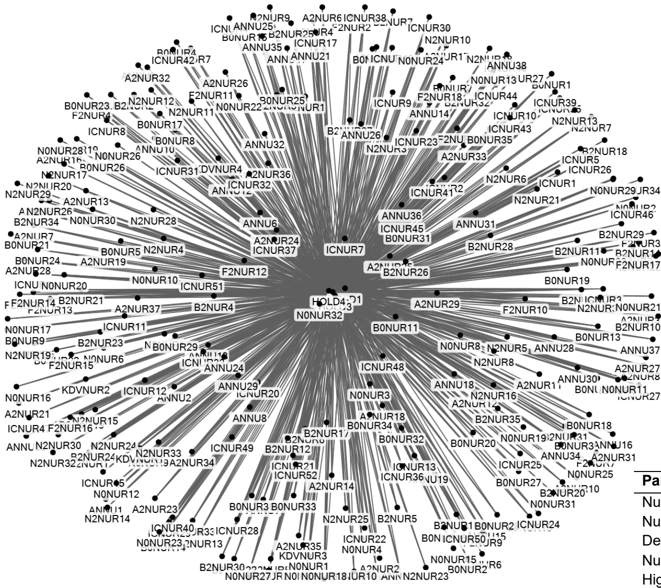


Parameter	Value
Number of agents	278
Number of unique ties	11.914
Density	0,3
Number of cliques	248
Highest degree	All nurse anesthetists
Highest betweenness centrality	All nurse anesthetists

Figure A5.2.7 Before and after social networks and metrics for task 14.

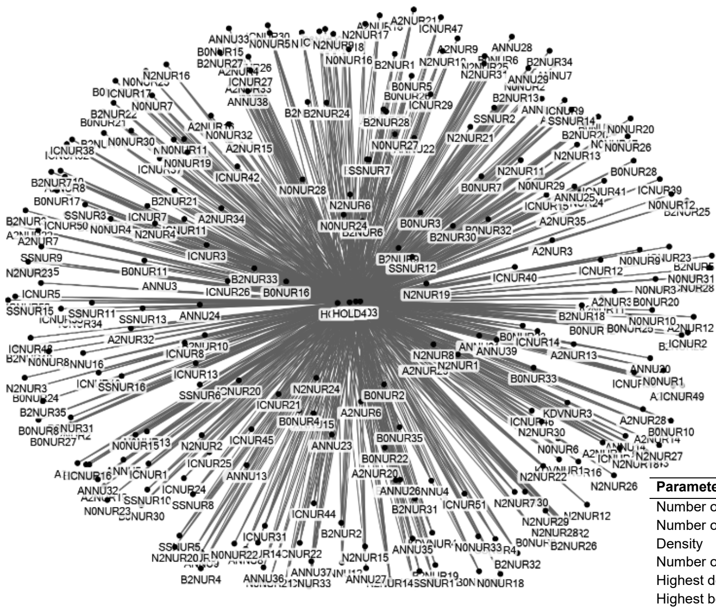
A5.2.8 Task 15: Prepare patient on holding

Before



Parameter	Value
Number of agents	282
Number of unique ties	1071
Density	0,03
Number of cliques	278
Highest degree	All holding nurses
Highest betweenness centrality	All holding nurses

After

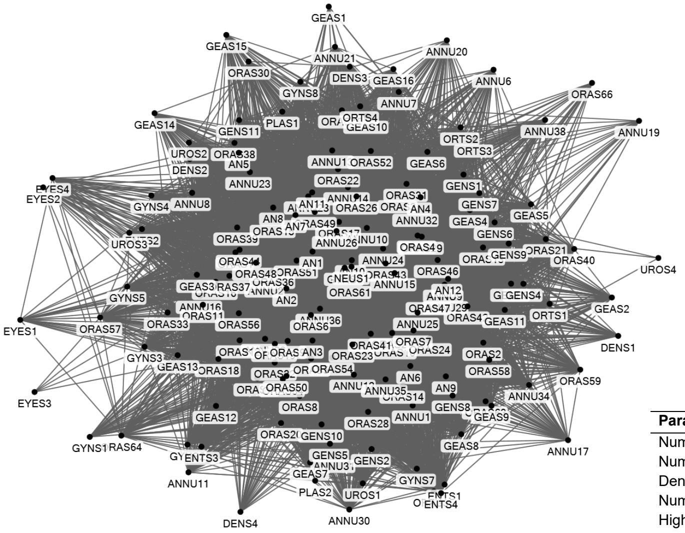


Parameter	Value
Number of agents	277
Number of unique ties	1054
Density	0,03
Number of cliques	273
Highest degree	All holding nurses
Highest betweenness centrality	All holding nurses

Figure A5.2.8 Before and after social networks and metrics for task 15.

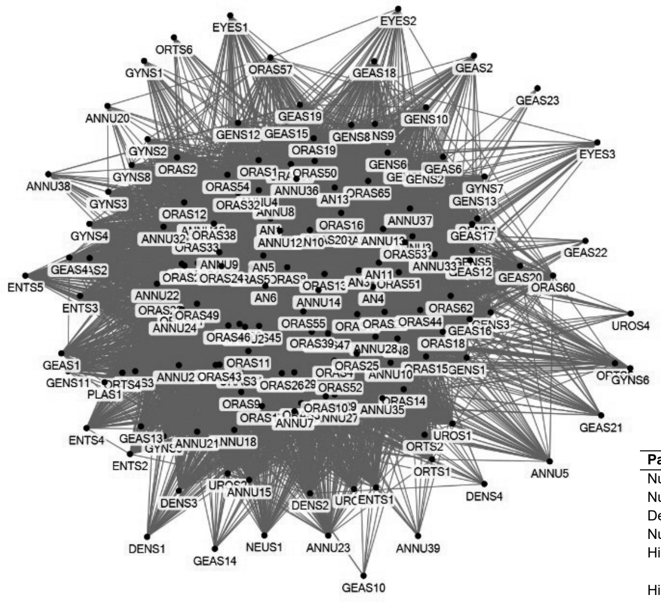
A5.2.9 Task 17: Perform surgery

Before



Parameter	Value
Number of agents	162
Number of unique ties	8653
Density	0.7
Number of cliques	6660
Highest degree	OR nurse 51
Highest betweenness centrality	OR nurse 17

After

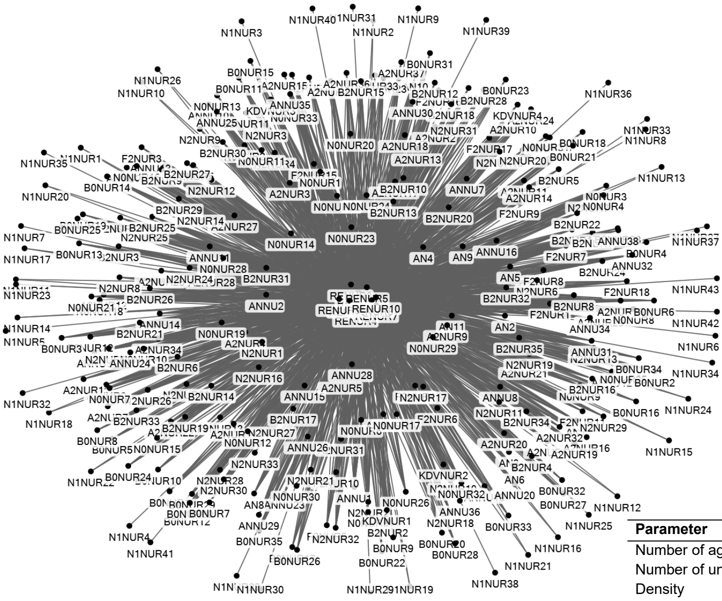


Parameter	Value
Number of agents	157
Number of unique ties	8183
Density	0.7
Number of cliques	5881
Highest degree	Nurse anesthetist 12, OR nurse 48
Highest betweenness centrality	OR nurse 25

Figure A5.2.9 Before and after social networks and metrics for task 17.

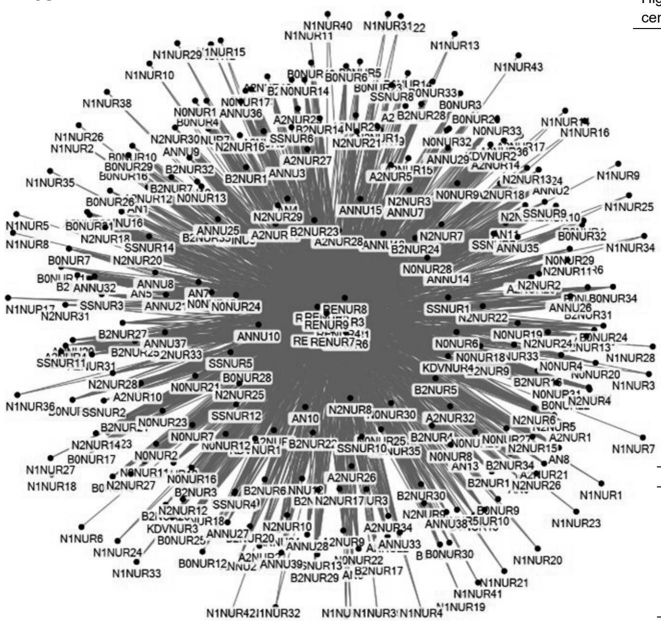
A5.2.10 Task 20: Patient care Recovery

Before



Parameter	Value
Number of agents	290
Number of unique ties	2383
Density	0,06
Number of cliques	253
Highest degree	All recovery nurses
Highest betweenness centrality	All recovery nurses

After

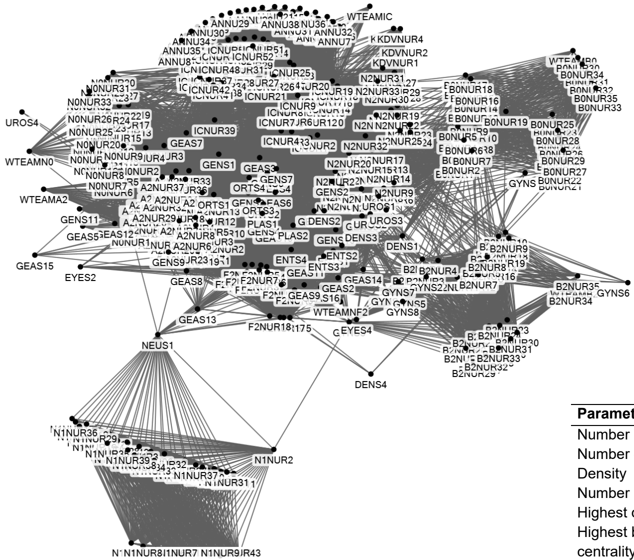


Parameter	Value
Number of agents	284
Number of unique ties	2374
Density	0,06
Number of cliques	249
Highest degree	All recovery nurses
Highest betweenness centrality	All recovery nurses

Figure A5.2.10 Before and after social networks and metrics for task 20.

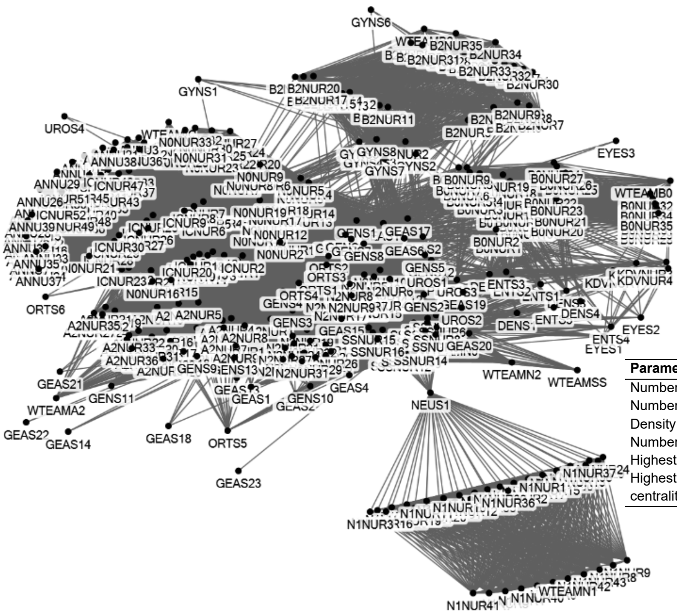
A5.2.11 Task 21: Aftercare patient

Before



Parameter	Value
Number of agents	383
Number of unique ties	12,630
Density	0.2
Number of cliques	171
Highest degree	Intensive care nurse 2
Highest betweenness centrality	Neurosurgeon

After

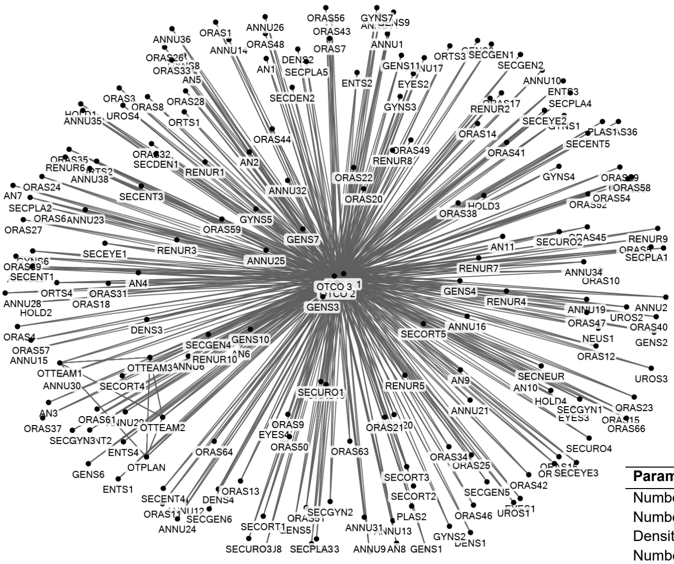


Parameter	Value
Number of agents	386
Number of unique ties	12,736
Density	0.2
Number of cliques	164
Highest degree	Intensive care nurse 1
Highest betweenness centrality	Neurosurgeon

Figure A5.2.11 Before and after social networks and metrics for task 21.

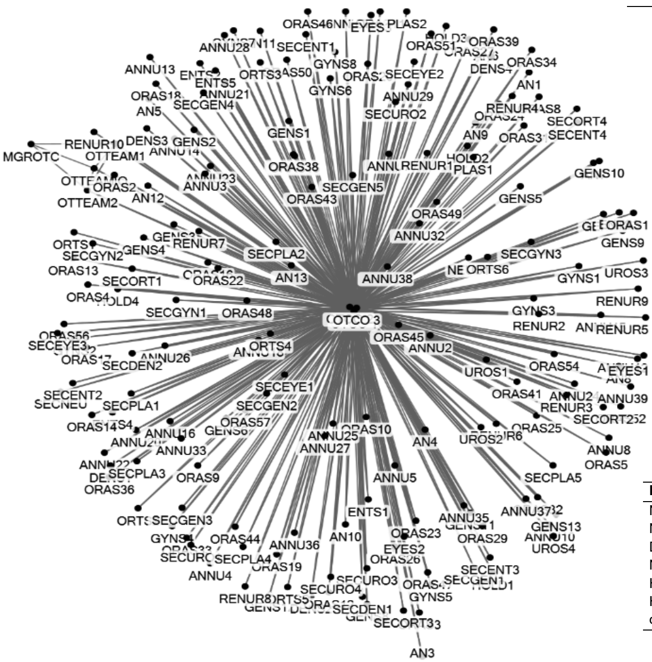
A5.2.12 Task 22: Manage OTC day program

Before



Parameter	Value
Number of agents	201
Number of unique ties	600
Density	0,03
Number of cliques	1
Highest degree	OTC day coordinator
Highest betweenness centrality	OTC day coordinator

After



Parameter	Value
Number of agents	187
Number of unique ties	555
Density	0,03
Number of cliques	1
Highest degree	OTC day coordinator
Highest betweenness centrality	OTC day coordinator

Figure A5.2.12 Before and after social networks and metrics for task 22.

A5.2.13 Description of agent codes in social networks

Agent code	Description
A2NUR	Ward A2 nurse
AN	Anesthesiologist
ANNU	Nurse anesthetist
B0NUR	Ward B0 nurse
B2NUR	Ward B2 nurse
CM	Cluster Manager
CPL	Central planner
DENS	Dental surgeon
ENTS	Ear Nose Throat surgeon
EYES	Eye surgeon
F2NUR	Ward F2 nurse
GEAS	Assistant surgeon
GENS	General surgeon
GYNS	Gynecological surgeon
HOLD	Holding nurse
ICNUR	Intensive care nurse
KDVNUR	Pediatric ward nurse
MGROTC	OTC Manager
N0NUR	Ward N0 nurse
N2NUR	Ward N2 nurse
NEUS	Neurosurgeon
ORAS	OR nurse
ORTS	Orthopedic surgeon
OTCO	OTC day coordinator
OTPLAN	OTC capacity planner
OTTEAM	Team leader OTC
OUTPNU	Outpatient department nurse
PLAS	Plastic surgeon
RENUR	Recovery nurse
SECANE	Secretary Anesthesia
SECDEN	Secretary Dental Surgery outpatient department
SECENT	Secretary ENT outpatient department
SECEYE	Secretary Ophthalmology outpatient department
SECGEN	Secretary General surgery outpatient department
SECGYN	Secretary Gynecology outpatient department
SECNEU	Secretary Neurology outpatient department
SECORT	Secretary Orthopedics outpatient department
SECPLA	Secretary Plastic surgery outpatient department
SECURO	Secretary Urology outpatient department
SSNUR	Short Stay nurse
UROS	Urology surgeon
WTEAMA2	Ward team leader A2
WTEAMIC	Ward team leader Intensive Care

APPENDIX 5.3: RULES AND COORDINATION MECHANISMS

All rules in the before and after period are presented. A rule applied in the before period either remains to exist in the after period, does not exist in the after period, is new or is adapted, in which case the adaptations to the rule are described.

Task 1: Make OR Master Schedule

Before period Rule #	Before period Rule	After period Rule #	After period Rule
Structuring time and space			
1	In the OR master schedule sessions are allocated to medical specialties for even and odd weeks in one quarter of the year.	1	In the OR master schedule, sessions are allocated to medical specialties for one standard week in one quarter of the year. Eye Surgery has a session on alternate Mondays. Sessions for Orthopedics, Neurosurgery, ENT and General Surgery are allocated every four weeks on different days and times than what is allocated in the standard OR master schedule.
2	The OR master schedule is set for 38 'regular weeks'. The other 14 weeks are reduction weeks and these are in national school holiday weeks.	2	Rule remains in the after period.
3	The OR master schedule is different on national holidays outside reduction weeks and on anesthesiology conference days.	3	Rule remains in the after period.
4	The OR master schedule is set quarterly, two quarters ahead.	4	Rule remains in the after period.
5	Each of nine operating rooms has two sessions - a morning and afternoon session - on weekdays and there are 90 sessions in one week.	5	Rule remains in the after period.
6	In the OR master schedule 70 to 73,5 sessions are allocated to either a medical specialty, a treatment type or labelled as flexible or as an emergency session.	6	Rule remains in the after period.
		NEW 1	On Mondays, Thursdays and Fridays there is one OR with a session that ends at 2 pm and other ORs ending at 4 pm.
7	One session is allocated to one medical specialty, or labelled as flexible or as an emergency session.	7	One session is allocated to one medical specialty or labelled as an emergency session.
8	Every day there is an emergency session from noon to 4 pm.	8	Every day there is an emergency session from 2 to 4 pm.
9	If all sessions are required by medical specialties, then there is no flexible session.		Rule does not exist in the after period.
10	Flexible sessions or sessions in reduction weeks are used for medical specialties with a high waiting list, for which no structural increase of session allocation is required.	10	Rule remains in the after period.
11	Session duration is 4 hours, from 8 am to noon and noon to 4 pm. Session times are different for Eye surgery, ENT, specific surgeries performed by General Surgery, Urology, Neurosurgery and Orthopedics.	11	Session duration is 4 hours, from 8 am to noon and noon to 4 pm. On specific days session times are different for Plastic Surgery, Orthopedics and Dental Surgery (8 am to 2 pm). Session duration for specific sessions is also different for Eye Surgery, Gynecology, ENT, specific surgeries performed by General Surgery and Neurosurgery.
12	Operating rooms 1 and 2 are used for defined surgeries for which a plenum is required. In addition a number of surgery types are defined for which OR 1 and 2 are to be used with strong preference.	12	Rule remains in the after period.
13	Operating rooms 8 and 9 are used for defined surgeries or treatments for which no complete anesthesia is required.	13	Rule remains in the after period.
14	Urology surgeries preferably take place in OR 7.	14	Rule remains in the after period.
15	Ear Nose Throat surgeries preferably take place in OR 5.	15	Rule remains in the after period.
16	OR 4 and 6 are preferably used by medical specialties that do surgery only in these ORs because the physical layout differs from the standard OR.	16	OR 6 is preferably used by medical specialties that do surgery only in these ORs because the physical layout differs from the standard OR. OR 4 is used for emergency surgeries.
17	On Wednesdays two sessions in OR 2 are used by either Orthopedics or Neurosurgery.	17	On Wednesdays once every four weeks two sessions in OR 2 are used by either Orthopedics instead of Neurosurgery.
18	Sessions are registered in the Hospital Information System (HIS).	18	Rule remains in the after period.
19	The OTC capacity planner, OTC day coordinator, OTC application controller, OTC secretary and the clinical bed planner are authorized to change sessions in the HIS.	19	The OTC capacity planner, OTC day coordinator, OTC application controller, OTC secretary and the central planners are authorized to change sessions in the HIS.

Hospital-wide or local

Before Rule #	After Rule #	Before period: Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	After period: Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology
1	1	X											X										
2	2	X											X										
3	3	X											X										
4	4	X											X										
5	5	X											X										
6	6	X											X										
	NEW 1												X										
7	7	X											X										
8	8	X											X										
9		X																					
10	10	X											X										
11	11	X											X										
12	12	X											X										
13	13	X											X										
14	14	X											X										
15	15	X											X										
16	16	X											X										
17	17	X											X										
18	18	X											X										
19	19	X											X										

Information carrier (R = Rule/O = and **Coordination mechanism**

Before Rule #	After Rule #	Info. Before: Document	Hospital Information System	People's knowledge	Info. After: Document	Hospital Information System	People's knowledge	Coord. Before: Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Coord. After: Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
1	1	R/O	O		R/O	O				X						X			
2	2	O	O	R	O	O	R			X						X			
3	3	O	O	R	O	O	R			X						X			
4	4	R			R					X						X			
5	5	O	O	R	O	O	R			X						X			
6	6	O	O	R	O	O	R			X						X			
	NEW 1				R	O										X			
7	7	O	O	R	O	O	R			X						X			
8	8	R				O				X						X			
9			O	R		O	R	X								X			
10	10			R			R	X						X					
11	11		O	R		O	R			X						X			
12	12	R		R	R		R	X		X				X		X			
13	13			R			R			X						X			
14	14	O	O	R	O	O	R	X		X				X		X			
15	15	O	O	R	O	O	R	X		X				X		X			
16	16	O	O	R	O	O	R	X		X				X		X			
17	17	O	O	R	O	O	R			X						X			
18	18	R	O	R	R	O	R			X						X			
19	19		O	R		O	R			X						X			

Task 1: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Making the OR master schedule																																											
20	The number of sessions a medical specialty gets, matches the number of sessions they need in order to be able to operate on patients.	20	Rule remains in the after period.	X											X													R			R	X						X					
21	The number of sessions a medical specialty needs is based on past session utilization, current and expected waiting list and resource availability.	21	Rule remains in the after period.	X											X											R		R	R		R	X						X					
22	The OR master schedule is based on past OR session allocation and is an adapted version of the previous OR master schedule.	22	Rule remains in the after period.	X											X											O		R	O		R	X						X					
23	Structural changes to the OR master schedule are made only when the changes are expected to last for the long term, based on expected demand and available staff resources (surgeons and OTC staff).	23	Structural changes to the OR master schedule are made only when the changes are expected to last for the long term, based on expected demand, available staff resources (surgeons and OTC staff) and available beds.	X											X													R			R	X						X					
24	Production figures of last year's same quarter are used to determine whether structurally changing the OR master schedule is necessary or not.	24	Rule remains in the after period.	X											X											R		R	R		R	X						X					
25	In reduction weeks medical specialties are entitled to 50% of the sessions they get during regular weeks.	25	Rule remains in the after period.	X											X													R			R			X						X			
26	On request, medical specialties can get more sessions during reduction weeks.	26	Rule remains in the after period.	X											X												O	R		O	R	X						X					
27	Medical specialties are allowed to decide to do less than 50% or no sessions during reduction weeks.	27	Rule remains in the after period.	X											X													R			R	X						X					
28	When sessions are taken away, it is guaranteed to the medical specialty that sessions are returned when the medical specialty needs these sessions.		Rule does not exist in the after period.	X																								R				X											
29	When sessions are taken away, this is discussed outside the TPM first, before deciding on the OR master schedule in the TPM.		Rule does not exist in the after period.	X																								R				X											
30	Although this is not considered desirable by the OTC, medical specialties are free to return more than 50% of sessions during reduction weeks.	30	Rule remains in the after period.	X											X											O		R	O		R	X					X	X					X
31	The OTC capacity planner proposes the OR master schedule in the pre-Tactical Planning Meeting, which involves the cluster manager of the OTC and Services and the cluster manager Surgery Care.	31	The OR master schedule is set by the OTC capacity planner and the OR manager and presented to the OTC commission.	X											X											R/O		R	R/O		R	X						X					
32	The OR master schedule is agreed upon in the Tactical Planning Meeting (TPM), which includes the cluster manager of OTC and Services, surgeons from medical specialties, and one anesthesiologist.	32	The OR master schedule is set by the OTC capacity planner and the OR manager and presented to the OTC commission.	X																						O		R	O		R	X						X					
33	OR sessions are released in the HIS after the TPM has taken place.	33	OR sessions are released in the HIS after the OTC commission has viewed the new OR master schedule.	X											X													R			R			X						X			

Task 1: (continued)

Before period Rule #	Before period Rule	After period Rule #	After period Rule
Session allocation and use			
34	Allocated OR sessions can be returned or additional OR sessions can be requested by medical specialties. Requests are made to the OTC capacity planner.	34	Allocated OR sessions can be returned or additional OR sessions can be requested by medical specialties. Requests are made to the Hospital Planning Centre.
35	If the waiting list of a medical specialty is above a certain number of weeks and the session utilization is high, additional sessions are allocated in regular weeks or in reduction weeks.	35	If the waiting list of a medical specialty is above a certain number of weeks and the session utilization is high, additional sessions are offered by the Hospital Planning Centre in regular weeks or in reduction weeks.
36	The waiting list has to be perceived as 'real' in order to act on it, meaning that this includes actual patients waiting, and not, for example, patients who wait at their own request.	36	Rule remains in the after period.
37	Extra sessions can be requested and are granted if session utilization meets utilization standards, if previously offered sessions were accepted, if the waiting list increases, and the resources are expected to be available.	37	Extra sessions can be requested, are granted or offered by the Hospital Planning Centre if session utilization meets utilization standards, if the waiting list is high and the resources are expected to be available.
38	A minimum of 95% of the initially allocated sessions in the OR master schedule should be used.	38	Rule remains in the after period.
39	A minimum of 85% of the sessions should be used for surgeries; for eye surgery this is 75%.	39	Rule remains in the after period.
40	When session utilization is expected to be 40% or below, sessions are to be returned or taken from the medical specialty.	40	When session utilization is expected to be low, the Hospital Planning Centre asks the medical specialty to return sessions from the medical specialty.
41	Sessions are taken from medical specialties through mutual agreement between the OTC capacity planner and the medical specialty.	41	Sessions are taken from medical specialties through mutual agreement between the Hospital Planning Centre and the medical specialty.
42	Returning OR sessions is considered to be unacceptable behaviour if there are no circumstances that justify this.	42	Rule remains in the after period.
43	Sessions should be returned preferably ten weeks beforehand and no later than 6 weeks beforehand.	43	Sessions can be returned at any time and are monitored by the Hospital Planning Centre from three weeks beforehand.
44	When the waiting list exceeds four weeks, allocating more sessions is considered.	44	Rule remains in the after period.
45	If there is an overall shortage of session time, sessions may be returned later than six weeks beforehand.		Sessions can be returned at any time and are monitored by the Hospital Planning Centre from three weeks beforehand.
46	Under specific incidental circumstances such as illness of surgeons or shortage of OTC staff, sessions may be returned later than 6 weeks beforehand.	46	Sessions can be returned at any time and are monitored by the Hospital Planning Centre from three weeks beforehand.
47	Changes in session allocation are made by the OTC capacity planner up until two weeks beforehand and by the day coordinator from two weeks beforehand	47	Changes in session allocation can made by the OTC capacity planner.
48	Changes in session allocation are discussed between the OTC capacity planner and the OTC day coordinator in order to make sure that the right OTC staff are available for the sessions.	48	Changes in session allocation are discussed between the Hospital Planning Centre, the OTC capacity planner, the OTC manager and the OTC day coordinator in order to make sure that the right OTC staff are available for the sessions.
49	General Surgery requests all sessions that are returned by other medical specialties.	49	General Surgery receives almost all of the sessions that are returned by other medical specialties.
50	Dental Surgery intends to use the sessions as allocated in the initial OR master schedule.	50	Rule remains in the after period.
51	Neurosurgery intends to use the sessions as allocated in the initial OR master schedule, except for when the neurosurgeon is absent.	51	Rule remains in the after period.
52	Eye surgery uses extra sessions preferably for 'one eye' surgery and not for 'two eye' surgeries.	52	Rule remains in the after period.
		NEW 2	Eye Surgery requests extra sessions from the OTC capacity planner or OTC manager.
53	Outpatient secretaries monitor the waiting list development and advise the surgeons on returning or requesting sessions.	53	Some outpatient secretaries monitor the waiting list development, others don't. They do not advise surgeons on returning or requesting sessions.

Hospital-wide or local

Rule # (before / after)	Before: Hospital wide	Before: Dental surgery	Before: General surgery	Before: Gynecology	Before: Ear Nose and Throat surgery	Before: Eye surgery	Before: Neurosurgery	Before: Orthopedics	Before: Plastic surgery	Before: Urology	Before: Anesthesiology	After: Hospital wide	After: Dental surgery	After: General surgery	After: Gynecology	After: Ear Nose and Throat surgery	After: Eye surgery	After: Neurosurgery	After: Orthopedics	After: Plastic surgery	After: Urology	After: Anesthesiology
34 / 34	X											X										
35 / 35	X											X										
36 / 36	X											X										
37 / 37	X											X										
38 / 38	X											X										
39 / 39	X											X										
40 / 40	X											X										
41 / 41	X											X										
42 / 42	X											X										
43 / 43	X											X										
44 / 44	X											X										
45 / –	X																					
46 / 46	X											X										
47 / 47	X											X										
48 / 48	X											X										
49 / 49			X									X										
50 / 50		X											X									
51 / 51							X											X				
52 / 52						X											X					
– / NEW 2												X										
53 / 53		X	X	X	X	X	X	X	X	X					X		X	X				

Information carrier (R = Rule/O =) and Coordination mechanism

Rule # (before / after)	Info before: Document	Info before: Hospital Information System	Info before: People's knowledge	Info after: Document	Info after: Hospital Information System	Info after: People's knowledge	Coord. before: Mutual adjustment	Coord. before: Direct supervision	Coord. before: Standarization of work	Coord. before: Standarization of output	Coord. before: Standarization of skils	Coord. before: Standarization of norms	Coord. after: Mutual adjustment	Coord. after: Direct supervision	Coord. after: Standarization of work	Coord. after: Standarization of output	Coord. after: Standarization of skils	Coord. after: Standarization of norms
34 / 34	O		R	O		R	X		X				X		X			
35 / 35			R			R	X						X					
36 / 36			R			R	X						X					
37 / 37		O	R		O	R	X						X					
38 / 38	R			R			X			X			X			X		
39 / 39	R			R			X			X			X			X		
40 / 40			R			R	X			X			X					
41 / 41			R			R	X						X					
42 / 42	R		R	R		R	X					X	X					X
43 / 43	R		R	R		R	X		X				X		X			
44 / 44			R			R	X		X				X		X			
45 / –			R			R	X		X				X		X			
46 / 46	R		R	R		R	X		X				X		X			
47 / 47			R			R			X						X			
48 / 48			R			R	X						X					
49 / 49			R			R	X						X					
50 / 50			R			R	X						X					
51 / 51			R			R	X						X					
52 / 52			R			R			X						X			
– / NEW 2						R									X			
53 / 53			R			R	X						X					

Task 2: Make Clinical Bed Plan

Before period Rule #	Before period Rule	After period Rule #	After period Rule
Structuring time and space			
54	The clinical bed plan has the same time structure as the OR master schedule.	54	Rule remains in the after period.
55	There is a fixed number of beds allocated to defined nursing departments.	55	Rule remains in the after period.
56	Specific beds, identified by a bed number, are allocated to a medical specialty or surgery type on each weekday.	56	Allocated beds, identified by a bed number, are allocated to a medical specialty or surgery type on each weekday.
57	Patients under 18 years old are cared for in the Pediatric Department.	57	Rule remains in the after period.
58	Patients that go home after surgery on the same day are prepped and recover in the Daycare Department.	58	Patients who are scheduled to go home within 48 hours after surgery are prepped and recover in the Short Stay Department.
59	The Daycare Department closes at 9:30 pm.		Rule does not exist in the after period.
60	Patients under 18 years of age who go home after surgery on the same day are prepped and recover in the Pediatric Daycare Department.	60	Rule remains in the after period.
		NEW 3	Surgery patients are primarily admitted to nursing ward N2 before surgery.
61	General surgery patients are primarily in the Daycare Department and in nursing departments A2 and N2.	61	Post surgery General Surgery patients are primarily in the Short Stay Department and in nursing departments A2 and N2.
62	Orthopedic patients are primarily in the Daycare Department and in nursing department A2.	62	Post surgery Orthopedic patients are primarily in the Short Stay Department and in nursing department A2.
63	Neurosurgery patients are primarily in the Daycare Department before surgery and in nursing department N1 after surgery.	63	Post surgery Neurosurgery patients are primarily in nursing department N1.
64	Gynecology patients are primarily in nursing department B2.	64	Post surgery Gynecology patients are primarily in nursing department B2.
65	Plastic surgery patients are primarily in the Daycare Department and on nursing department A2.	65	Post surgery Plastic Surgery patients are primarily in the Short Stay Department.
66	Ear Nose and Throat patients are in the Daycare Department and on nursing department A2.	66	Post surgery Ear Nose and Throat patients are primarily in the Short Stay Department.
67	Dental surgery patients are primarily in the Daycare Department and in nursing department A2.	67	Post surgery Dental patients are primarily in the Short Stay Department and on nursing department B0.
68	Urology patients are primarily in the Daycare Department and in nursing department N2.	68	Post surgery Urology patients are primarily in the Short Stay Department and on nursing department N2.
69	Patients who require surgery and who entered the hospital through the Emergency Department are in the Acute Intake Department.	69	Rule remains in the after period.
70	Patients who require surgery and who enter the hospital through the Emergency Department but who are diagnosed in the outpatient department, are not admitted to the Acute Intake Department.	70	Rule remains in the after period.
71	Patients who have a trauma that has existed for more than one week, are not admitted to the Acute Intake Department.	71	Rule remains in the after period.
72	Patients admitted to the Acute Intake Department should leave the department within 48 hours.	72	Rule remains in the after period.
Setting the clinical bed plan			
73	For each OR session a number of beds is allocated to a medical specialty operating in the OR session per nursing department.	73	No beds are allocated for surgery patients on nursing wards A2, F2 and N2. For non-surgery patients a number of beds are allocated on nursing wards A2, the Short Stay Department and N2. For other nursing wards a number of beds for surgery patients are allocated to various medical specialties.
74	Final bed allocation to medical specialties is based on the surgeon allocated to the OR session and/or the type of surgery taking place.	74	Rule remains in the after period.

Hospital-wide or local

Before Rule #	After Rule #	Before period: Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	After period: Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology
54	54	X											X										
55	55	X											X										
56	56	X											X										
57	57	X											X										
58	58	X											X										
59		X																					
60	60	X											X										
	NEW 3												X										
61	61	X											X										
62	62	X											X										
63	63	X											X										
64	64	X											X										
65	65	X											X										
66	66	X											X										
67	67	X											X										
68	68	X											X										
69	69	X											X										
70	70	X											X										
71	71	X											X										
72	72	X											X										
73	73	X											X										
74	74	X											X										

Information carrier (R = Rule/O = and **Coordination mechanism**

Before Rule #	After Rule #	Information carrier Before period: Document	Hospital Information System	People's knowledge	Information carrier After period: Document	Hospital Information System	People's knowledge	Coordination Before period: Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Coordination After period: Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
54	54	R/O			R/O					X						X			
55	55	R/O	O	R	R/O	O	R			X						X			
56	56	O	O		O	O				X						X			
57	57			R			R			X						X			
58	58			R			R			X						X			
59		R		R						X									
60	60			R			R			X						X			
	NEW 3						R									X			
61	61			R			R	X		X				X		X			
62	62			R			R	X		X				X		X			
63	63			R			R	X		X				X		X			
64	64	R		R	R		R	X		X				X		X			
65	65			R			R	X		X				X		X			
66	66			R			R	X		X				X		X			
67	67			R			R	X		X				X		X			
68	68			R			R	X		X				X		X			
69	69			R			R			X						X			
70	70			R			R	X		X				X		X			
71	71			R			R			X						X			
72	72	R			R					X						X			
73	73	O	O	R	O	O	R	X		X				X		X			
74	74		O	R		O	R	X						X					

Task 2: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				ospital wide	ental surgery	eneral surgery	ynecology	ar Nose and Throat surgery	ye surgery	eurosurgery	rthopedics	lastic surgery	rology	nesthesiology	ospital wide	ental surgery	eneral surgery	ynecology	ar Nose and Throat surgery	ye surgery	eurosurgery	rthopedics	lastic surgery	rology	nesthesiology	ocument	ospital Information System	eople's knowledge	ocument	ospital Information System	eople's knowledge	utual adjustment	irect supervision	tandarization of work	tandarization of output	tandarization of skils	tandarization of norms	utual adjustment	irect supervision	tandarization of work	tandarization of output	tandarization of skils	tandarization of norms
Bed allocation and use																																											
		NEW 4	The Hospital Planning Centre is responsible for planning beds for surgery patients and for non-surgery patients on nursing wards A2, the Short Stay Department and N2.												X															O	R							X		X			
75	In principle medical specialties are only allowed to reserve beds that have been allocated to them according to the clinical bed plan.		Rule does not exist in the after period.	X																						R						X		X									
76	Bed allocation is tailored as much as possible to each medical specialty's demand for beds.		Rule does not exist in the after period.	X																								R				X											
77	Outpatient secretaries can request additional beds from the clinical bed planner.		Rule does not exist in the after period.	X																								R				X											
78	Based on the final OTC program and how many patients require a bed specific beds are allocated to specific patients, on the basis of practical experience and knowledge.	78	Rule remains in the after period.	X											X												O	R		O	R	X						X					
79	The medical specialty, as represented by the outpatient department, is responsible for reserving beds for patients six weeks ahead.	79	The Hospital Planning Centre is responsible for reserving beds for patients.	X											X													R	O	O	R			X						X			
80	The medical specialty, as represented by the outpatient department, is responsible for a good ratio between day care and clinical bed patients.	80	The Hospital Planning Centre is responsible for a good ratio between day care patients and clinical bed patients.	X											X													R			R	X						X					
81	The allocated beds in the clinical bed plan can be reserved for patients by outpatient secretaries without consultation with the clinical bed planner.		Rule does not exist in the after period.	X																								R						X									
82	Beds may be exchanged between sub-specialties within General Surgery (Vascular Surgery, Oncology and Trauma surgery) without consulting the clinical bed planner.		Rule does not exist in the after period.	X																								R				X											
83	A standard number of beds are reserved for as yet unknown emergency patients in nursing departments.	83	Rule remains in the after period.	X											X												O	R		O	R			X						X			
84	A bed that is required for a small number of hours per day is not reserved for one patient.	84	Rule remains in the after period.	X											X												O	R		O	R			X						X			
85	Deviations from the allocated number of beds in the clinical bed plan have to be discussed with the clinical bed planner.		Rule does not exist in the after period.	X																								R				X											
86	The clinical bed planner monitors the planning of OR sessions and bed reservations and takes proactive action if there is a risk of a possible mismatch between the number of patients and the number of available beds on specific days.	86	The central planners monitor the planning of OR sessions and bed reservations and take proactive action if there is a risk of a possible mismatch between the number of patients and the number of available beds on specific days.	X											X													R			R	X						X					
87	The clinical bed planner takes action two weeks ahead of planned surgeries.	87	The central planners take action three weeks ahead of planned surgeries. They have a meeting every Monday to discuss the surgeries of the upcoming three weeks.	X											X													R			R	X		X				X		X			
88	Requesting beds on short notice or reserving beds that are not allocated to your department according to the clinical bed plan, is not considered as be acceptable behaviour.		Rule does not exist in the after period.	X																								R				X					X						
89	The more outpatient secretaries share the need for beds on time and consult with the clinical bed planner on bed requirements the more she is willing to find a solution for any bed shortages. This is a give and take process.		Rule does not exist in the after period.	X																								R				X					X						
90	If a medical specialty does not behave as expected, the clinical bed planner waits with communication on a possible solution, in order to enforce improved planning behaviour for the future.		Rule does not exist in the after period.	X																								R				X					X						

Task 2: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
91	If no beds are available in the nursing department where a patient of a medical specialty should be, then the patient is allocated to another nursing department.	91	Rule remains in the after period.	X											X											R	O	R	R	O	R	X						X					
92	Shifting patients to a different nursing department is possible when the required level of care of the patient and the knowledge and skills of nurses, which are acquired in training, in the other nursing department matches.	92	Rule remains in the after period.	X											X											R		R	R		R	X				X		X				X	
93	If OR sessions are planned 100% for a specific medical specialty, then the allocation of beds in the clinical bed plan for that day is not applicable.		Rule does not exist in the after period.	X																								R				X		X									
94	If beds are not reserved two weeks ahead, the allocated beds in the clinical bed plan for that week are cancelled.		Rule does not exist in the after period.	X																						R						X		X									
95	If all allocated beds are reserved for a specific medical specialty, but the OR session is not, then the clinical bed planner contacts the outpatient department in order to discuss a possible need for additional beds.		Rule does not exist in the after period.	X																								R				X											
96	Patients for whom no bed is available yet or for which no allocated bed is yet required, are placed in the 'ball box'. This is a registry of all patients in the HIS, which includes all patients who are planned for surgery and allocated to a nursing department, but who do not yet have a reserved bed.		Rule does not exist in the after period.	X																							O	R				X		X									
97	The final bed allocation is made by the team leader of the nursing department, on the day before patient admission.	97	The final bed allocation is made by the Hospital Planning Centre for nursing wards A2, N2 and the Short Stay Department. For other nursing wards, the team leader of the nursing ward makes the final bed allocation on the day before the patient is admitted.	X											X												O	R		O	R			X						X			
98	In case of conflicts between the clinical bed planner and a medical specialty on bed requests, the clinical bed planner consults with the nursing departments team leaders and/or the OTC capacity planner in order to determine a common policy.	98	In case of conflicts on bed requests between the central planner and a medical specialty, the clinical bed planner consults with the nursing departments' team leaders and/or the OTC capacity planner in order to determine a common policy.	X											X													R			R	X						X					
99	Patients with sleeping apnea or lung surgery are cared for in the Intensive Care Department after surgery.	99	Rule remains in the after period.	X											X											R		R	R		R			X						X			
100	If there are only daycare patients on the waiting list of a medical specialty, it is allowed to request additional beds two weeks beforehand.		Rule does not exist in the after period.	X																								R				X		X									
101	Specific requests of patients, e.g., to stay in a single room, are taken into account and granted if possible.	101	Rule remains in the after period.	X											X													R			R	X						X					
102	If the expected length of stay of a patient is expected to be high or the patient is infected with MRSA, the outpatient secretary discusses the bed reservation with the clinical bed planner.		Rule does not exist in the after period.	X											X													R			R	X		X				X		X			
103	Oncology patients have priority over all other patients when allocating beds to specific patients.	103	Rule remains in the after period.	X											X													R			R	X		X				X		X			
104	Specific combinations of patients that are being cared for in nursing departments are averted, based on past experience. For example, one rule is that when a bed is required for a patient in nursing department N0, no vascular surgeries, which can have a heavy impact on the patient, should be planned for at the same time.	104	Rule remains in the after period.	X											X													R			R	X		X				X		X			

Task 3: Schedule surgeons and anesthesiologists

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Structuring time and space																																											
105	The surgeons' and anesthesiologists' schedules have the same time structure as the OR master schedule as far as surgery time is concerned.	105	Rule remains in the after period.	X											X											O		R	O		R			X						X			
106	The surgeons' and anesthesiologists' schedules use their own scheduling method for scheduling OTC, outpatient and clinical activities.	106	Rule remains in the after period.		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	O		R	O		R	X		X				X		X			
107	Each year there are predefined Anesthesiology and General Surgery meetings, during which surgeons are scheduled from 9 am at the earliest.	107	Rule remains in the after period.	X											X											O		R	O		R			X						X			
Setting the surgeon's and anesthesiologist schedules																																											
108	Each medical specialty schedules its own surgeons or anesthesiologists, based on sessions allocated in the OR master schedule.	108	Rule remains in the after period.	X											X											O		R	O		R			X						X			
109	The individual surgeon's schedule is tailormade and depends on the number and type of surgeries, the outpatient activities he or she does, on what days he or she works at Slingeland Hospital and on the surgeons' personal preferences.	109	Rule remains in the after period.	X											X											R		R	R		R	X						X					
110	Medical specialties are expected to allocate surgeons to specific OR sessions no later than 10 weeks ahead.	110	Rule remains in the after period.	X											X											R		R	R		R	X		X				X		X			
111	The surgeons' or anesthesiologists' considerations are in the lead regarding how the schedule is made within the medical specialty.	111	Rule remains in the after period.		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X		X	X	X			R			R			X						X			
	Each medical specialty follows its own scheduling policies, e.g.,:																											R			R												
112	The scheduling horizon varies per medical specialty, from three to six months ahead.	112	Rule remains in the after period.		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X			R			R			X						X			
	Surgeons are scheduled per week either on:																											R			R												
113	- fixed weekdays	113	Rule remains in the after period.		X			X	X	X		X	X	X		X			X	X	X		X	X	X	O		R	O		R			X						X			
114	- on different weekdays	114	Rule remains in the after period.			X	X				X						X	X				X				O		R	O		R			X						X			
	The following principles are agreed upon between surgeons and used for allocating OR sessions to specific surgeons:																											R			R												
115	- waiting list per surgeon	115	Rule remains in the after period.		X		X				X					X		X				X						R			R	X		X				X		X			
116	- proportionate allocation based on the number of working hours per surgeon	116	Rule remains in the after period.					X											X									R			R	X		X				X		X			
117	- an agreed distribution of outpatient, treatment and surgery activities among the surgeons within one medical discpline	117	Rule remains in the after period.				X											X										R			R	X		X				X		X			
118	- even distribution accross sub-specialties	118	Rule remains in the after period.			X											X											R			R	X		X				X		X			
119	- the way night and weekend shifts are allocated to surgeons.	119	Rule remains in the after period.				X											X										R			R	X		X				X		X			
120	If a surgeon operates extra hours, the extra time is returned to the surgeon.	120	Rule remains in the after period.						X											X								R			R			X						X			

Task 3: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	Before period											After period											Before period			After period			Before period						After period					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
121	After a night shift the surgeon has a day off work.	121	Rule remains in the after period.				X											X										R			R			X						X			
	Surgeons are scheduled for:																																										
122	- a full day (two OR sessions)	122	Rule remains in the after period.		X					X	X	X	X	X		X					X	X	X	X	X	O		R	O		R			X						X			
123	- half a day (one OR session)	123	Rule remains in the after period.		X		X	X	X							X		X	X	X						O		R	O		R			X						X			
124	- both full and half days.	124	Rule remains in the after period.			X					X						X					X				O		R	O		R			X						X			
125	In reduction weeks, sessions are either distributed accross available surgeons or all surgery activities are put on hold, if all surgeons are on leave at the same time.	125	Rule remains in the after period.		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	O		R	O		R	X						X					
126	Each medical specialty has its own agreements on who is allowed to take leave when.	126	Rule remains in the after period.		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	O		R	O		R	X						X					
	The schedule is made by an agent who is part of an outpatient department and who is the point of contact for discussion on the schedule. This can be:																											R			R												
127	- one surgeon	127	Rule remains in the after period.			X	X	X	X	X		X	X	X			X	X	X	X	X		X	X	X			R			R	X		X				X		X			
128	- the outpatient secretary	128	Rule remains in the after period.								X											X						R			R	X		X				X		X			
129	- an outpatient nurse.	129	Rule remains in the after period.		X											X												R			R	X		X				X		X			
130	For trauma patients, surgeons are scheduled on fixed days: every Tuesday afternoon and one weekend per month.	130	Rule remains in the after period.			X					X						X					X						R			R			X						X			
131	Orthopedic surgeons who work quickly, are not scheduled on Mondays because of the number of available beds on Monday.	131	Rule remains in the after period.								X											X						R			R	X		X				X		X			
132	Shifts are evenly distributed accross all surgeons, independent of the number of working hours.	132	Rule remains in the after period.				X											X								O		R	O		R	X		X				X		X			
133	In case surgeons perform surgeries together with another surgeon, dentist or orthodontist, the schedule is set in consultation between these practitioners.	133	Rule remains in the after period.		X	X			X			X				X	X			X			X					R			R	X		X				X		X			
134	Every day there has to be at least one surgeon available for doing breast cancer surgery; therefore they can never all take leave at the same time.	134	Rule remains in the after period.			X											X											R			R	X		X				X		X			
135	Schedules for assistant surgeons are not made by the scheduler; they make their own schedule for participating in surgeries	135	Rule remains in the after period.			X											X											R			R	X		X				X		X			
136	Complex lung surgeries are performed by two surgeons and therefore these surgeons never take leave at the same time.	136	Rule remains in the after period.			X											X											R			R	X		X				X		X			
137	Every day at least one surgeon from every sub-specialty - Vascular Surgery, Trauma Surgery or Oncology - must be available.	137	Rule remains in the after period.			X											X									O		R	O		R	X		X				X		X			
138	The surgeon looks one week ahead to see what he is going to do.	138	Rule remains in the after period.			X											X											R			R			X						X			

Tasks 6 and 11: Plan patient and control planning

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
				Before period											*After period*											*Before period*			*After period*			*Before period*						*After period*					
Rule #	Rule	Rule #	Rule	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Definition of surgeries																																											
139	A surgery type is defined by a surgery code and surgery name.	139	Rule remains in the after period.	X											X											R	O	R	R	O	R				X						X		
140	Each surgery type is allocated to one of nine medical specialties, with the exception of trauma surgeries.	140	Rule remains in the after period.	X											X											R	O	R	R	O	R				X						X		
141	Surgery codes of a medical specialty can only be registered in the HIS in sessions allocated to that medical specialty.	141	Rule remains in the after period.	X											X												O	R		O	R			X						X			
142	For surgeries that are not defined in a surgery code, the code 'Miscellaneous' is used.	142	Rule remains in the after period.	X											X												O	R			R				X								X
143	The use of the code 'Miscellaneous' is not accepted by the OTC capacity planner.		Rule does not exist in the after period.	X																								R									X						
144	Emergency surgeries are scheduled in HIS without a surgery code.	144	Rule remains in the after period.	X											X													R			R			X						X			
145	No elective surgeries are allowed to be scheduled in the emergency OR sessions, although in the HIS this is possible. Elective surgeries can be scheduled in emergency OR sessions when this is agreed upon	145	Rule remains in the after period.	X											X											R		R	R		R	X		X				X		X			
146	Emergency surgeries are registered into the emergency OR sessions, even when the time of surgery does not lie within the time frame of the OR session.	146	Rule remains in the after period.	X											X												O	R		O	R			X						X			
Required resources																																											
147	Specified surgery types can only performed by specific surgeons, based on what skills are required	147	Rule remains in the after period.		X	X	X	X	X	X	X	X	X		X											R		R	R		R					X						X	
148	Surgery types are performed by specific surgeons based on their personal preference	148	Rule remains in the after period.		X	X	X	X	X	X	X	X	X		X													R			R	X						X					
149	Specified surgery types can only performed by two surgeons within the same medical specialty, which is based on what skills are required.	149	Rule remains in the after period.		X	X	X	X	X	X	X	X	X		X											R		R	R		R					X						X	
150	Specified surgery types can only performed by two surgeons of two different medical specialties, based what skills are required.	150	Rule remains in the after period.		X	X						X			X											R		R	R		R					X						X	
151	Specified surgery types require specific medical instruments, equipment, accessories and/or materials with limited availability	151	Rule remains in the after period.		X	X		X		X	X	X	X		X											R	R	R	R	R	R			X						X			
152	Specified surgery types require experts with specific skills or knowledge, either from another hospital department (e.g., Radiology) of an external firm (e.g., for assisting with medical instruments)	152	Rule remains in the after period.			X					X	X			X											R	R	R	R	R	R					X						X	
153	Resource related rules are registerered in the HIS per surgery code and are shown when a patient is planned for that surgery type	153	Resource-related rules are registerered in a handbook and in the HIS per surgery code, and the relevant rules appear when a patient is scheduled for that surgery type.	X											X											R	O	R	R	O	R			X						X			
154	The HIS provides a signal in case more medical instruments of one sort are required than what is available	154	Rule remains in the after period.	X											X												O	R		O	R			X						X			
155	For surgeries a 'first responsible' OR nurse, who is specialized in a medical specialty through training, is required.	155	Rule remains in the after period.	X											X											R		R	R		R					X						X	
156	For specified surgeries the required equipment is operated by a Radiology staff member, except when a surgeon is capable of doing this himself, as a result of trained skills.	156	Rule remains in the after period.			X									X												O	R		O	R					X						X	
157	For surgeries two OR nurses are required from the OR nurses cluster to which a medical specialty belongs. A nurse cluster is based on trained skills of nurses.	157	Rule remains in the after period.	X											X											O		R	O		R					X						X	

Tasks 6 and 11: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	**Rule**	**Rule #**	**Rule**	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	**Dental surgery**	**General surgery**	**Gynecology**	**Ear Nose and Throat surgery**	**Eye surgery**	**Neurosurgery**	**Orthopedics**	**Plastic surgery**	**Urology**	**Anesthesiology**	**Hospital wide**	**Dental surgery**	**General surgery**	**Gynecology**	**Ear Nose and Throat surgery**	**Eye surgery**	**Neurosurgery**	**Orthopedics**	**Plastic surgery**	**Urology**	**Anesthesiology**	**Document**	**Hospital Information System**	**People's knowledge**	**Document**	**Hospital Information System**	**People's knowledge**	**Mutual adjustment**	**Direct supervision**	**Standarization of work**	**Standarization of output**	**Standarization of skils**	**Standarization of norms**	**Mutual adjustment**	**Direct supervision**	**Standarization of work**	**Standarization of output**	**Standarization of skils**	**Standarization of norms**
Demand management																																											
158	Each medical specialty has its own way of managing demand.	158	Rule remains in the after period.	X											X													R			R	X						X					
		NEW5	Surgeries and resources are scheduled in relation to urgency, waiting list and resource availability.												X														R		R							X		X			
159	Surgeries and resources are scheduled in relation to the first available surgeon.		Rule does not exist in the after period.		X	X		X			X	X	X														O	R				X		X									
160	Surgeries and resources are scheduled with the intention of filling OR sessions.		Rule does not exist in the after period.			X	X		X	X	X																	R						X	X								
161	The maximum number of weeks on the waiting list is defined and used for planning.		Rule does not exist in the after period.										X															R						X	X								
162	The maximum number of weeks on the waiting list is not defined nor used for planning.		Rule does not exist in the after period.		X		X	X		X			X															R				X		X									
163	Resources are mostly fixed and determine how many surgeries are performed, independent of demand.	163	Rule remains in the after period.		X					X						X		X	X	X	X		X	X				R			R	X			X			X			X		
164	If there is a population screening for breast cancer in the region, then OR sessions are reserved for these patients.	164	Rule remains in the after period.			X									X													R			R	X						X					
		NEW 6	The Hospital Planning Centre is responsible for planning beds for surgery patients in ORs 1 to 7 and for non-surgery patients on nursing wards A2, in the Short Stay Department and N2. The Hospital Planning Centre is also responsible for arranging preoperative preparations for the patient.												X															O	R							X		X			
		NEW 7	Every central planner is primarily responsible for a number of assigned medical specialties.												X																R									X			
		NEW 8	The surgeons and outpatient secretaries are responsible for planning surgeries in ORs 8 to 9 and for arranging beds via the Hospital Planning Centre for non-surgery patients.												X															O	R							X		X			
		NEW 9	For the same day emergency surgeries are planned by the surgeon and the outpatient secretary in consultation with the OTC day coordinator.												X																R							X		X			
		NEW 10	Vasectomy reversal surgeries are scheduled by the secretaries of the Urology outpatient department.												X																R										X		
Schedule surgeries																																											
165	Each medical specialty has its own way of scheduling surgeries.		Rule does not exist in the after period.	X																								R				X											
166	The surgeon or outpatient secretary schedules the surgery.		Rule does not exist in the after period.	X																							O	R				X											
		NEW 11	Patients go from the outpatient department to the front desk of the Hospital Planning Centre or they call the Hospital Planning Centre to discuss the surgery that is to be planned.												X																R							X		X			
167	The outpatient secretary initially schedules the surgery on paper, e.g., in a book, diary or ticket folder, and at a later stage, in the OR sessions in the HIS.	167	The central planner plans surgeries in the HIS as much as possible, and not in separate paper files.		X	X	X	X	X	X	X	X	X		X											O	O	R	O	O	R			X						X			
168	Surgeries can be scheduled until the OR session is filled to a maximum of 105%.	168	Surgeries can be scheduled until the OR session is filled to a maximum of 100%.	X											X												O	R		O	R			X						X			
169	Each OR session consists of surgery time and turnover time.	169	Rule remains in the after period.	X											X												O	R		O	R				X						X		
170	Standard turnover time is 10 minutes.	170	Rule remains in the after period.	X											X												O	R		O	R				X						X		
171	For Eye Surgery turnover time is 5 minutes.	171	Rule remains in the after period.						X											X							O	R		O	R				X						X		
172	For ENT sessions in which children are operated turnover time is 6 minutes.	172	Rule remains in the after period.					X							X												O	R		O	R				X						X		
173	A predefined number of surgeries per surgeon can be performed within one session.	173	Rule remains in the after period.						X											X							O	R		O	R				X						X		
		NEW 12	One reversal vasectomy may be planned per Urology session.												X																R										X		
174	Specified surgery types can be performed only at a maximum of specified times per OR session, based on either the surgeon's capacity or preference, the number of available medical instruments, the available number of beds or as a result of hospital policy with regard to children (a maximum number of children in surgery per day).	174	Rule remains in the after period.						X		X		X		X			X		X						R	R	R	R	R	R			X						X			
175	A surgery date is set after the preoperative screening has taken place and the anesthesiologist has approved of the surgery.	175	Rule remains in the after period.	X											X											R		R	R		R			X						X			

Tasks 6 and 11: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
176	A surgery date is set when the surgeon and patient decide upon the surgery, before the preoperative screening takes place.	176	Only for urgent surgeries is a surgery date set when the surgeon and patient decide upon the surgery, before the preoperative screening takes place.					X				X	X		X											O		R	O		R			X						X			
177	A surgery date is set when the insurance company or patient has given an approval.	177	Rule remains in the after period.									X											X			O		R	O		R			X						X			
178	Emergency surgeries are planned in elective OR sessions, when the surgery needs to be performed within two weeks.	178	Semi-urgent surgeries are planned following the same rules as for elective surgeries, and these are planned in regular OR sessions.			X									X												O	R		O	R			X				X		X			
179	OR sessions labelled as emergency sessions are intended for emergency patients who entered the hospital on the same day.	179	Rule remains in the after period.	X											X													R			R			X						X			
180	Emergency patients are allowed to be scheduled only by consultation with the OTC day coordinator.		Rule does not exist in the after period.	X																								R				X		X									
181	Elective surgeries are planned at the last possible moment, when no (more) emergency patients are expected to arrive. Elective surgeries fill any gaps in the available OR sessions.	181	Elective surgeries are provisionally planned two weeks ahead and confirmed or changed the day before surgery.			X									X													R			R	X		X				X		X			
182	Surgeries can be planned in the HIS 2 quarters ahead at the earliest. Surgeries that are planned early are planned outside the HIS, i.e., in a book, paper diary or on a whiteboard.	182	Rule remains in the after period.		X				X			X			X													R			R			X						X			
183	The patient is operated on by the surgeon who has set the diagnosis, except in cases where the timing of the surgery is essential, for surgeries in OR 8 and 9 and when the surgeon indicates otherwise and the patient agrees.	183	Rule remains in the after period.		X	X	X	X	X	X	X	X	X		X													R			R	X		X				X		X			
184	The assistant surgeon performs the surgery after consultation with the patient and/or the surgeon involved.	184	Rule remains in the after period.			X									X													R			R	X		X				X		X			
		NEW 13	For staffing reasons at least five overnight patients are required for the Short Stay Department.												X																R							X			X		
185	MRSA-infected patients are planned in consultation with the OTC capacity planner.		Rule does not exist in the after period.	X																								R				X											
186	A maximum of one MRSA-infected patient is allowed in the OTC on one day.	186	Rule remains in the after period.	X											X													R			R			X						X			
187	Patients who weigh over 150 kilograms who are operated on OR 8 or 9 require an OR table, instead of a chair.	187	Rule remains in the after period.	X											X													R			R			X						X			
188	Orthopedics schedules 20 prosthesis surgeries every week, 4 per day.		Rule does not exist in the after period.								X																	R							X								
189	Three gallbladder surgeries are planned for each Friday.		Rule does not exist in the after period.			X																						R							X								
190	Four sentinel node surgeries are performed on Mondays, after scintygraphy has taken place.		Rule does not exist in the after period.			X																						R							X								
191	For revisions, surgery is planned as soon as the delivery date of the required materials is known.	191	Rule remains in the after period.								X				X													R			R	X		X				X		X			
192	Eye surgeries for two eyes need to be performed using one and the same surgical technique and by the same surgeon.	192	Rule remains in the after period.						X											X								R			R			X						X			
193	A maximum of three patients who require intensive care in the ICU are allowed in one day on the OTC program. During reduction weeks, the maximum is two patients.	193	Rule remains in the after period.	X											X													R			R			X	X					X	X		
194	If the anesthesiologist has not approved the surgery two days before surgery, the surgery date needs to be rescheduled.	194	If the anesthesiologist has not approved the surgery the day before surgery, the surgery needs to be rescheduled.	X											X													R			R	X		X				X		X			
195	For prosthesis surgery no staff replacement is allowed during surgery.	195	Rule remains in the after period.								X	X			X													R			R			X						X			
196	Each anesthesiologist serves two ORs on one day.	196	Rule remains in the after period.	X											X													R			R			X						X			
197	For surgeries on children one anesthesiologist serves one OR.	197	Rule remains in the after period.	X											X													R			R			X						X			
198	Surgeries taking place in OR 8 and in OR 9 each require the supervision of one anesthesiologist.	198	Rule remains in the after period.	X											X													R			R			X						X			
199	The X-ray equipment is available primarily for Neurosurgery on Wednesdays.	199	Rule remains in the after period.	X											X													R			R	X		X				X		X			
200	When a surgeon is unexpectedly absent, surgeries are cancelled and outpatient activities are prioritized.	200	When a surgeon is unexpectedly absent, surgeries are rescheduled and the central planner consults with the outpatient department on any consquences.						X				X		X													R			R	X		X				X		X			

Tasks 6 and 11: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Surgery timing																																											
201	The surgery date is planned in accordance with the patient's preference.	201	The surgery date is planned in some degree in accordance with the patient's preference.		X	X	X	X	X	X	X	X	X		X													R			R	X						X					
202	Patients who use blood thinners have to be planned for a specific day at least five days ahead.	202	Rule remains in the after period.	X											X													R			R			X						X			
203	Specified surgery types need to be performed within days after the diagnosis is set, according to guidelines.	203	Rule remains in the after period.		X	X	X	X				X	X		X											R		R	R		R				X						X		
204	A patient surgery is planned on the first date that any surgeon is available.		Rule does not exist in the after period.			X	X	X		X		X	X															R				X		X									
205	The patient's surgery is planned for the first date that the surgeon who made the diagnosis is available.		Rule does not exist in the after period.			X	X	X		X		X	X															R				X		X									
206	Surgeries are performed as soon as possible in one of three hospitals within a regional network collaborative.	206	Rule remains in the after period.			X									X													R			R	X		X				X		X			
207	The timing of specified surgery types depends on the menstrual cycle of the patient.	207	Rule remains in the after period.				X								X											R		R	R		R	X		X				X		X			
208	Surgeries, for which specific equipment with limited availability is required (e.g., gammaprobe, lonestar, saw, drill) cannot be performed at the same time and/or at a specified maximum number of times a day.	208	Rule remains in the after period.	X											X											R		R	R		R			X	X					X	X		
209	The surgery for patients who have had a miscarriage are planned as soon as possible.	209	Rule remains in the after period.				X								X													R			R	X		X				X		X			
210	Patients in a dental treatment process are operated as soon as the braces are removed.	210	Rule remains in the after period.		X										X													R			R	X		X				X		X			
211	When surgery on two eyes must be performed at different times, there must be four weeks between the first and the second surgery.	211	Rule remains in the after period.						X											X						R		R	R		R			X						X			
212	Surgeries for which Radiology is required are not planned before 8:30 am because the Radiology Department starts working at 8:30 am.	212	Rule remains in the after period.	X											X											R		R	R		R			X						X			
213	When a different medical specialty uses the afternoon OR session, the medical specialty using the morning session has to be finished strictly at 12:30 pm.	213	Rule remains in the after period.	X											X													R			R			X						X			
214	Patients undergoing specified surgery types need be researched or prepared before surgery can take place (e.g., dental imprints, scintigraphy, urine or blood tests etc.). This has to be accounted for when scheduling the surgery.	214	Rule remains in the after period.		X	X			X				X		X											R		R	R		R			X						X			
215	Patients should be admitted to the hospital at least two hours before surgery.	215	Rule remains in the after period.	X											X											R		R	R		R			X						X			
216	Patients receiving a block should be admitted to the hospital at least two and a half hours before surgery.	216	Rule remains in the after period.	X											X													R			R			X						X			
217	Children shoud be admitted to the hospital at least 1 hour before surgery.	217	Rule remains in the after period.	X											X													R			R			X						X			
Surgery time																																											
218	The surgery time is proposed by the HIS and is based on the last 25 times that the specific surgeon has performed this surgery type.	218	Rule remains in the after period.	X											X												R			R					X						X		
219	The proposed surgery time may be changed by the surgeon or outpatient secretary.	219	The proposed surgery time may be changed by the surgeon or by the central planner.	X											X												O	R		O	R	X						X					
220	The surgery time depends on the surgical technique, anesthesia method, what is to be done in the surgery (e.g., one eye/two eyes, one finger/multiple fingers etc.) and the condition of the patient, the work pace of the surgeon.	220	Rule remains in the after period.	X											X													R			R	X						X					
221	The surgical technique of individual surgeons may vary for one surgery type and this has to be accounted for when registering the surgery time.	221	Rule remains in the after period.	X											X													R			R	X				X		X				X	
222	The anesthesia method impacts the surgery time.	222	Rule remains in the after period.	X											X													R			R	X						X					
223	Anesthesia method depends on the surgeon who performs the surgery, the patient's preference and/or the anesthesiologist's orders.	223	Rule remains in the after period.	X											X													R			R	X						X					

Tasks 6 and 11: (continued)

Before period		After period	
Rule #	Rule	Rule #	Rule
Order of surgeries			
224	The order in which surgeries are planned is determined by the OTC capacity planner.	224	The order in which surgeries are planned is determined by the central planners.
225	For children, the order in which surgeries are planned is determined by the Pediatric Daycare.	225	Rule remains in the after period.
226	Surgeries of patients with diabetes are scheduled for early in the day.	226	Rule remains in the after period.
227	Patients who receive a block as anesthesia, are scheduled preferably after 9:30 am.	227	Rule remains in the after period.
228	Surgeries of children are scheduled for early in the day.	228	Rule remains in the after period.
229	MRSA-infected patients are scheduled for the end of the day.	229	Rule remains in the after period.
230	Lengthy surgeries are preferably scheduled for the start of the day and shorter surgeries at the end.	230	Rule remains in the after period.
231	Surgeries for which the patient's body is marked are not scheduled for early in the day.	231	Rule remains in the after period.
232	Patients who require intensive care are not scheduled as the first patients in the OTC program.	232	Rule remains in the after period.
233	Patients with a latex allergy are preferable scheduled for early in the day.	233	Rule remains in the after period.
234	Patients who require an INR value test are preferably not scheduled for early in the day.	234	Rule remains in the after period.
235	Oral diabetes patients are preferably scheduled for early in the day.	235	Rule remains in the after period.
236	Insuline diabetes patients have to be admitted before 8:30 am, not scheduled as a first patient, but later in the morning.	236	Rule remains in the after period.
237	Ureterorenoscopy surgeries should be scheduled from 9:30 am, in case an X-ray has to be made.	237	Rule remains in the after period.
238	Sentinel node procedures are scheduled in the morning, apart from the sentinel node surgeries in OR 8 en 9.	238	Rule remains in the after period.
239	Patients with contact isolation are preferably scheduled for the end of the day.	239	Rule remains in the after period.
240	Carotis procedures are not scheduled for the start of the day.	240	Rule remains in the after period.
241	Small standard surgeries are scheduled between the morning and afternoon session in order to control variation for the entire day program.	241	Rule remains in the after period.
Finalise OTC program			
242	There is a weekly meeting between the OTC capacity planner, the outpatient secretaries and the nursing ward team leaders on the planning for the upcoming week.	242	
243	OR sessions are closed on Thursdays before 9:30 am for the upcoming week, which means that after that no surgeries can be scheduled for that week.	243	
244	When the OTC program is closed the following checks are made by the OTC capacity planner: Are surgery times well planned and realistic? Is the OR session filled sufficiently? How many IC patients are on the program? Did the anesthesiologist approve the surgery in the preoperative screening? Is Radiology required for the surgeries and can this be handled by one Radiology staff member? Are there enough available medical instruments for all surgeries planned? Are there enough available Storz endoscope for all surgeries planned? Are surgeries planned in the right OR? Are there any patient specifics indicated by anesthesiologists that need to be accounted for the order of surgeries? Are patients planned at the right time of day? Is the patient admission time correct? Is there a bed reservation?	244	

Rule #	Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
	Before period											After period											Before period			After period			Before period						After period					
	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Order of surgeries																																								
224	X											X													R			R			X						X			
225	X											X													R			R			X						X			
226	X											X											R			R					X						X			
227	X											X											R			R			X		X				X		X			
228	X											X											R			R					X						X			
229	X											X											R			R					X						X			
230	X											X											R			R			X		X				X		X			
231	X											X											R			R					X						X			
232	X											X											R			R					X						X			
233	X											X											R			R			X		X				X		X			
234	X											X											R			R			X		X				X		X			
235	X											X											R			R			X		X				X		X			
236	X											X											R			R					X						X			
237	X											X											R			R					X						X			
238	X											X											R			R					X						X			
239	X											X											R			R			X		X				X		X			
240	X											X											R			R					X						X			
241	X											X													R			R			X						X			
Finalise OTC program																																								
242	X											X											R			R			X		X				X		X			
243	X											X												O	R		O	R			X						X			
244	X											X											R			R					X						X			

Tasks 14,15,17,20,21 and 22: Prepare patient on ward, holding, perform surgery and aftercare on recovery and nursing ward, control OTC program

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Time Out Procedure																																											
245	Each step in the patient process is performed according to the Time Out Procedure (TOP). In the TOP standard procedures and required outcomes are specified in order for the patient to proceed to the next (sub)process.	245	Rule remains in the after period.	X											X												R			R				X	X					X	X		
246	Approval of surgeon	246	Rule remains in the after period.	X											X												R			R				X	X					X	X		
247	Nurse intake	247	Rule remains in the after period.	X											X												R			R				X	X					X	X		
248	Approval of anesthesiologist	248	Rule remains in the after period.	X											X												R			R				X	X					X	X		
249	Release OTC planning	249	Rule remains in the after period.	X											X												R			R				X	X					X	X		
250	Admission to nursing department	250	Rule remains in the after period.	X											X												R			R				X	X					X	X		
251	Sign in part 1	251	Rule remains in the after period.	X											X												R			R				X	X					X	X		
252	Sign in part 2	252	Rule remains in the after period.	X											X												R			R				X	X					X	X		
253	Pre-time out procedure in recovery	253	Rule remains in the after period.	X											X												R			R				X	X					X	X		
254	Time out in the Operating Room	254	Rule remains in the after period.	X											X												R			R				X	X					X	X		
255	Sign out in the Operating Room	255	Rule remains in the after period.	X											X												R			R				X	X					X	X		
256	Sign in at recovery	256	Rule remains in the after period.	X											X												R			R				X	X					X	X		
257	Check out of recovery	257	Rule remains in the after period.	X											X												R			R				X	X					X	X		
258	Checklist in nursing department by surgeon	258	Rule remains in the after period.	X											X												R			R				X	X					X	X		
259	Checklist in nursing department by nurse.	259	Rule remains in the after period.	X											X												R			R				X	X					X	X		
260	In the TOP for each step, all requirements that need to be met and checks that need to be performed are specified.	260	Rule remains in the after period.	X											X												R			R				X	X					X	X		

Tasks 14,15,17,20,21 and 22: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Prepare the patient on the ward																																											
261	The ward nurse prepares the patient for the holding area and makes sure that the patient is ready on time.	261	Rule remains in the after period.	X											X													R			R			X	X					X	X		
262	Ward nurses are allocated to specific rooms of patients.	262	Rule remains in the after period.		X											X												R			R			X						X			
263	Patients who receive a block go to the recovery area and not to holding.	263	Rule remains in the after period.	X											X											R			R					X						X			
264	The ward nurse who takes the patient to the holding performs the TOP procedure with a holding nurse.	264	Rule remains in the after period.	X											X												O	R		O	R			X						X			
265	Emergency patients are admitted to the Acute Admissions Department.	265	Rule remains in the after period.	X											X													R			R			X						X			
266	If a patient in the Emergency Department is operated on within half an hour, then the patient goes directly from the Emergency Department to the OTC.	266	Rule remains in the after period.	X											X													R			R	X		X				X		X			
267	The nurse anesthetist tells the ward nurse when to administer premedication with the patient	267	Rule remains in the after period.	X											X													R			R	X		X				X		X			
268	The nurse anesthetist tells the ward nurse when to take the patient to the OTC	268	Rule remains in the after period.	X											X													R			R	X		X				X		X			
269	Ward nurses serve each other's patients when this supports the flow of patients.	269	Rule remains in the after period.		X											X												R			R	X						X					
270	Ward nurses ask another ward nurse to check the medication that they administer to the patient.	270	Rule remains in the after period.	X											X													R			R	X		X				X		X			
271	If blood needs to be taken from the patient before surgery, the patient is sent to the lab. When the patient is not in a well enough state, the lab technician is asked to come to the nursing ward.	271	Rule remains in the after period.		X											X												R			R	X		X				X		X			
Prepare the patient in the holding																																											
272	The holding nurse prepares the patient for surgery and makes sure that the patient is ready on time.	272	Rule remains in the after period.	X											X													R			R				X						X		
273	Holding nurses insert patients with puncture drips, except when it is busy. Then this is done by the nurse anesthetist.	273	Rule remains in the after period.			X											X											R			R	X			X			X			X		
274	Nursing staff from outside the holding assist holding nurses at the start of the day, when it is busy.	274	Rule remains in the after period.			X											X											R			R	X						X					
275	There are standard procedures for preparing equipment, materials and medication.	275	Rule remains in the after period.			X											X									R			R					X						X			
276	There are standard procedures per anesthesia method on what patients are allowed to wear, e.g., glasses, make-up etc.	276	Rule remains in the after period.	X											X											R			R						X						X		
277	The nurse anesthetist who takes the patient from the holding area to the OR performs the TOP procedure with a holding nurse.	277	Rule remains in the after period.	X											X													R			R			X						X			
278	The nurse anesthetist stays with the patient from holding to recovery.	278	Rule remains in the after period.	X											X													R			R			X						X			

Tasks 14,15,17,20,21 and 22: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	Rule	Rule #	Rule	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Hospital wide	Dental surgery	General surgery	Gynecology	Ear Nose and Throat surgery	Eye surgery	Neurosurgery	Orthopedics	Plastic surgery	Urology	Anesthesiology	Document	Hospital Information System	People's knowledge	Document	Hospital Information System	People's knowledge	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms	Mutual adjustment	Direct supervision	Standarization of work	Standarization of output	Standarization of skils	Standarization of norms
Perform surgery																																											
279	The surgeon is responsible for the surgery and determines when to start and end with the surgery.	279	Rule remains in the after period.	X											X													R			R					X						X	
280	The anesthesiologist is responsible for the anesthesia and determines when to start and end anesthesia and any medication during the surgery.	280	Rule remains in the after period.	X											X													R			R					X						X	
281	The OR nurse assists the surgeon.	281	Rule remains in the after period.	X											X													R			R					X						X	
282	The nurse anesthetist assists the anesthesiologist and is responsible for monitoring the patient during surgery, informing the anesthesiologist on this.	282	Rule remains in the after period.	X											X													R			R	X				X		X				X	
283	All checks of the TOP are performed with all members of the operating team and the patient.	283	Rule remains in the after period.	X											X												R			R		X		X	X			X		X	X		
284	In case x-ray photos are taken during surgery, the OTC day coordinator or OTC secretary asks the Radiology Department to send someone to the OTC.	284	Rule remains in the after period.					X											X									R			R	X						X					
Patient care recovery																																											
285	The nurse anesthetist who takes the patient to recovery performs the TOP procedure with a recovery nurse.	285	Rule remains in the after period.	X											X												R			R		X		X	X			X		X	X		
286	The recovery nurse prepares the patient for transfer to the nursing department and makes sure that the recovery area does not get crowded.	286	Rule remains in the after period.	X											X													R			R	X		X	X			X		X	X		
287	The ward nurse that takes the patient to the nursing department performs the TOP procedure with a recovery nurse.	287	Rule remains in the after period.	X											X												R			R		X		X	X			X		X	X		
288	The patient is transferred to the nursing ward when all required PAR-scores are met.	288	Rule remains in the after period.	X											X												O	R		O	R	X		X	X			X		X	X		
289	Two recovery beds are allocated to specific recovery nurses for the day.	289	Rule remains in the after period.						X											X								R			R			X						X			
290	If a recovery nurse has few patients to care for, then the first entering patient is allocated to that nurse, if she desires. Patients are distributed equally.	290	Rule remains in the after period.						X											X								R			R	X						X					
291	In case PAR scores suggest that more medication is required, the recovery nurse consults with an anesthesiologist.	291	Rule remains in the after period.	X											X											R		R	R		R	X			X			X			X		
292	Recovery nurses have to ask another recovery nurse to check the medication that they administer with the patient	292	Rule remains in the after period.	X											X													R			R	X		X				X		X			
293	The recovery area closes at 6:00 pm.	293	Rule remains in the after period.	X											X													R			R			X						X			
294	In case surgeries run late, patients go directly to the Intensive Care Department.	294	Rule remains in the after period.	X											X													R			R	X		X				X		X			
295	In case x-ray photos are taken during surgery, a recovery nurse asks the Radiology Department to send someone to come to the recovery.	295	Rule remains in the after period.	X											X													R			R	X						X					

Tasks 14,15,17,20,21 and 22: (continued)

Before period		After period		Hospital-wide or local																						Information carrier (R = Rule/O =						Coordination mechanism											
Rule #	**Rule**	**Rule #**	**Rule**	*Before period*											*After period*											*Before period*			*After period*			*Before period*						*After period*					
				Hospital wide	**Dental surgery**	**General surgery**	**Gynecology**	**Ear Nose and Throat surgery**	**Eye surgery**	**Neurosurgery**	**Orthopedics**	**Plastic surgery**	**Urology**	**Anesthesiology**	**Hospital wide**	**Dental surgery**	**General surgery**	**Gynecology**	**Ear Nose and Throat surgery**	**Eye surgery**	**Neurosurgery**	**Orthopedics**	**Plastic surgery**	**Urology**	**Anesthesiology**	**Document**	**Hospital Information System**	**People's knowledge**	**Document**	**Hospital Information System**	**People's knowledge**	**Mutual adjustment**	**Direct supervision**	**Standarization of work**	**Standarization of output**	**Standarization of skils**	**Standarization of norms**	**Mutual adjustment**	**Direct supervision**	**Standarization of work**	**Standarization of output**	**Standarization of skils**	**Standarization of norms**
Aftercare patient																																											
296	The ward nurse prepares the patient for going home.	296	Rule remains in the after period.	X											X													R			R			X	X					X	X		
297	The surgeon visits the patient and checks his or her condition, thereby informed by a ward nurse.	297	Rule remains in the after period.	X											X													R			R	X						X					
298	The patient is discharged based on the checks as specified in the TOP procedure.	298	Rule remains in the after period.	X											X												O	R		O	R			X	X					X	X		
Manage OTC day program																																											
299	All surgeries have to be finished at 4 pm	299	Rule remains in the after period.	X											X													R			R			X						X			
300	No more than two operating rooms are allowed to finish late.	300	Rule remains in the after period.	X											X													R			R				X						X		
301	If the OTC program is (possibly) running late, the OTC day coordinator consults with the anesthesiologist on changing the OTC program, e.g., regarding shifting or cancelling surgeries.	301	Rule remains in the after period.	X											X													R			R	X						X					
302	If the OTC program is (possibly) running late, the anesthesiologist consults with the involved surgeon(s).	302	Rule remains in the after period.	X											X													R			R	X						X					
303	On one day one anesthesiologist acts as point of contact for the OTC day coordinator.	303	Rule remains in the after period.	X											X													R			R	X						X					
304	If the OTC program is (possibly) running late, the surgeon may decide to skip breaks.	304	Rule remains in the after period.					X											X									R			R	X						X					
305	The OTC capacity planner monitors real time course of the OTC program and estimates whether any delays in surgeries impact the course of the OTC program as a whole.	305	Rule remains in the after period.					X											X									R			R			X						X			
306	The OTC capacity planner monitors all potential factors that cause the OTC day program to run late, using rules such as:	306	Rule remains in the after period.					X											X									R			R			X						X			
307	- OR sessions that are filled 105% may run late	307	Rule remains in the after period.					X											X									R			R				X						X		
308	- Estimated surgery time is (un)reliable depending on the medical discipline or surgeon who scheduled the surgery	308	Rule remains in the after period.					X											X									R			R				X						X		
309	- Large complex surgeries that are on the OTC program in the afternoon increase probability of lateness	309	Rule remains in the after period.					X											X									R			R				X						X		
310	- Surgery time of 31 minutes is unreliable because this is the default surgery time as set by the HIS	310	Rule remains in the after period.					X											X									R			R				X						X		
311	- If the time planned for anesthesia with blocks is too low, there is possible delay	311	Rule remains in the after period.					X											X									R			R				X						X		
312	- If preoperative screening has not been performed, then the surgery may have to be postponed	312	Rule remains in the after period.					X											X									R			R			X						X			
313	- Specific issues related to the condition of the patient may cause surgeries to take more time than the scheduled surgery time.	313	Rule remains in the after period.					X											X									R			R				X						X		
314	Every day there is a clinical bed meeting with the OTC capacity planner and the team leaders of the nursing wards to discuss today's bed allocation.	314	Every day there is a meeting with the central planners, the OTC day coordinator and the team leaders of the nursing wards to discuss the day's bed allocation.	X											X											R			R			X		X				X		X			

APPENDIX 5.4: PERFORMANCE INDICATORS

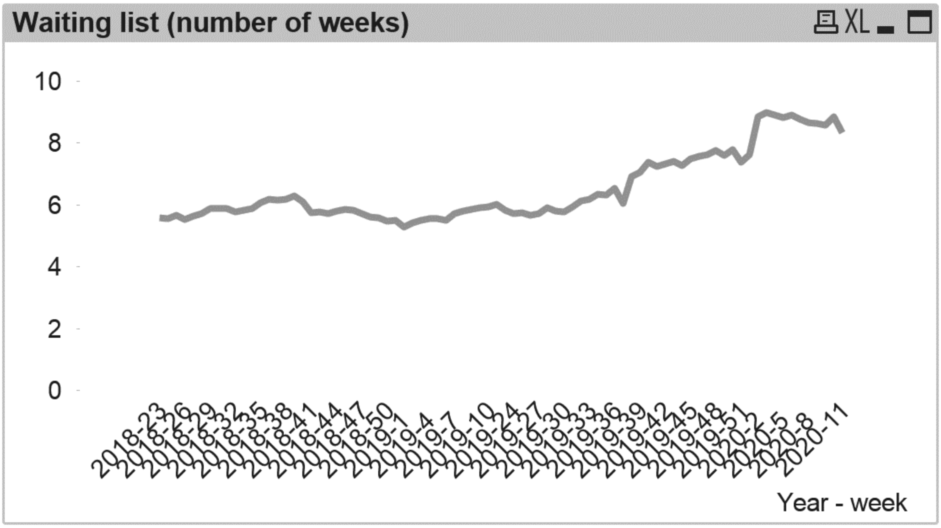


Figure A5.4.1 Waiting list development.

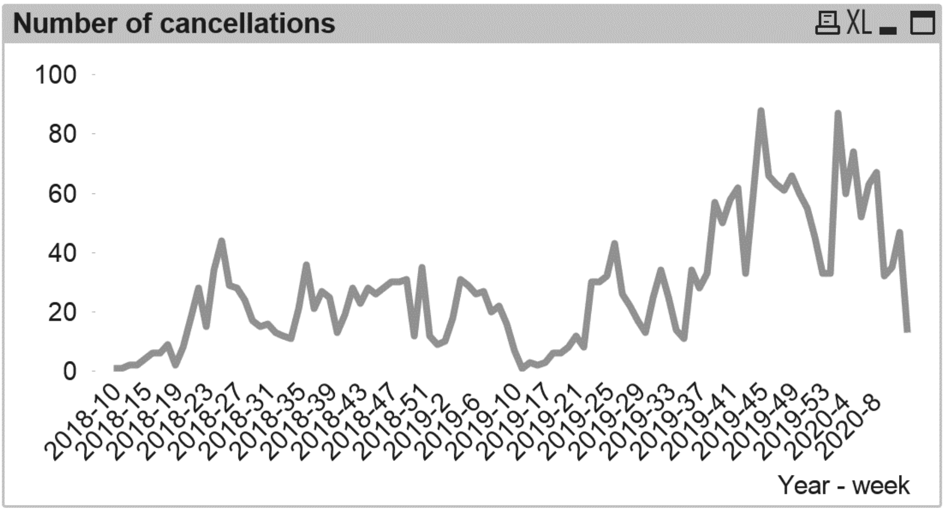
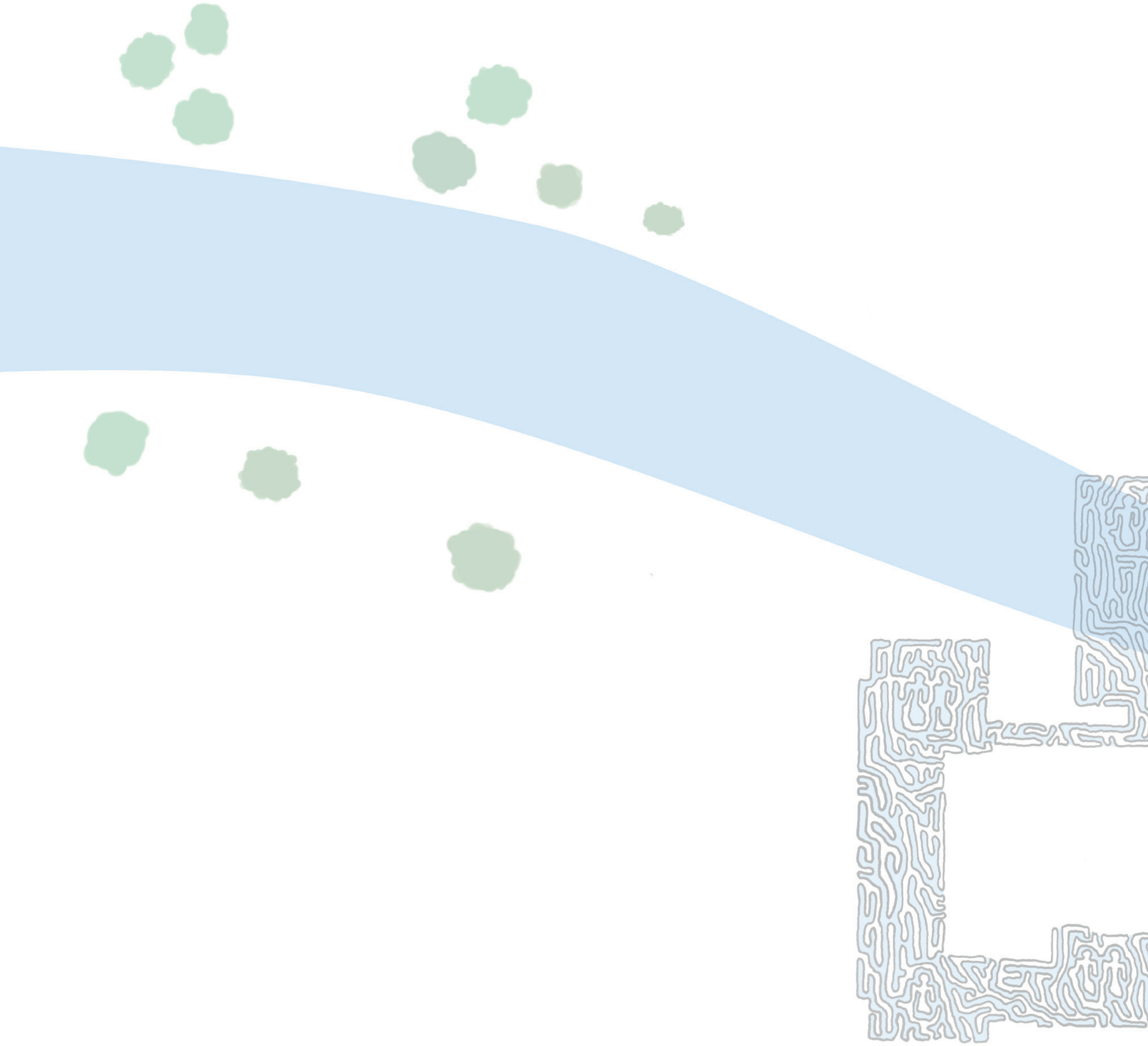


Figure A5.4.2 Number of cancellations.

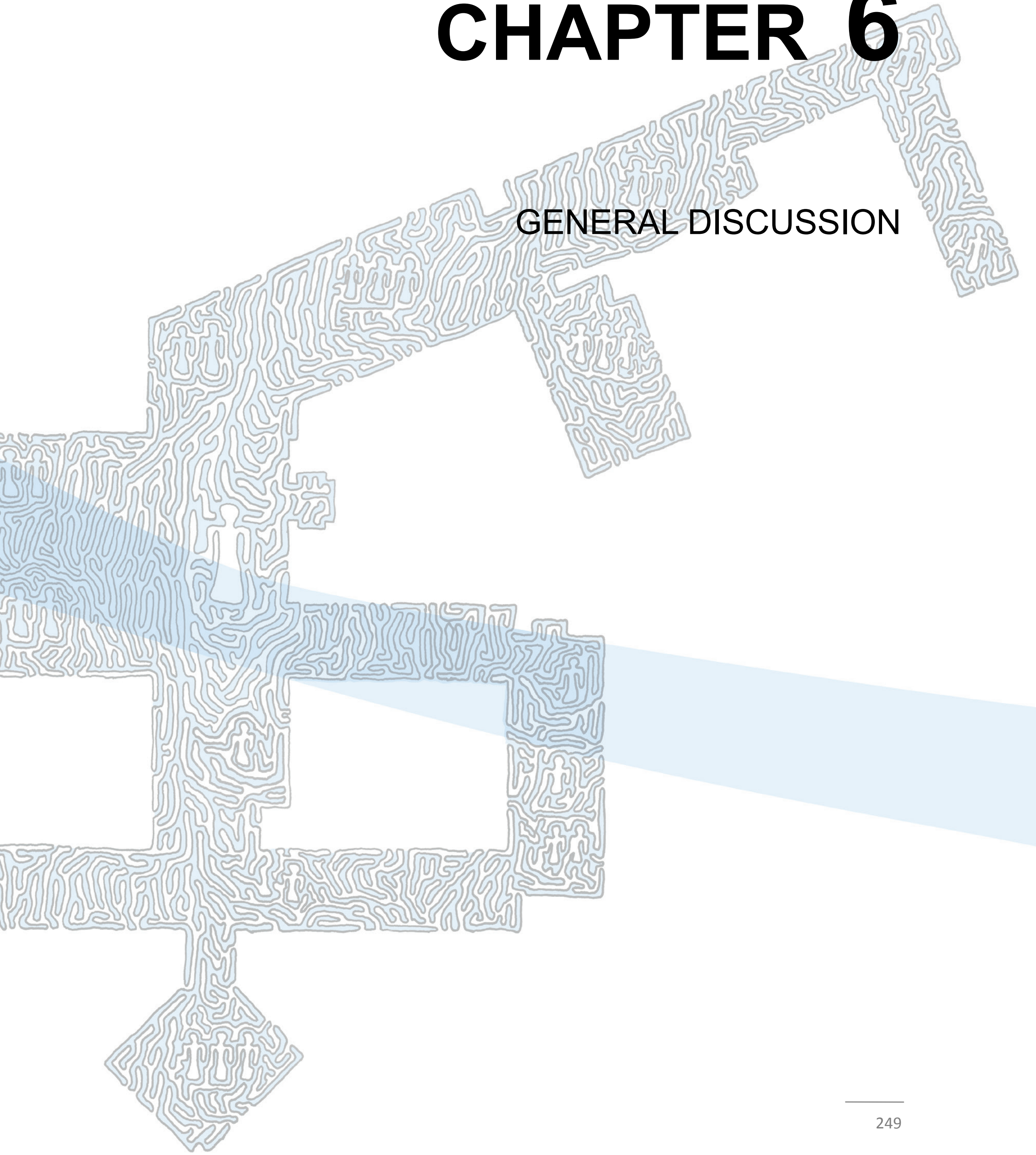
Table A5.4.1 Registered reasons for cancellation in the before and after period.

Reason for cancellation	Before		After		Change
	Number	***%***	***Number***	***%***	
Entered incorrectly in system	338	34%	921	49%	172%
Patient wishes different OR date	216	22%	262	14%	21%
OTC program too large	75	7%	49	3%	-35%
No preoperative approval	59	6%	60	3%	2%
Illness patient	56	6%	57	3%	2%
Cancelled in consultation with parents/physician	54	5%	55	3%	2%
Patient cancelled surgery	31	3%	54	3%	74%
Cancelled for emergency surgery	30	3%	86	5%	187%
Absent surgeon	29	3%	11	1%	-62%
No Intensive Care bed available	20	2%	18	1%	-10%
Cancelled because of MRSA bacteria	17	2%	3	0%	-82%
OTC program too small	15	1%	17	1%	13%
Reservation removed	11	1%	2	0%	-82%
No medical instruments available	8	1%	10	1%	25%
Medical condition observed when patient on OR	8	1%	4	0,2%	-50%
No approval from co-practitioner	7	1%	4	0,2%	-43%
Patient did not stop medication	6	1%	4	0,2%	-33%
Surgery date is yet unknown	4	0.4%	214	11%	5250%
No available nurse anesthetist	3	0.3%	2	0,1%	-33%
Admission stop	3	0.3%	5	0,3%	67%
Patient has eaten/drunk before surgery	3	0.3%	4	0,2%	33%
Patient has been operated on	3	0.3%	1	0,1%	-67%
Ilness surgeon	3	0.3%	7	0,4%	133%
No implants available	1	0.1%		0,0%	-100%
Lack of staff in the OTC	1	0.1%	15	1%	1400%
Surgery is combined with other surgery	1	0.1%	2	0,1%	100%
Equipment broke down	1	0.1%	6	0,3%	500%
Patient went home	1	0.1%		0,0%	-100%
Medical diagnosis changed			5	0,3%	
Patient has not responded			2	0,1%	
Patient cannot be contacted			4	0,2%	
Patient did not show up			3	0,2%	



CHAPTER 6

GENERAL DISCUSSION



GENERAL DISCUSSION

"We often achieve our success through the collaborations we have and the bonds we have among ourselves, which are very good. When I am involved in planning issues, I often succeed in planning, not so much because there is capacity somewhere, but because of the cooperation and the fact that everyone is willing to cooperate. You get results because of good relationships and not necessarily due to the right configuration of the system."

This statement was made by the Operating Theatre Complex (OTC) capacity planner of Slingeland Hospital in 2018 and has a similar ambiguity with regard to hospital logistics as the statements of the surgeon of the same hospital in **Chapter 1**. The surgeon states that on the one hand, hospital logistics can be planned, because he perceives patient demand as stable and predictable, and at the same time, he indicates that planning ahead makes no sense as things change all the time. The OTC capacity planner indicates that on the one hand planning succeeds because of good collaboration, and at the same time she believes that the system is poorly configurated.

As stated in **Chapter 1**, the aim of this thesis is to thoroughly understand how a hospital's logistical system works, i.e., to what extent there is integration and differentiation and how rules and coordination mechanisms shape the hospital's network structure. By deepening and developing the concept of integration, we aim to operationalize the concept better for hospital practice, thereby explaining the apparent ambiguities in hospital operations as illustrated by the OTC capacity planner's and surgeon's statements.

In this final chapter, we will first present the main findings and then reflect on these from a theoretical and methodological perspective. Accordingly, future directions for practice, policy and research will be recommended.

MAIN FINDINGS

First of all, a scoping study (**Chapter 2**) was conducted in order to understand the state of affairs in hospitals with respect to logistics and integration. More specific, logistical parameters that are mentioned in the international literature with regard to hospital logistics were identified, as well as the way literature reflects integration in hospitals. The scoping study shows that in international literature, there is fragmentation with regard to hospital logistics. In literature, 106 logistical parameters are identified, which are studied in the context of 92 subsystems, i.e., parts of hospitals with tasks related to specific departments, flows or processes. Among the most mentioned logistical parameters were length of stay, waiting time, resource utilization and lead time. Studies focus mostly on patient flows and a minority of selected articles concern material or staff flows. One percent of the selected papers focus on both patient and material flows. Thus, although in many of the 287 studied papers integration was advocated, hospital logistics is barely studied in a hospital-wide setting including all departments, flows and processes. A clear view on how integration could enhance hospital performance could not be derived from international literature on hospital logistics.

In our first case study (**Chapter 3**), the extent to which integration and differentiation exist in practice was studied through social network analysis. For organizing and performing surgeries, 23 logistical tasks that are performed in-hospital were identified. Tasks are performed by 635 different agents of 26 different agent types, who interact via 31,499 ties. Agent types include a ward nurse, a surgeon, and an OTC capacity planner among others.

Agents are involved in different tasks both related to patient, material and staff flows, suggesting integration. Integration is further observed by the 65% of all agents who participate in multiple cliques, both for the performance of one task and across related tasks. Secondly, a number of centrally positioned cliques, which connect more peripherally positioned cliques, demonstrate integration. Thirdly, there are relatively large differences between agents degrees and betweenness centrality, indicating the existence of brokers performing integrative activities. Several agents act as brokers, i.e., they have a central position between otherwise separated groups of agents or subsystems, thus contributing to integration. Nurse anesthetists and nurses in the nursing wards, holding and recovery are most central, based on degree and betweenness centrality. The OTC day coordinator and the OTC capacity planner are the only two central agents in the network whose primary tasks involve coordination and planning, which are typical broker tasks. Agents with hierarchical positions, e.g. team leaders or managers, contribute relatively little to integration, based on their low degree and betweenness centrality.

With regard to differentiation, network density and cliques of agents performing the same task were identified. It was observed that with a network density of 0.16, that is the percentage of ties agents have in relation to the number of ties they could have if they were all connected, the hospital network integration is relatively low. Low network integration suggests that there are agents or groups that are less connected, demonstrating the presence of subsystems and differentiation. Groups of agents who share the same task or knowledge were identified, as illustrated by the 8,698 cliques that were found. Differentiation results from task segmentation based on medical disciplines, organizational units, length of stay and patient characteristics, i.e., age and condition.

The social network analysis of Chapter 3 identifies the network structure and the agents' positions. What happens between agents and why they interact this way is explained in **Chapter 4**. In **Chapter 4** the rules and coordination mechanisms observed in the social network analysis are identified. Rules result from defined or accepted ways of performing tasks and can be documented, exist in people's minds, or both. Rules can be hospital-wide or local, i.e., used by a particular department, group of people or person. Coordination mechanisms, which are based on these rules, require interactions between agents. Different coordination mechanisms result in different interaction patterns, resulting in a certain network structure, i.e., integration and differentiation.

For planning and performing surgeries, 314 rules were found, of which the majority (70%) apply hospital-wide. However, rules are not always generally known as these are largely undocumented; 31% of all rules are written down in documents and 7% are in the hospital's information system. Moreover, 82% of all documents concern local or personal documents, such as checklists and memos, or were delivered in internal presentations. As a consequence, rules are often shared throughout the hospital through social interaction. As a consequence, 85% of all rules exist predominantly in people's minds.

Task performance is mostly coordinated through standardization of work (67%) and mutual adjustment (49%). In the early stages of planning, there is mainly mutual adjustment using hospital-wide rules; whereas closer to the day of surgery, there is more standardization of work, based on both hospital-wide and local rules. The scheduling of surgeons and anesthesiologists is mainly based on locally standardized working procedures that physicians agree upon within their own medical discipline.
It was observed that planning processes start with long-term schedules, which are based on largely fixed time and space structures. These schedules are not based on future patient demand, resulting in a push system[1], which creates open loops. Open loop systems are affected by their environment, but do not utilize feedback, nor take action to improve the workflow, which potentially leads to instability[2]. In the shorter term, these schedules are subsequently adapted to the circumstances through negotiation by agents in the social network, using pull[1] principles, thereby closing the loops. The interaction between agents mainly serves to observe the expected future as well as the current state of the system, and

to continuously adapt the hospital's system, taking into account the rules. Most agents interact shortly before or on the day of surgery.

The network changed in 2019 when the Hospital Planning Centre (HPC) was introduced, as described in **Chapter 5**. This chapter evaluates whether integration, differentiation, coordination mechanisms and performance change after this organizational intervention. First of all, the overall network integration increased slightly (4%), based on density. This means that the number of ties between agents in relation to the number of ties they could have if they were all connected, has increased. On a task level, network integration remained the same for eight tasks, while a clear increase in network density was observed for three tasks: for making the OR master schedule (209%), for planning patients (83%) and for controlling the planning (356%). In addition, the OTC manager gained a more central position, and the OTC capacity manager took a much less central role, as most of her tasks were taken over by six central planners who had taken central positions. Differentiation based on medical discipline, length of stay and patient characteristics remained.

After the HPC was introduced, there are 7% more hospital-wide and 38% less local rules, as several rules became the hospital-wide standard or new hospital-wide rules were set. Rules remained for 85% in people's minds, and there was an increase of 2% in documented rules. Coordination mechanisms also remained largely the same after the HPC was introduced, being mainly standardization of work (70% after, compared to 67% before) and mutual adjustment (47% after, compared to 49% before).
Bed utilization increased by 11%, and peak values for bed and OR utilization decreased. Remarkable increases in waiting list length of 21% and cancellations of 88% were observed following the introduction of the HPC. Variability in bed and OR utilization remained the same, while waiting list variability increased by 19%.

THEORETICAL REFLECTIONS

As stated in Chapter 1, the research undertaken for this thesis focuses on integration and differentiation as it is observed in practice. Theory was mainly used as an instrument, firstly, to position our research perspective, secondly, to understand integration and differentiation, thirdly, as theory for data analysis, and fourthly, to relate the findings from hospital practice to existing theories. In this section, we first reflect on how the findings relate to the concept of integration and differentiation as it is described in a hospital context in literature.

The concepts of integration, differentiation and fragmentation

With regard to the concept of integration, we agree with others[3-5] that integration involves the alignment of activities along the patient or material flow for which coordination of operations between different members is required. In addition, we have taken a process orientation for this study, which is common for many studies in this field[6]. Integration is important because more efficient hospitals score high on cooperation, while efficient departments within a hospital do not necessarily contribute to the hospital's overall efficiency[7]. In literature, the oft mentioned functional organization of medical disciplines was also found in the case studies (Chapters 3 to 5). However, while literature states that there is a lack of integration in hospitals, integration was observed in our case studies. Integration is achieved by agents who interact in social network structures, thereby connecting the different subsystems through coordinative activities.

In literature, fragmentation is often directly attributed to a lack of integration, thereby suggesting that integration is good on its own. But, similar to Munavalli et al.[2], who warn us not to use words such as 'lean', 'push and pull' normatively, the concept of integration should not be used normatively either. What is the appropriate integration or differentiation depends on the demands from the environment that the hospital needs to respond to, which is in line with Lawrence and Lorsch[8]. As defined in Chapter 1, differentiation refers to 'the state of segmentation of the organizational system into subsystems'[8]. Differentiation is a result of a division of tasks among groups of agents. There is fragmentation when task performance in subsystems is not aligned when this is necessary for the organization to be able to respond to the environment's needs. When task alignment is not necessary, there is differentiation, but no fragmentation. In line with Lawrence and Lorsch[8], we therefore believe that integration should not be seen as the opposite of fragmentation.

Integration and differentiation in hospital practice

To the best of our knowledge, our study is the first to identify hospital-wide integration and differentiation for hospital logistics using social network analysis. This research, therefore, responds to the statement that most studies are theoretical, not empirical, and fail to address the entire hospital supply chain or network (Chapter 2). As a consequence, the findings with regard to integration and differentiation, as found in these hospital case studies, cannot be directly related to other hospital case studies in literature. We will therefore reflect on integration and differentiation in hospital practice, based on social network and organizational theory that was developed outside a hospital context.

In line with several authors[5,7,9] who refer to the functional organization of medical disciplines as a cause for a lack of integration, this study clearly shows that there is differentiation in hospitals. Differentiation comes naturally in hospitals, as it is inextricably linked to medical and nursing tasks for which specific knowledge and experience are required in relation to the many different patient groups that are serviced. Differentiation is complex because of multiple differentiation principles. Besides on medical discipline, differentiation is based on length of stay, patient characteristics and division of labour. Subsystems result from one of more differentiation principles and surgeons and anesthesiologists perform tasks in multiple subsystems.

Whether integration is lacking, is just right or there is too much of it, depends on how interdependent differentiated tasks are, and to what extent integration is required to meet the demands of the environment. From this study, it has become clear that subsystems depend on one another, because tasks performed in subsystems are time related, i.e., these are sequential or to be synchronized, or they share the same resources. Integration appears to be developed because of these dependencies, when open loops are detected mainly by nurses, surgeons, anesthesiologists and coordinators. They detect (potential) instability that results from misaligned tasks or mismatches between planned patients and required resources. They accordingly perform integrative tasks by interacting with others, thus acting as brokers. The potential causes for instability are mostly revealed to agents shortly before, or on the day of surgery. As a result of their integrative (inter)actions, they have gained a central position in the network, which is more central than agents with formal hierarchical positions.

Thus, integration and differentiation in hospitals do not seem to be designed or planned beforehand in conjunction with each other. They – and in particular, integration - seem to be developed when the need for it emerges. This is in line with Lawrence and Lorsch's statement that 'when the environment requires both a high degree of subsystem differentiation and a high degree of integration, integrative devices will tend to emerge.'[8] As a result of differentiation and the resulting interdependent subsystems, there is a 'felt need for joint decision making'[8]. Following this line of reasoning, the HPC may have emerged as well. The findings suggest that the HPC was planned and designed to a limited extent, because rules remained largely undocumented and coordination mechanisms remained the same. Tummers et al.[10] found evidence that agents with high autonomy adapt organizational structure to fit their own work needs. Perhaps, a hospital's organizational structure develops in the way described by Tummers et al.[10].

At the same time, this study demonstrates that in particular differentiation seems to be partly immutable. From Chapter 5, it was observed that after the introduction of the HPC the scheduling of surgeons remained differentiated, and because surgeons' schedules were not aligned, there was still fragmentation. Considering the fact that hospital performance did not increase after the introduction of the HPC, we believe a more conscious and deliberate approach to achieving integration and differentiation is needed.

A deliberate approach to integration and differentiation

Considering the suggestions of several researchers that logistics in a hospital could be very hard to oversee[3,6,11-13] and statements that network structures are effective for dealing with complex issues[14,15], achieving integration through social relations might be indispensable for a hospital to function effectively. However, this study shows that, even though the observed self-organizing and adaptive abilities may be a strength of the hospital, performance does not increase by the agents' initiatives alone. Certainly, the integration, as found here is 'right' in the sense that it is there for several reasons. In other words, the ways through which integration is achieved would probably not have existed if there was no need for it. But the fact that integration is there and that it has emerged from the need for alignment does not necessarily mean that the hospital has achieved the right degree of integration and differentiation, nor that integration will always be there as some sort of rule of nature. We believe that we should not merely trust that integration will emerge whenever it is needed, but that a more deliberate and conscious approach towards achieving integration is required for several reasons.

Firstly, whereas differentiation is naturally there in hospitals, as pointed out by many authors[4,7], integration is not so self-evident. If there are no agents who feel or see the need or responsibility to coordinate and align activities, or if they are temporarily absent, there are no other mechanisms in place to make sure that the required integration is achieved and that loops are closed. And, even if these agents are there, the alignment of tasks can be extremely challenging and, as the OTC capacity planner's statement lightly indicates, it could lead to frustration with how the systems works. This could even lead to the rejection of the idea that the system is functioning properly, thereby ignoring the qualities of the social network altogether.

Secondly, from Chapter 5 we observe that more integration has not led to an overall higher performance. This is partly because open loops are partly 'programmed' into the system, with largely local undocumented working procedures and long term schedules that are not based on future patient demand. The phenomenon of open loops has also been identified by Munavalli[2] who proposes real-time planning methods for closing the loops. We believe that the introduction of the HPC is a step in the right direction for effectively closing the loops, because network integration has increased in some parts of the network, i.e., there are more central agents who connect subsystems. However, we also believe that integration is lacking, because not all differentiated tasks are aligned by the HPC, when they should be. The HPC plans specific patient groups, thereby excluding non-surgery patients who need beds in the same nursing wards as surgery patients. Also, surgeons' schedules are not controlled or coordinated by the HPC. As argued in Chapter 5, there should be hospital-wide integration and horizontal coordination, as described by Aoki[16]. Integration should be strengthened by creating hospital-wide understanding of the whole work process by all agents and their internalizing the organizational goals.

In addition, we agree with Galbraith[17] that the social network should be viewed as an information processing system. From our findings we conclude that information needs are fulfilled both by social interaction and the hospital information system, i.e., the social network exists in an addition to the more formal information systems. In line with Van Merode et al.[4], information systems can facilitate differentiated task performance under less dynamic circumstances, and for alignment of differentiated complex tasks under changing circumstances, social interaction is required in addition to that.

Because, according to Lawrence and Lorsch, 'integration and differentiation are essentially antagonistic'[8], trade-offs have to be made explicitly with regard to several topics. In our case studies, we observed that both planning standards and mutual adjustment are used, that there is both long term forecasting and short term planning and fine-tuning, based on both central and decentralised control. If we consider each topic to have two extreme ends, then the extent to which one or the other is required depends on the demands of the environment. Environments' demands can vary per medical discipline and change over time. For example, in our study period, eye surgery appeared to have a relatively stable demand for performing mainly cataract surgeries in one OR, while trauma surgeries involve more uncertainty, require a short-term orientation and less structured interaction structures[8]. Both medical disciplines may require - and have in our case study - a different degree of integration and differentiation. Essentially integration and differentiation are dynamic concepts, as circumstances will continue to change, and agents will see or identify new integration needs over time. We believe learning processes are essential to continuously achieve the right degree of integration and differentiation. Through expansive learning, as described by Engeström[18], engaged agents that have differentiated tasks produce new patterns of activity, driven by their shared responsibility for patients. According to Aoki[15], horizontal coordination involves collective learning and knowledge sharing based on informal and mostly verbal communication, for example, by job rotation[16], which will increase the hospital-wide comprehension of processes.

Connecting existing theories on planning and integration

In summary, integration in hospitals is essentially about closing loops, for which a certain degree of integration, differentiation and coordination mechanisms based on rules are required. The degree depends on what is required from the environment. There is a vast amount of literature with regard to planning performance measurement, simulation modelling and mathematical algorithms that offer solutions for developing planning rules on a subsystem level, as shown in Chapter 2. Organization theory offers many organizational concepts and models, such as presented by Aoki[16], Galbraith[17], Lawrence and Lorsch[8], Mintzberg[19] and Provan[20], that could be used for more deliberate design of organisational structures and coordination mechanisms. These organizational concepts should be connected to operations research concepts. In particular, Takt Time Management as described and applied by Munavalli et al.[21] offers a complementary coordination mechanism to the mechanisms offered by organization theory. We believe that these theories are not conflicting, nor mutually exclusive, but should be integrated into effective evidence based hospital management practices.

METHODOLOGICAL REFLECTIONS

For this study, both social network analysis and a hospital-wide case study approach including naturalistic inquiry were combined. In this section, the case study approach and, in particular data triangulation, social network analysis and the hospital-wide approach are reflected upon.

Case study and data triangulation

The three case studies are based on the case study research method devised by Yin[22]. Data were collected from multiple sources and analyzed through data triangulation. Data were collected from four different sources: the Hospital Information System (HIS), documentation, observations and interviews. Each source proved to be useful and is therefore necessary to identify interaction relations between the agents, rules and coordination mechanisms.

From this research, we found that it is important to collect and analyse data iteratively and discuss this repeatedly with hospital staff. This iterative process of data collection, analysis, verification and validation starts with collecting and analysing HIS data and documents on working procedures. The analysis of HIS data and documents provides an overview of the hospital processes and output, and it reveals which data are available for establishing relations between agents. For example, in Slingeland Hospital the members of the surgery team for each surgery were registered. From this, the ties between agents who perform surgery were established. Having analyzed HIS data and documents, observations were performed. Before conducting an observation, a memo was written on what to expect during the observation based on the HIS data and documents. In doing this, any discrepancies between the reality of the data and real life were found. Such discrepancies were then discussed during interviews, which were mostly held after the observations.

The iterative nature of data triangulation is best illustrated by the following example. During observations in the nursing wards no surgeons were observed visiting the nursing department. Hence, this interaction was not found from data or from observations. Later, during an interview, a surgeon explained his activities and interactions with other agents when patients are in the nursing ward after surgery. From this interview and the HIS data collected earlier, the nursing wards that each surgeon's patients stayed in could be identified.

For interviews on rules and coordination mechanisms data dashboards proved very useful (Chapter 3). Data dashboards included data that most interviewees had not seen before, such as the number of surgeries per surgeon, yearly and weekly patterns of OR sessions and surgeries, waiting list development and the number of patients who stayed on each nursing ward, among other things. Discussing these data with hospital staff proved very useful for discovering the unwritten rules. In addition, interviewees often provided explanations for the facts, or hypotheses on what was suggested by data, thereby contributing to data triangulation. Data triangulation is thus performed several times until, at some point, no new facts or explanations are found.

Social network analysis

With regard to social network analysis, the main contribution of this study lies in the fact that social network analysis was used to provide a hospital-wide overview of integration and differentiation. Through data triangulation[22] of data from different sources, social networks per task could be constructed and then combined into a hospital-wide network for surgery patients. In particular, social network analysis has proven very useful to visualise the changed networks following the introduction of the HPC. Social network analysis facilitates revealing the coherence in the system when existing relations change, thereby also revealing what remains the same. This phenomenon is described by Jullien as 'dé-coincidence'[23]. In particular, the visual diagrams of the (changed) social networks on task level provide a clear overview of network structures and central or peripheral positions of agents.

Secondly, in this study the concepts and metrics that social network theory offers were further operationalised in relation to integration and differentiation, thus contributing to existing social network studies. The main metrics used for integration and differentiation are density, the number of cliques, clique overlap, betweenness centrality and centralization. Low network density and the presence of cliques suggest differentiation. Interestingly, at the same time cliques that include agents from multiple subsystems, e.g., from the different medical disciplines for making the OR master schedule, show integration. High betweenness centrality of agents and clique overlap suggest integration through brokerage. In addition, centralization was established, showing that agents may derive power from having central positions in networks, because they are best informed and have connections with agents that others do not have.

Thirdly, this study demonstrates that modelling organizational changes in social networks reveals to what factors changes, such as the introduction of the HPC, can be attributed. For example, in our case study (Chapter 5), we found that less cliques existed after the introduction of the HPC, which was mainly attributed to a lower number of unique OR teams performing surgeries. Also, the number of operating surgeons or assisting OR nurses impacts metrics for integration, such as density. In theory, more part-time working nurses would therefore decrease integration values.

Fourthly, in contrast to some authors who state that certain network structures work effectively[20,24], we conclude from our case studies that SNA should be accompanied by naturalistic inquiry in order to establish the coordination mechanisms and rules that explain network structures. Without observing the agent's behaviour, established ties between agents are neutral in the sense that an existing tie does not reveal whether agent interaction is effective or counterproductive. Without knowing what the interaction is about, interaction could be about debating issues and not solving any conflict, or about aligning the work. Through naturalistic inquiry, the nature of the interaction was established in our study.

Even though social network theory needs further development in relation to organisational concepts, in line with other researchers[24-26], we believe that social network theory has great potential for addressing complex issues such as hospital logistics and operations. For this study, network concepts and metrics have proven to be very useful for comparing different networks that have similar tasks or for networks that evolve over time. In addition, we agree with De Vries and Beuving[27] that social network analysis should be accompanied by studying agents rules and coordination activities in order to understand integration and differentiation.

Hospital-wide approach

A hospital-wide approach is clearly challenging, as reported by many other researchers[3,6,11-13]. The development of empirical hospital-wide research approach was the main aim from a methodological perspective. In order to be able to use this methodology in practice, it was decided to conduct a single case. Hospital-wide research is time consuming, because researchers need to build up a social network of their own in the hospital, and data has to be collected from a large number of departments and agents. Data collected from different sources can be conflicting, and any inconsistencies need to be resolved through data triangulation[22] and validation with hospital agents. This could easily lead to a long research period, which carries the risk that the hospital changes take place faster than the research can keep up with. As a result of unforeseen events, the evaluation period in the final case study (Chapter 5) was relatively short, when the Covid-19 pandemic changed hospital planning dramatically. When selecting cases and during research, one needs to be aware of such changes and accordingly adapt the research approach to the circumstances as they present themselves.

Clearly, a single case needs replication in other hospitals in order to establish integration and differentiation in hospital settings and to generalize the mechanisms that were found in this study. Besides the fact that integration and differentiation are contingent, social networks could be influenced by organizational or even regional culture, by hospital scale or by the personalities of the agents involved. Therefore, the findings of this study should be used for 'analytic generalization'[22], which means that the lessons learned provide input to working hypotheses for future research.

FUTURE DIRECTIONS

For both practice and research, the existing theories from the logistics and the related operations research field, organization theory and social network theory should be used together for future studies and experiments regarding hospital management, organizational concepts, planning and operations. We will address future directions more specifically for policy, practice and research in this section.

Implications for policy and practice

For hospital practice, the concepts and findings in this study provide a foundation on which to build further. The most important recommendation is to organize integration and differentiation more deliberately and not depend only on personal initiatives of individual agents. Our case studies showed that hospital performance seems to be vulnerable (Chapter 3 and Chapter 4), and even though the introduction of the HPC (Chapter 5) appears to be an important step towards a more robust integration, performance has not yet increased as desired.

Our second recommendation is to use a system-wide perspective for system redesign for improving effectiveness, including in network structure, rules and coordination mechanisms. At the same time, and because of the system-wide perspective, hospital-wide system redesign is complex, takes time and cannot be done in one piece. Consequently, any step taken in the redesign and implementation process may not increase performance right away. This does not necessarily mean that the concept that is implemented is failing, but that most likely the system is not well enough understood yet. Using the methodology as developed in this study, successive implementations can be evaluated, so that new future interventions can be made based on more knowledge on how the system behaves.

Because of not being able to completely oversee a hospital system at once, nor at all times, we believe that adopting a stepwise learning approach for both everyday business and implementation of new concepts is important. Clearly there are challenges to achieve integration and differentiation, because it is contingent, and there are many antagonistic elements in the related concepts of rules, coordination mechanisms and performance indicators. In addition, the sub environments of the hospital which are not included in this study need to be better understood for refining integration and differentiation.

A system-wide learning perspective also implies that the concept of optimization can be problematic, as what is optimal for one subsystem may not be optimal for others, and what is optimal at one moment in time may not work at a future time. We therefore recommend not to focus on optimization, but on system stabilization, which can be operationalised by lead-time and waiting time for patient flows and resource utilization.

Hospital leadership should play an important role in deliberately organizing integration and differentiation. Hospital leadership includes monitoring the hospital's environment on a strategic, tactical and operational level, detecting improvement areas, setting performance goals and deciding on any new ways of working, systems or organizational structure. For this, there also needs to be a balance between providing directives and giving space to agents' own initiatives, depending on the environment's demands. At least, it should be clear, for example, who is allowed to introduce new ways of working and how much standardization of formalization is required under what circumstances. A potentially helpful method for this could be 'Hoshin Kanri'; literally translated from Japanese, 'Hoshin' means compass and 'Kanri' is management or control[28]. This method aims to align goals at strategic, tactical and operational levels through continuous coordination and is described by Winasti et al.[28] and Tennant and Roberts[29]. Both vertical and horizontal alignment are important in a well performed Hoshin Kanri process.

Hospital leadership should also involve, or create, the right subsystems by connecting the right agents, and make sure that together they evaluate changes made and use lessons learned for the future.
Social network analysis can help leaders in this in several ways. First, to identify the central agents who can be of help for influencing the network and, second, to identify any need to reshape the network by connecting the agents who are needed for more integration. The leadership can also be of great value for central agents who face the challenge of connecting subsystems, thereby continuously solving conflicts. If the leadership explicitly supports these central agents, their task will be (and will feel) less challenging. Moreover, rewarding agents who base their actions on a total system perspective will most likely have a positive impact on hospital effectiveness, as suggested by Aoki[16].

Implications for research

The aforementioned stepwise approach for improving hospital performance also applies for research. For researchers, it is barely possible to examine a hospital in its entirety, given the fact that ideally the research is conducted within a limited time period during which the hospital is more or less in a steady state. However, by selecting an aspect system - in this case, the part of the hospital system that services surgery patients - a hospital-wide research perspective can be used. Social network analysis has proven to be useful for identifying hospital-wide integration and differentiation.

In future research, therefore, we propose to use social network analysis when implementing organizational changes. Changes could be evaluated in a similar way as in the case study in Chapter 5 or through action research[30]. We should then be able to assess, for example, whether having many or a few cliques in a hospital is more effective;

how density or betweenness centrality is related to performance; or, whether more explicit standardization of norms, as suggested by Mintzberg[31], leads to different interaction patterns and, accordingly, to different integration and differentiation. By evaluating performance accordingly, more knowledge will be developed on effective network structures and governance of networks.

In this research, it should be considered to include interaction frequency and timing of interaction, as this could lead to more insights on how integration and differentiation work in hospitals. In addition, it is important to find ways to take into account processes other than logistical processes, such as financial, medical, human resource management or contracting processes. Tasks related to these processes take place in other subsystems that are related to different hospital sub environments such as insurance companies or professional associations of medical disciplines. Integration and differentiation for the hospital as a whole could be explained by such processes and the behaviour of the related subsystems.

Last but not least, we believe it is important to develop social network theory by connecting its concepts and metrics to the concepts of integration and differentiation. Replication of this study will contribute to theory building as well as experiments with the implementation and evaluation of organizational concepts.

In conclusion, the foundation laid in this thesis with regard to integration and differentiation should be further explored and refined. Future studies could be performed in hospital settings and, also, in other organizations that provide healthcare, or partnerships of healthcare organizations who collaborate within a certain region or, even nationwide. In addition, it would be interesting to study integration and differentiation under various changing circumstances, for example, in times of a pandemic or the more common flu epidemics, hospital mergers or hospital building renewal.

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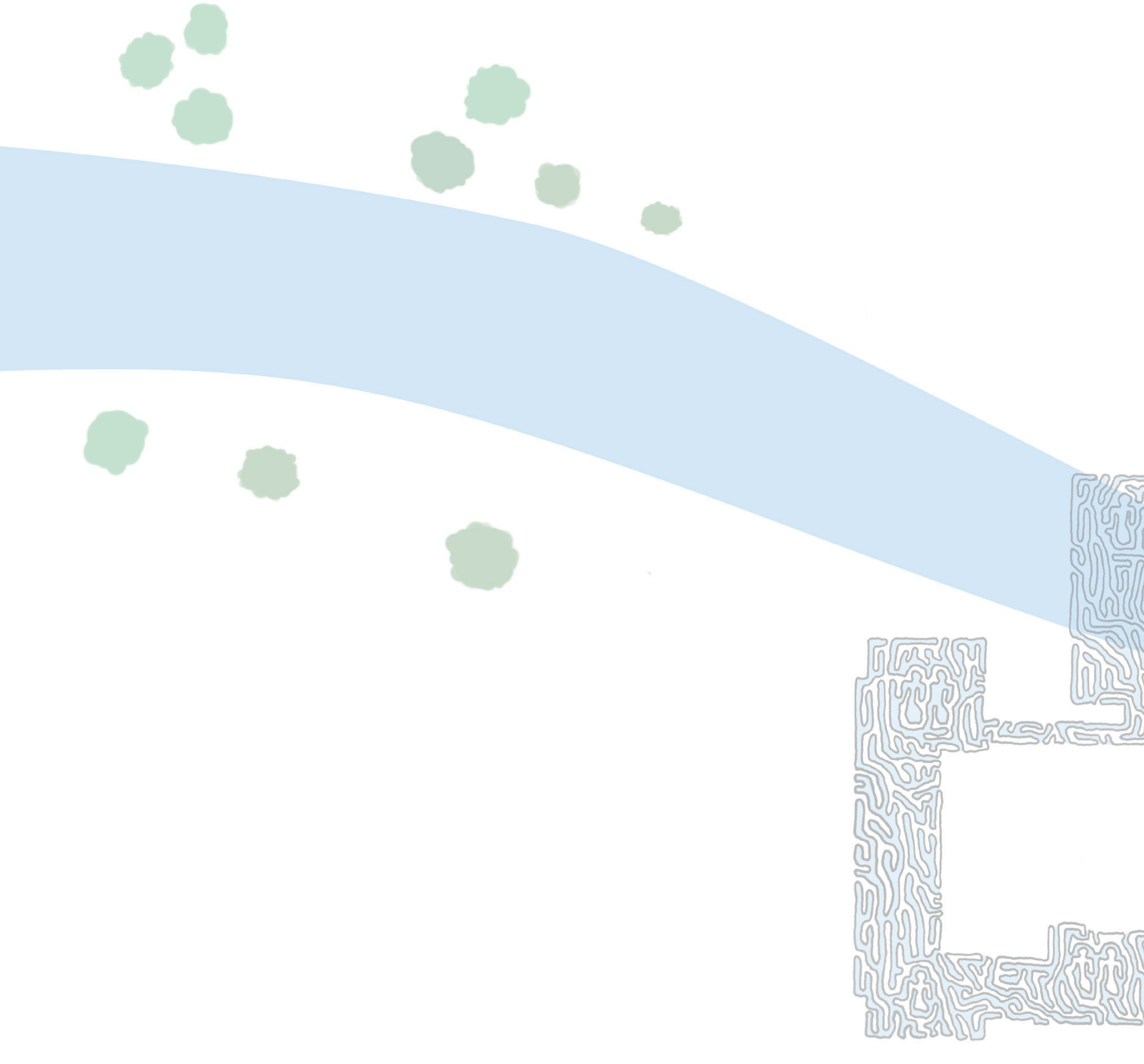
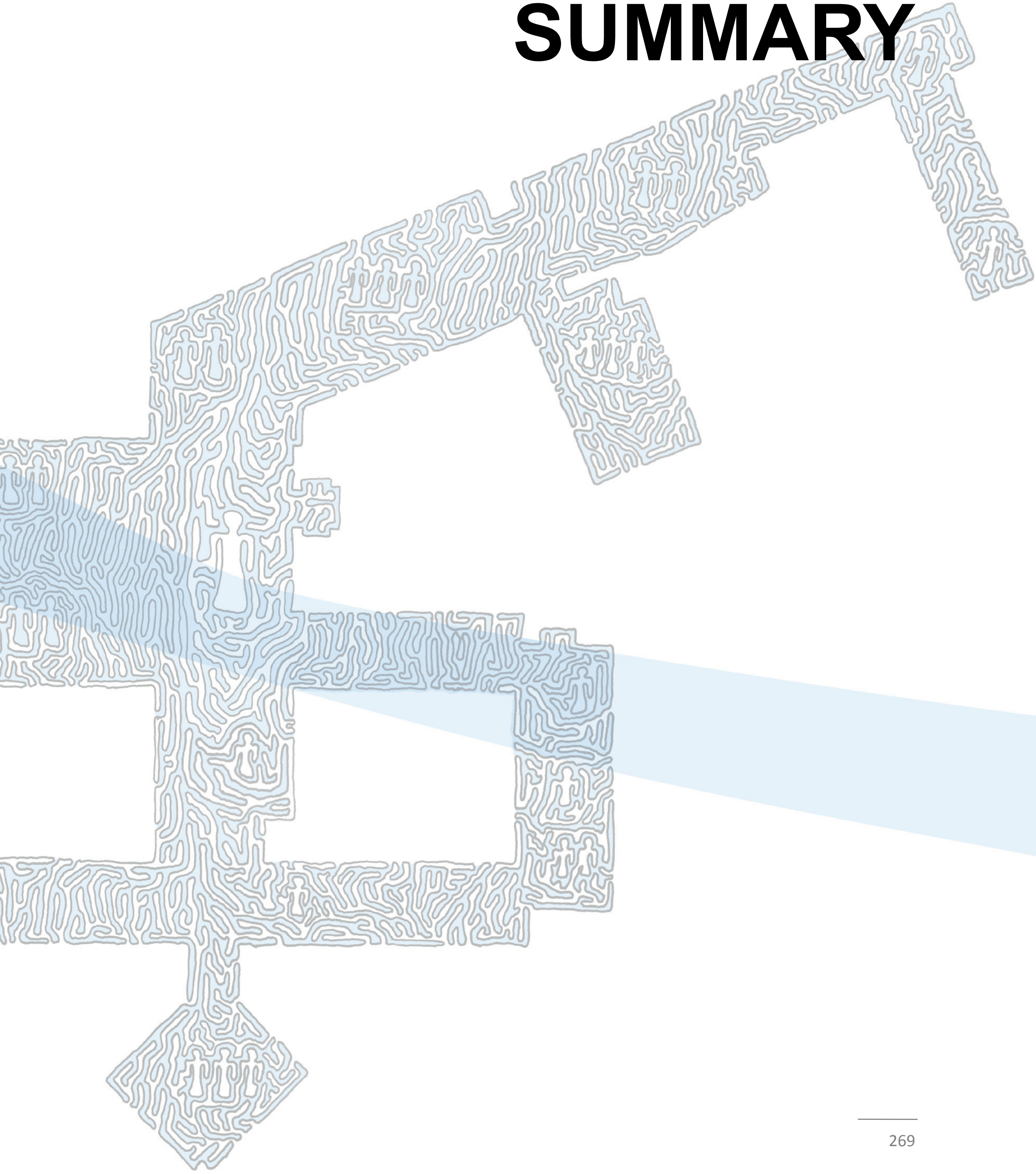


SUMMARY



SUMMARY

In response to worldwide concerns regarding increasing healthcare expenditure and the recent pressure on hospital capacity during the Covid-19 pandemic, governments, healthcare organizations, researchers and other parties involved in healthcare are looking for ways to maintain and improve the accessibility and affordability of healthcare. In particular, hospitals receive attention because they are a major cost item in healthcare systems, and the fact that they were stretched beyond their capacity during the Covid-19 pandemic had a major impact on societies worldwide.

Integration, that is the hospital-wide alignment and coordination of tasks and activities, is considered essential for hospital performance. Although several theories on integration exist, the question of how integration is achieved in hospital practice is relatively unaddressed. A full understanding of factors that determine the course of reality in hospitals is important to be able to effectively transform hospital logistics and operations. The aim of this thesis, therefore, is to thoroughly understand how a hospital's logistical system works, in particular how integration is achieved.

Chapter 1 introduces the topic of this thesis and the concepts used. Firstly, based on contingency theory, integration and differentiation are both considered essential for effective performance of organizations[1]. Integration is 'achieving unity of effort among the various subsystems in the accomplishment of the organization's task'[1]. Differentiation refers to 'the state of segmentation of the organizational system into subsystems'[1]. Secondly, concepts and metrics from social network analysis are introduced. Thirdly, the concepts of rules and coordination mechanisms are described, as both social network theory and literature pertaining to integration often mention coordination as a core activity.
Based on these concepts, Chapter 1 explains that the research for this thesis was conducted in four research steps, starting with understanding the state of affairs in hospitals with respect to logistics and integration (step 1). Then, three case studies in Slingeland Hospital were conducted which *describe* (step 2) how a hospital's logistical system works in practice and, in particular, to what extent there is integration and differentiation, and which *explain* (step 3) integration and differentiation by studying the rules and coordination mechanisms and which then *evaluate* (step 4) whether integration, differentiation, coordination mechanisms and performance change after the introduction of a hospital planning centre (HPC).

Chapter 2 describes the results of a scoping study that identifies the logistical parameters mentioned in international research on hospitals and indicates whether literature reflects system integration.
The scoping study shows that in international literature there is fragmentation with regard to hospital logistics. Studies also show integration, although this takes place mainly within the subsystems of hospitals, i.e., within parts of hospitals with tasks related to specific departments, flows or processes. Therefore, from international literature on hospital logistics, a clear view on how integration could enhance hospital performance could not be derived. From this scoping study, it was concluded that more knowledge regarding the degree of integration and performance indicators is required for better hospital performance.

Chapter 3 describes how a hospital organizes logistical processes. The agents and the interactions involved are identified, and the extent to which there is differentiation and whether these tasks are coordinated and aligned, thus achieving integration, is established. Integration and differentiation are described in terms of concepts and metrics from social network analysis.
This first case study shows that 23 tasks are executed by 635 different agents who interact through 31,499 ties, i.e., interaction links. Agents include outpatient secretaries, ward nurses, surgeons and an OTC capacity planner among others. The social network of the hospital demonstrates both integration and differentiation. Nurses, surgeons and anesthesiologists have central network positions and perform integrative tasks, and two central agents who mainly coordinate the tasks in the network, have no hierarchical position towards other agents. Agents with hierarchical positions, e.g., team leaders or managers, contribute relatively little to integration, based on their network positions.
With regard to differentiation, groups of highly connected agents performing the same task were identified. Differentiation results from task segmentation based on medical disciplines, organizational units, length of stay and patient characteristics.
This exploratory study reveals the network structure of a hospital and sets a basis for further research on how integration is achieved in hospital practice. In addition it discusses in what way organization theory concepts and social network analysis could be used in conjunction with one another.

Chapter 4 carries the case study presented in Chapter 3 further, by explaining integration and differentiation through identifying the rules and coordination mechanisms that agents in a hospital network use. Rules result from defined or accepted ways of performing tasks and can be documented, exist in people's minds, or both. Coordination mechanisms, which are based on these rules, require interactions between

agents. Different coordination mechanisms result in different interaction patterns, resulting in a certain network structure, i.e., integration and differentiation.
For planning and performing surgeries, 314 rules were found, of which the majority applies hospital-wide. Because rules are often undocumented, they are not always generally known. Moreover, 82% of all documents concern local or personal documents such as checklists and memos or were delivered in internal presentations. As a consequence, rules are often shared throughout the hospital through social interaction, as most rules exist predominantly in people's minds.
Coordination mostly takes place through standardization of work and mutual adjustment. In the early planning stages for a surgery procedure, mutual adjustment based on hospital-wide rules is dominant. Closer to the day of surgery, local rules are used and open loops are closed through mutual adjustment, thus achieving integration. Open loops are created by long term schedules that are not based on future patient demand. Open loop systems are affected by their environment, but do not utilize feedback nor take action to improve the workflow, which potentially leads to instability. On the day of surgery, there is mainly standardization of work and output, based on hospital-wide rules.
Both Chapters 3 and 4 discuss the hospital's stability and potential vulnerability and propose to further develop Slingeland Hospital's logistical system in order to increase its robustness.

Chapter 5 describes the results of the evaluation of the hospital's social network, rules, coordination mechanisms and performance after a hospital planning centre (HPC) was introduced.
Following the introduction of the HPC, bed utilization increased with peak utilization of beds and operating rooms decreasing, and increases were observed in the waiting list, in cancellations and in waiting list variability. More integration was observed for specific planning tasks, but not for the hospital network as a whole. Differentiation based on medical discipline, organizational unit, length of stay and patient characteristics remained. More hospital-wide and fewer local rules exist, and these have remained largely undocumented, i.e., exist in people's minds. Coordination mechanisms both before and after the introduction of the HPC are mainly mutual adjustment and standardization of work. Based on these observations and literature, Chapter 5 proposes further development and system redesign from a system-wide perspective that includes network structure, rules and coordination mechanisms.

Chapter 6 presents the main findings of this thesis, reflects on these from a theoretical and methodological perspective and discusses implications for policy, practice and research. From a theoretical perspective, the concepts of integration, differentiation and fragmentation are discussed. The appropriate integration or differentiation depends on the demands from the environment that the hospital needs to respond to. In hospital practice, essentially, integration is about closing loops, for which a certain degree of integration, differentiation and coordination mechanisms based on rules, are required. Integration and differentiation in hospitals, however, do not seem to be designed or premeditated beforehand in conjunction with each other, and this could lead to instability. A more deliberate approach towards integration and differentiation is proposed, which includes stepwise learning aimed at system stabilization under changing circumstances. Hospital leadership is important for this to succeed.

It is recommended to conduct more empirical studies, based on theory with regard to planning, performance measurement, simulation modelling and mathematical algorithms, organization theory and social network theory. Accordingly, recommendations are presented on how to conduct such research, which includes hospital-wide or even healthcare network case study research using social network analysis and naturalistic inquiry.

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SAMENVATTING

SAMENVATTING

Wereldwijd zoeken overheden, zorginstellingen, kennisinstellingen en andere organisaties betrokken bij de gezondheidszorg naar manieren om de toegankelijkheid en betaalbaarheid van zorg te garanderen en te verbeteren. Lang voordat de Covid-19 pandemie uitbrak, waren er al grote zorgen over toenemende zorgkosten, waarbij veel aandacht uit ging naar ziekenhuizen, omdat zij relatief veel kosten. Door de pandemie werden de grenzen aan het oprekken van ziekenhuis capaciteit pijnlijk duidelijk, met grote gevolgen voor samenlevingen wereldwijd.

Tegen deze achtergrond wordt er al geruime tijd gepleit voor meer integratie in ziekenhuizen, dat wil zeggen meer ziekenhuisbrede afstemming en coördinatie van taken en activiteiten. Het idee dat integratie leidt tot effectiever en efficiënter functioneren van ziekenhuizen wordt breed gedeeld in de wetenschap en er bestaan diverse theorieën over. Tegelijkertijd is een nog onbeantwoorde vraag *hoe* integratie in de ziekenhuis praktijk tot stand komt. Om ziekenhuizen effectief te verbeteren is het belangrijk om volledig te begrijpen hoe ziekenhuizen eigenlijk werken. Het doel van dit proefschrift is daarom om te ontdekken hoe het logistieke systeem van een ziekenhuis functioneert, en dan in het bijzonder hoe integratie tot stand komt.

In **hoofdstuk 1** worden de concepten van dit proefschrift geïntroduceerd. Het gaat daarbij ten eerste om integratie en differentiatie, die op basis van de contingentietheorie beide als essentieel beschouwd worden voor de effectiviteit van organisaties[1]. Integratie is ‘het bereiken van eenheid van inspanning tussen de verschillende subsystemen bij het vervullen van de taak van de organisatie’[1]. Differentiatie verwijst naar ‘de mate van segmentatie van het organisatiesysteem in subsystemen’[1]. Ten tweede worden concepten uit sociale netwerk theorie geïntroduceerd. Tenslotte worden regels en coördinatie-mechanismen toegelicht; coördinatie wordt zowel in sociale netwerk theorie als in de literatuur over integratie genoemd als kern activiteit.
Vervolgens worden in hoofdstuk 1 de vier stappen van het onderzoek voor dit proefschrift toegelicht. Het onderzoek is gestart met een inventarisatie van de stand van zaken in de literatuur met betrekking tot logistiek en integratie in ziekenhuizen (stap 1). Vervolgens zijn in het Slingeland Ziekenhuis Slingeland drie case studies uitgevoerd. De eerste case study (stap 2) *beschrijft* hoe het logistieke systeem van een ziekenhuis in de praktijk werkt en dan vooral in hoeverre er sprake is van integratie en differentiatie. De tweede case study (stap 3) *verklaart* de integratie en differentiatie door de regels en coördinatiemechanismen te bestuderen. In de laatste case study (stap 4) wordt

geëvalueerd in hoeverre integratie, differentiatie, regels, coördinatiemechanismen en effectiviteit veranderen na de introductie van een centraal planbureau in het ziekenhuis.

Hoofdstuk 2 beschrijft de resultaten van een scoping study. In deze literatuur studie worden logistieke parameters die worden genoemd in internationaal onderzoek naar ziekenhuizen, geïdentificeerd. De scoping study laat zien dat in internationale literatuur sprake is van fragmentatie ten aanzien van ziekenhuis logistiek. Studies adresseren integratie wel, maar dan voor het merendeel in de context van subsystemen in ziekenhuizen, dat wil zeggen binnen delen van ziekenhuizen, met taken die verband houden met specifieke afdelingen, logistieke stromen of processen. Uit internationale literatuur komt geen duidelijk beeld naar voren hoe integratie de prestaties van ziekenhuizen zou kunnen verbeteren. Op basis hiervan concluderen wij dat er meer kennis nodig is over integratie en de relatie met prestatie-indicatoren om te komen tot betere ziekenhuis prestaties.

Hoofdstuk 3 beschrijft hoe een ziekenhuis logistieke taken en processen in de praktijk organiseert. Ten eerste zijn de taken, de betrokken agenten en hun interacties geïdentificeerd. Met behulp van sociale netwerkanalyse wordt vervolgens vastgesteld of er sprake is van differentiatie en hoe taken op elkaar worden afgestemd, waardoor er integratie wordt gerealiseerd.
Deze eerste case study laat zien dat 23 taken worden uitgevoerd door 635 verschillende agenten die communiceren via 31.499 interactielijnen. Agenten zijn onder andere polikliniek secretaresses, afdelingsverpleegkundigen, chirurgen en capaciteitsplanners van het operatiekamercomplex. In het sociale netwerk van het ziekenhuis is zowel sprake van integratie als van differentiatie. Verpleegkundigen, chirurgen en anesthesiologen hebben centrale netwerkposities en voeren integratietaken uit. De twee meest centrale agenten, wiens voornaamste taak het is om het netwerk te coördineren, hebben geen hiërarchische positie ten opzichte van andere agenten. Agenten met hiërarchische posities, zoals teamleiders of managers, dragen op basis van hun netwerkposities relatief weinig bij aan integratie.
Met betrekking tot differentiatie zijn groepen van sterk verbonden agenten geïdentificeerd die dezelfde taak uitvoeren. Differentiatie komt voort uit taaksegmentatie op basis van medische disciplines, afdelingen, ligduur en patiëntkenmerken.
Deze verkennende studie legt de netwerkstructuur van een ziekenhuis bloot en vormt daarmee een basis voor verder onderzoek naar de wijze waarop integratie in de ziekenhuispraktijk tot stand komt. Daarnaast wordt besproken op welke manier organisatietheorieconcepten en sociale netwerkanalyse in samenhang met elkaar kunnen worden toegepast.

Hoofdstuk 4 gaat dieper in op de case study van hoofdstuk 3, door de gevonden integratie en differentiatie te verklaren door de regels en coördinatiemechanismen te bestuderen. In dit hoofdstuk worden de regels en coördinatiemechanismen geïdentificeerd, die de agenten in het ziekenhuisnetwerk gebruiken. Regels zijn het resultaat van gedefinieerde of geaccepteerde manieren om taken uit te voeren en kunnen gedocumenteerd zijn, in het hoofd van agenten zitten, of beide. Coördinatiemechanismen, die op deze regels zijn gebaseerd, vereisen interacties tussen agenten. Coördinatie activiteiten resulteren dus in interactiepatronen, en bepalen daarmee ook een bepaalde netwerkstructuur, dat wil zeggen integratie en differentiatie.
Er zijn voor het plannen en uitvoeren van operaties 314 regels, waarvan het merendeel ziekenhuisbreed geldt. Omdat regels vaak niet vastgelegd zijn, zijn deze niet altijd algemeen bekend. Van de vastgelegde regels is 82% terug te vinden in lokale of persoonlijke documenten zoals checklists, memo's of in intern gegeven presentaties. Aangezien de meeste regels voornamelijk in het hoofd van de agenten zitten, worden deze vaak via sociale interactie gedeeld.
Coördinatie vindt vooral plaats door standaardisatie van werk en onderlinge afstemming. In vroege planningsfases van een operatieve ingreep vindt onderlinge afstemming vooral plaats op basis van ziekenhuisbrede regels. Dichter op de dag van de operatie worden lokale regels gehanteerd en worden door onderlinge afstemming *open loops* gesloten, waardoor integratie wordt bereikt. *Open loops* worden gecreëerd door langetermijn-planningen, die niet zijn gebaseerd op toekomstige vraag van patiënten. *Open loop systemen* worden beïnvloed door hun omgeving, maar gebruiken geen feedback om te reageren op hun omgeving, wat tot instabiliteit kan leiden. Op de dag van de operatie is er vooral standaardisatie van werk en output, gebaseerd op ziekenhuisbrede regels.
In zowel hoofdstuk 3 als hoofdstuk 4 wordt geconstateerd dat het ziekenhuis systeem mogelijk instabiel en kwetsbaar is. Het is daarom van belang om het logistieke systeem van het Slingeland Ziekenhuis verder te ontwikkelen om de robuustheid ervan te vergroten.

In **hoofdstuk 5** worden de resultaten van de evaluatie van het sociale netwerk, de regels, de coördinatiemechanismen en de prestaties van het ziekenhuis na de introductie van een centraal planbureau in het ziekenhuis beschreven. Na de introductie van de centraal planbureau neemt de gemiddelde bedbezetting toe, terwijl de piekbenutting van bedden en operatiekamers afneemt. De hoogte van de wachtlijst neemt toe, evenals het aantal geannuleerde operaties en de variabiliteit. Er wordt meer integratie waargenomen voor specifieke planningstaken, maar niet voor het ziekenhuisnetwerk als geheel. Differentiatie op basis van medische disciplines, afdelingen, ligduur en patiëntkenmerken blijft bestaan. Na de introductie van het centraal planbureau neemt het aantal ziekenhuisbrede regels toe en vermindert het aantal lokale regels. Wel blijven regels grotendeels in het hoofd van agenten zitten en worden ze niet vastgelegd. Onderlinge afstemming en standaardisatie van werk zijn zowel voor als na de invoering van het centraal planbureau de meest gebruikte coördinatiemechanismen. Op basis van deze observaties en van literatuur wordt aanbevolen om het ziekenhuis verder te ontwerpen en te ontwikkelen vanuit een vanuit een systeem breed perspectief dat netwerkstructuur, regels en coördinatiemechanismen omvat.

Hoofdstuk 6 presenteert de belangrijkste bevindingen van dit proefschrift, reflecteert hier op vanuit theoretisch en methodologisch perspectief en bespreekt implicaties voor beleid, praktijk en onderzoek. Vanuit een theoretisch perspectief gaat het dan vooral om de concepten integratie, differentiatie en fragmentatie. De juiste integratie of differentiatie hangt af van de eisen uit de omgeving waar het ziekenhuis op moet inspelen. In de ziekenhuispraktijk gaat integratie over het sluiten van *open loops* waarvoor integratie-, differentiatie- en coördinatiemechanismen bestaan, gebaseerd op bepaalde regels. Integratie en differentiatie in ziekenhuizen lijken niet vooraf in samenhang met elkaar te zijn ontworpen of beoogd en dit zou tot instabiliteit kunnen leiden. We stellen een meer bewuste benadering van integratie en differentiatie voor, waarbij stapsgewijs leren en systeemstabilisatie onder veranderende omstandigheden centraal staan. Ziekenhuis management moet hierin een nadrukkelijker rol spelen dan zij in de praktijk nu lijken te doen.

Aanbevolen wordt om meer empirisch onderzoek te doen, daarbij gebruikmakend van bestaande theorie op het gebied van planning, prestatiemeting, simulatie, wiskundige algoritmen, organisatietheorie en sociale netwerktheorie. In aanvulling hierop worden aanbevelingen gedaan voor het uitvoeren van dergelijk onderzoek, waaronder case study-onderzoek in het hele ziekenhuis of zelfs in gezondheidszorgnetwerken met behulp van sociale netwerkanalyse en naturalistisch onderzoek.

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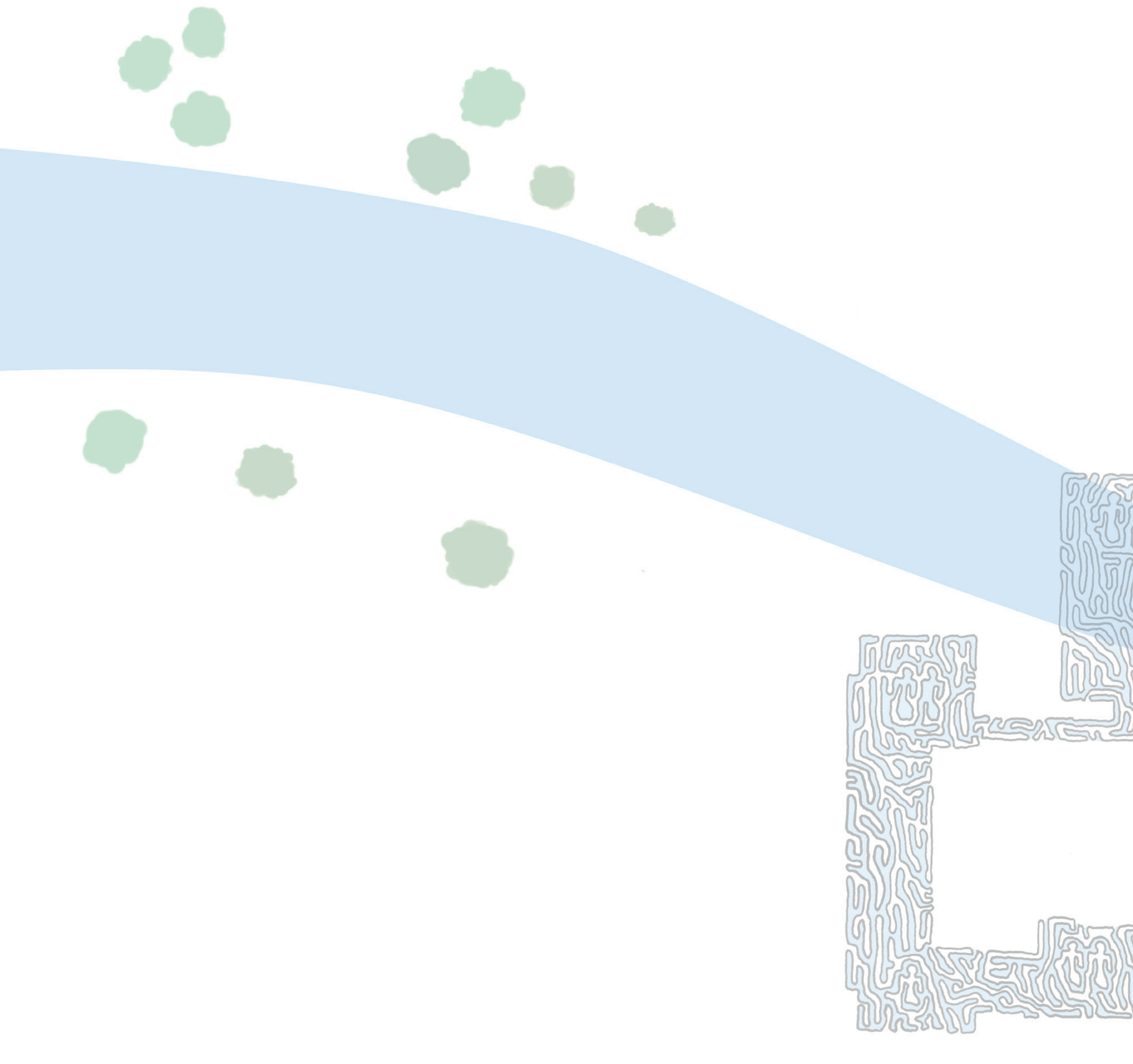
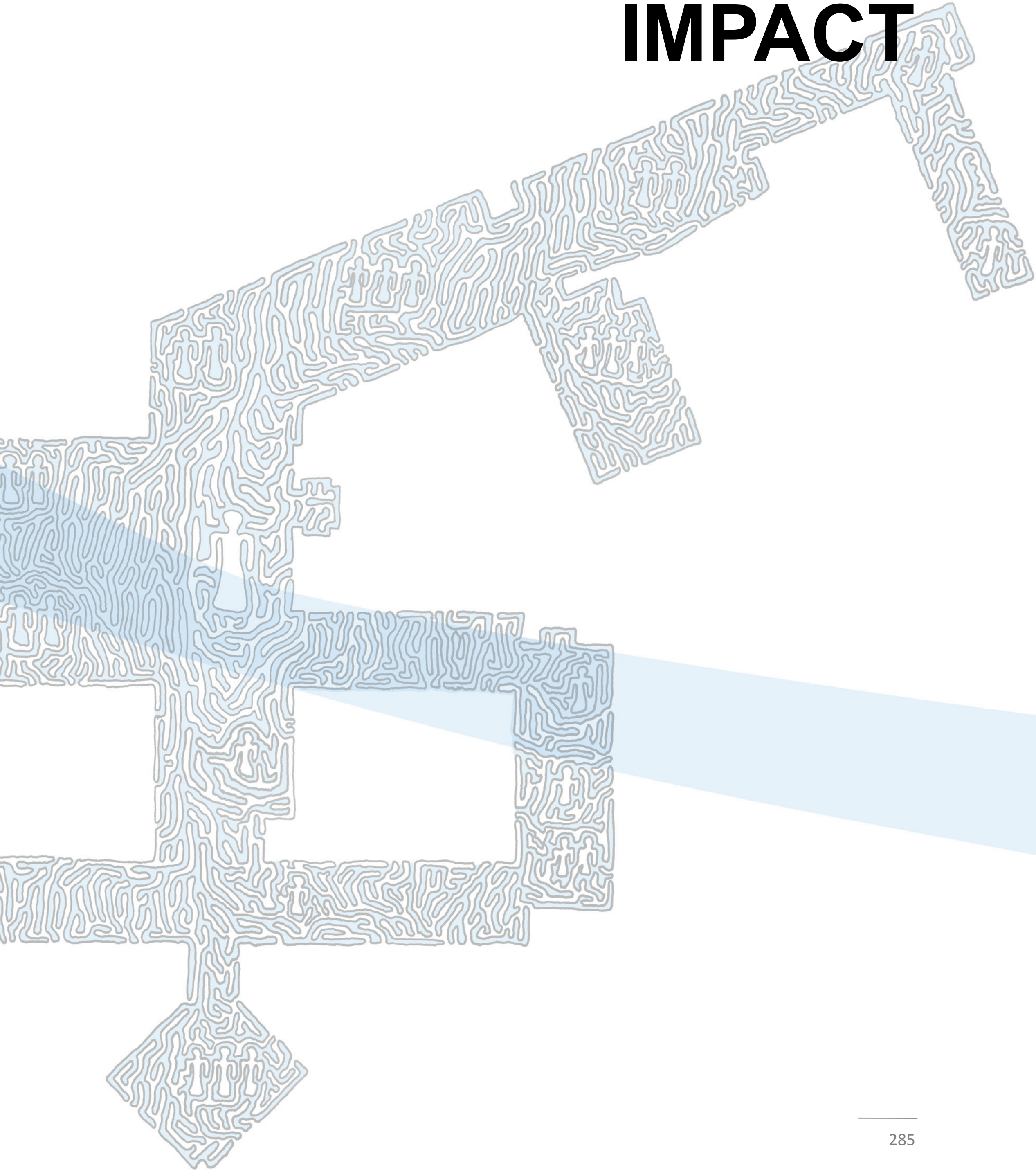


IMPACT



IMPACT

"I showed up on time on the date of the meeting which I had agreed to join for observation. Ten minutes before it was supposed to start, someone told me that the meeting had been rescheduled and they had arranged for me to join the logistical workers in the OTC central storage room, now! I felt somewhat disturbed and confused, as I was not able to prepare myself for observing logistical workers and didn't know right away exactly what I wanted from the observation. This happens quite often during this research: things are cancelled and then rearranged at the same time and on the spot. I worry a bit that I may look like an ill-prepared idiot. But, probably, the best thing is to accept it as part of the experience, to open my eyes and ears, write it all down, and then learn from it."

This personal diary note, made on 29 January 2018, illustrates what it means to be working in a dynamic environment. For people, who are used to working with plans and concepts - researchers, consultants, (project) managers and others like them - the dynamics in hospital operations can be overwhelming and the seeming lack of control can be hard to accept.

The concerns regarding this way of working are not unfounded, given the widely felt need to increase the affordability and accessibility of healthcare services (Chapter 1) and hospitals in particular. Hospitals are a major cost item in healthcare systems, and during the Covid-19 pandemic hospitals were stretched beyond their capacity to such an extent that it had a major impact on societies worldwide. Many researchers consider the concept of integration important for improving hospital performance. Integration involves aligning and coordinating activities from a hospital-wide perspective to make sure that patients, materials and staff flow smoothly through hospital processes. Activities are integrated when, for example, for a surgery that is planned by the outpatient department, also a bed is also planned for by the nursing ward, both for before and after the surgery is performed.

Although several theories on integration exist, the question of how integration is achieved in hospital practice is relatively unaddressed. A full understanding of factors that determine the course of things in hospital practice is important to be able to effectively transform hospital logistics and operations. The aim of this thesis, therefore, is to thoroughly understand how a hospital's logistical system works, in particular, integration. Theory states that for effective hospital's integration, i.e. alignment and coordination and differentiation, i.e., the division of tasks throughout an organization, are both required.

To what degree activities can be performed independently of other activities, thereby not requiring integration, depends on the demands that the environment puts on the organization.

The question of how integration is achieved in hospital practice is relatively unaddressed and considered difficult, or even problematic by researchers. This thesis, therefore, contributes to thoroughly understanding how a hospital's logistical system works, in particular with regard to integration and differentiation. This is important, because like for any other system that requires improvement, knowing how the system works, and why, is essential. From the findings of this thesis, an approach is proposed that includes both elements of deliberate, conscious planning based on standards and, also, of adaptability that is based on mutual adjustment. In this chapter the societal and scientific impact and the dissemination and the future of the results in this thesis are explained.

SOCIETAL IMPACT

First and foremost, from this study we know how a hospital and, in particular, its logistical system works in practice from a system-wide perspective, more particularly for performing surgeries and all that is required to arrange for that. It has become clear that differentiation is more or less 'programmed' or comes naturally because the division of tasks and departments in hospitals is based on medical disciplines, patient characteristics and length of stay. Integration largely emerges through agents who observe potential instability, e.g., unnecessary waiting, a lack of materials or staff for surgeries or patient care, and who mutually adjust in social networks. Most importantly, several of the ways of working and coordination mechanisms found in this study turned out to be insensitive to change. After the hospital planning centre (HPC) was introduced several intended performance improvements were not achieved and open loops and mutual adjustment remained. As a consequence the potential causes for hospital instability seem to have remained.

We believe that the findings on how hospitals function is important for anyone who works in, for, or with hospitals. Whether you work in a hospital daily or work on design and change projects, knowing how and why the system functions is essential to be effective. First, this study provides detailed descriptions of processes, tasks, agents who perform tasks, which rules are used and what interactions that take place. Second, this study shows that integration is achieved by healthcare professionals and a few coordinators and that they coordinate mainly through standardization of work and mutual adjustment, based on, often, local and undocumented rules. Third, given the complexity and variability of hospital operations, this thesis proposes a more deliberate, conscious and dynamic approach towards integration and differentiation. This includes stepwise learning aimed at system stabilization under changing circumstances. Fourth, social network analysis and naturalistic inquiry offer concepts and methods for evaluating changes in hospital performance, and these can be used by a diverse audience.

For hospital staff, this thesis can be used to create system-wide awareness on what happens outside their own workplace and department, so that they understand how the system functions as a whole and how they can contribute to this most effectively. It could also be used for preparing future staff, i.e. students in medical and nursing education, to understand the position they will be in as a physician, nurse or coordinator when working in a hospital.

Clearly, for (future) hospital leadership a system-wide understanding of hospitals is important in order to be able to effectively lead and manage smaller or larger parts of the hospital. They need to be aware and understand that changes in one part of the hospital may impact hospital performance as a whole or in other departments. Furthermore, they should play an important role in more deliberately organizing integration and differentiation. This includes monitoring and aligning the hospital's environment on a strategic, tactical and operational level, detecting improvement areas, setting performance goals and deciding on any new ways of working, systems or organizational structure. When they know the social structure of their hospital, they are able to involve the right agents for this. Social network analysis identifies the central agents who can be of help in influencing the network and taking care of any disconnections between agents that are needed to reshape the network. Hospital leadership can also be of great value for central agents who face the challenge of connecting subsystems, thereby continuously solving conflicts. If the leadership explicitly supports or rewards these central agents, their task will be less challenging.

Agents who provide services to healthcare professionals, either externally or internally, can use this thesis for agents designing, developing and implementing for example organizational policies, information technology solutions, financial models, human resource management programs, building designs housing and/or facility services, etc. Their solutions or models can only effectively support the hospital system when they support agent's working processes. In order to do so, integration, differentiation, rules and coordination mechanisms must be understood.

The same applies to agents outside hospitals, such as policy makers, insurance companies, management consultants and supply chain partners, i.e. nursing homes or material suppliers.

RESEARCH IMPACT

For this thesis, a case study approach including data triangulation, social network analysis and the hospital-wide approach were combined. Similar to the aforementioned stepwise hospital improvement, hospital-wide research should also be conducted in a stepwise manner.

For a hospital-wide case study, research data should be collected from multiple sources, e.g. the hospital information system, documents, observations and interviews. Data, accordingly, need to be analyzed in an iterative manner, thus discussing findings repeatedly with hospital staff. Clearly, the hospital-wide approach comes with the challenge to achieve results within a restricted period of time. Selecting an aspect system, i.e., the part of the hospital system that services surgery patients, proved valuable, while at the same time, the limitations are recognized.

Social network analysis facilitates analyzing hospital-wide integration and differentiation. Using data triangulation, social networks for each task can be constructed, combined into a hospital-wide network and, most importantly, visualized. The concepts and metrics that social network theory offers can be used to detect integration and differentiation, with the main metrics being density, the number of cliques, clique overlap, betweenness centrality and centralization. Social network analysis should be accompanied by naturalistic inquiry in order to establish the coordination mechanisms and rules that explain network structures.

In future research, social network analysis and naturalistic inquiry can be used for replication of this study in other hospitals and for evaluating organizational changes that have been implemented. By evaluating performance, more knowledge will be developed on effective network structures and governance of networks. Social network theory can, accordingly, be developed further by connecting its concepts and metrics to the concepts of integration and differentiation.

For researchers, the findings of this research are also relevant for the way research is conducted in hospital practice. As illustrated by the diary notes, doing research in hospitals requires mutual adjustment and adaptability skills from researchers. In particular, planning interviews and observations requires a flexible attitude, as these can be rescheduled or rearranged on the spot. For this, a well-prepared research plan is required, which includes both clear and well-defined objectives and research questions, and facilitates agility in doing the research. For example, by preparing interview topic lists for interviewees from all departments beforehand, the researcher is able to conduct any interview at any time. At the same time, such topic lists may require adjustment when interviews that were held provide new insights.

DISSEMINATION OF FINDINGS

Various channels have been used to disseminate the findings of this research. Three out of four papers have been published in international peer reviewed journals, and the fourth paper (Chapter 5) has been submitted for publication as well. The published papers have all been published open access and are accessible to anyone free-of-charge.

In addition to that, the findings of this research have been shared mainly with a practical audience. Naturally, during the case studies, intermediate and final results were shared with Slingeland Hospital, either via email or personally. A ‘thank-you’ note was given to all Slingeland Hospital staff that participated in the first case study (Chapter 2) and in it the position of the note recipient was highlighted. From the response, it was clear that this was not only appreciated, but several staff members indicated that this made them more aware of their (in that case often central) position. In July 2021, the findings of this research were presented to Slingeland Hospitals Board of Directors and middle management.

For a wider audience, 44 blogs were published between 2017 and 2021 on www.squrious.nl, presenting the research results and reflections on these. The blogs were well read by over a thousand different people, mostly working in or for hospitals. Throughout the entire PhD research, several workshops and presentations were held with consultancy firms and hospitals, among others, often as a result of a blog or through personal relationships in the Dutch healthcare sector of the researchers involved.

Research findings were also presented in a book chapter of ‘Capaciteitsplanning in de zorg’[2], which was published in 2021 and written for a professional audience of managers, boards, physicians, students and other people involved in healthcare operations management. Also, this research was presented to a professional audience in master classes on capacity planning 2021.

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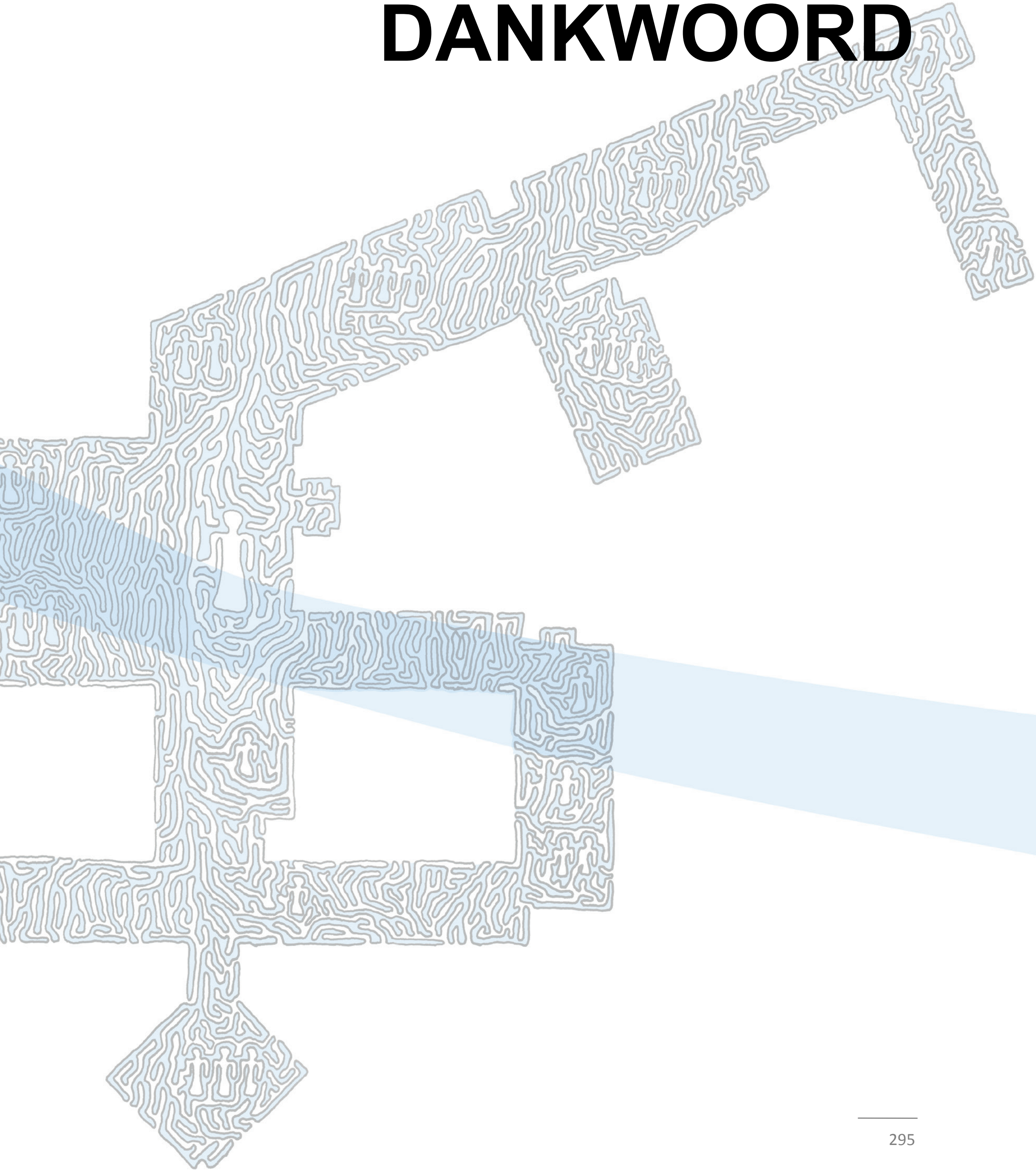
DANKWOORD



DANKWOORD

Het proefschrift dat je nu in handen hebt is het topje van de ijsberg, dat wat zichtbaar is van bijna zeven jaar nadenken, lezen, analyseren, gesprekken voeren en schrijven. Veel van wat onder water gebeurde past niet echt in een proefschrift, en daarom neem ik de vrijheid om in het dankwoord een kijkje onder water te nemen.

Ik heb veel interessants gelezen gedurende het promotie traject, maar het boek dat mij echt greep was 'Treatise of Efficacy' van François Jullien. Zijn werk was me aangeraden door Frits van Merode, een liefhebber van Jullien's werk. Er zijn diverse boeken en stukken van deze Franse sinoloog en dit Engelstalige boek was één van de weinige voor mij leesbare stukken. Ondanks mijn aangetrouwde Waalse familie is mijn Frans wat roestig, maar ook in het Engels vond ik het niet bepaald eenvoudige kost. Ik las het in Spanje, in de zomervakantie van 2015, op een moment dat ik wist dat mijn leven een andere wending zou gaan nemen. Ik wist nog niet waar het allemaal heen zou gaan, alleen dát het zo was. En het was inmiddels ook al aan het gebeuren.

In het boek beschrijft Jullien hoe in de Westerse en Chinese oudheid aangekeken werd tegen strategie en effectiviteit. Eén van de dingen die me vooral bij bleef was dat de sleutel tot een effectieve strategie is om te vertrouwen op het potentieel van de situatie, er als het ware door gedragen te worden, terwijl deze zich ontwikkelt. Vrij vertaald heb ik het opgevat als dat je niet moet proberen een situatie te forceren, maar dat je er voor moet zorgen dat je de omstandigheden en de factoren die de loop der dingen beïnvloeden zó goed kent, dat je deze met kleine veranderingen de goede kant op kan sturen. Zoiets als het verleggen van een takje in een rivier, waardoor het water nét even anders gaat lopen. Toen ik het boek las, begreep ik direct dat ik precies dát aan het doen was, alleen leek het in mijn hoofd geen strategie, maar meer iets als 'gewoon maar wat doen' of op zijn best 'experimenteren'.

Een jaar voordat ik kennis maakte met Jullien, in 2014, had ik het 'Handboek Buitenpromoveren' van Floor Basten en Kerstin van Tiggelen gekocht. Het idee om te promoveren was al eens eerder in mijn leven voorbij gekomen, maar toen wist ik niet waar het over zou moeten gaan. Na tien jaar consultancy in diverse ziekenhuizen had ik wel ideeën én inspiratie, waarbij je enige mate van frustratie ook als een soort omgekeerde inspiratie mag zien. Promoveren leek me op dat moment alleen niet voor de hand liggend, omdat ik mijn bezigheden toen – een jong gezin, een eigen bedrijf en veeleisende projecten - al behoorlijk pittig, soms zelfs ondoenlijk vond. Dat vond het handboek trouwens ook. Maar het kopen van het boek bleek een belangrijker stap te zijn, dan het lezen ervan. Ik besloot het boek niet uit te lezen, want eigenlijk maakte het me niet echt uit wat erin stond. Nog een paar kleine stapjes later besloot ik om het maar gewoon te gaan doen, promotie onderzoek.

Op de dag van mijn besluit reageerde een vriend met een appje met een Chinese spreuk: 'It's OK to be crazy, but don't be insane'. Ik wist niet waar op de schaal van gekte ik nu precies zat, maar dat ik dit ging doen voelde eigenlijk wel ontzettend goed en dat bleef zo. En mijn toen zesjarige zoon Bjorn zong het aan de lopende band: 'laat het los, laat het gaan!' Disney's *Frozen* was dé beste film van 2014, voor iedereen onder de 8 jaar dan toch, maar stiekem ook een beetje voor mij.
Ik besloot promoveren eerst maar eens als een hobby te beschouwen; de ene moeder gaat een cursus mindfulness doen of begint een taarten webshop, ik ga promoveren, dacht ik dan maar, een beetje om mijzelf te beschermen tegen al te hoge verwachtingen. Toen ik een jaar later Jullien las, begreep ik dat deze aanloop van kleine stapjes onderdeel waren van een strategie die zeer effectief zou blijken. En de eerste stapjes van het onderzoek bevielen erg goed. Ik kwam in mijn eigen fijne denkbubbel, af en toe even weg van de rauwe realiteit van dat jaar. Heel *mindful* leek me dat toch wel, erg van deze tijd, dus hoezo gek?

Aanvankelijk leken de omstandigheden voor een succesvol promotie traject in 2015 nou niet bepaald gunstig. Mijn gezin transformeerde in 2015 naar co-ouderschap, een door onszelf op maat gemaakte vorm van gezinsleven op twee adressen. Vanaf het moment van mijn eerste verhuizing eind 2015 – gevolgd door een tweede verhuizing in 2017 - leefde ik als het ware zélf in de logistieke complexiteit van mijn promotie onderzoek. In mijn advieswerk en onderzoek was ik bezig met grootschalige transformatie van ziekenhuizen zoals fusie of nieuwbouw en de impact daarvan op het logistieke systeem. In mijn eigen kleine wereld woonde ik zelf op meerdere locaties, mijn kinderen ook, en de huis-tuin en keuken logistiek was uitdagend en als je niet uit keek, ontwrichtend. Te veel voorraad in het ene huis met de verkeerde spullen, dan weer te weinig, misgrijpen, heen-en-weer fietsen tussen de gezinslocaties….co-ouderschap is geen optimaal logistiek concept. Ik besefte daardoor dat logistiek misschien niet *leidend* is voor besluitvorming maar wel essentieel is om complexe systemen te laten functioneren. Dat was waar mijn promotie onderzoek ook over moest gaan.

Mijn proefschrift is daarom min of meer 'als vanzelf' uit de omstandigheden voortgekomen. Maar vanzelf gaat natuurlijk niets. Je moet de omstandigheden wel zíen en weten te gebruiken. Wanneer iets tot stand komt weet je dan niet, dat moet blijken. Daarvoor is geduld en vertrouwen in een goede afloop nodig en natuurlijk had ik dat vertrouwen lang niet altijd. Mijn dank gaat daarom vooral uit naar iedereen die mij vertrouwen heeft gegeven, door een aanmoediging, door een kritische vraag, of door gewoon even niets te zeggen, het aan te kijken, maar mij vooral niet aan mijn lot over te laten.

Daarvoor dank ik in de eerste plaats mijn promotie begeleiders, Frits van Merode, Arno van Raak en Dirk Ruwaard. Jullie gaven mij vertrouwen, ideeën, praktische tips, adviezen en zetten mij op diverse sporen op een manier zoals Jullien het beschrijft: een plant moet je niet omhoog trekken om te groeien, maar je moet hem voeden.
Frits, voor mij ben jij de inspirator van dit onderzoek en je hebt ontzettend veel van jouw schijnbaar oneindige kennis, onderzoeks- en werkervaring met mij gedeeld. Jouw manier van begeleiden – een mix van ideeën inbrengen, soms een beetje ontregelen, aanmoedigen en soms ook grenzen stellen – heeft veel voor dit onderzoek, en zeker ook voor mij persoonlijk, betekend.
Arno, jou dank ik in de eerste plaats voor het bieden van houvast als ik ergens in het woud van wetenschappelijke methoden of literatuur verdwaald dreigde te raken. Ook zal ik jouw onomwonden enthousiasme voor de sociale netwerk analyse waarmee ik op een kladblaadje langs kwam op het Dubois domein, nooit vergeten.
Dirk, bij de start van ons onderzoeksteam sprak je uit dat een promotie onderzoek een *team effort* is en ook op diverse andere momenten liet je blijken dat ik er niet alleen voor stond. Jouw scherpe feedback – geen detail ontgaat jou –, en goede tips versterkten dat gevoel. Dank ook voor het achter de schermen regelen van de praktische en administratieve zaken, zoals budget voor opleiding en de proofreading.
Dit onderzoek is echt een team prestatie geworden. Ik dank jullie alle drie voor de altijd inspirerende en boeiende gesprekken, waarin vaak veel gelachen werd, ook niet onbelangrijk bij ondernemingen als deze.

De andere onmisbare pijler van dit onderzoek is het Slingeland Ziekenhuis en dan in het bijzonder René Nummerdor, Annemijn Houwers en Anne Oostendorp. René, dank dat je de deuren van het ziekenhuis open hebt gezet om waar ik maar wilde met mensen te spreken, observaties te doen en data te verzamelen. Annemijn, jouw enthousiasme en doortastendheid om zaken aan te pakken, werkten zeer aanstekelijk op mij. Dank voor je fantastische hulp door me wegwijs te maken in Slingeland Ziekenhuis, met documenten, data en contacten. Anne, dank voor je enorm inzet om mij te helpen met data uit HiX, zelfs als ik tot in den treure vragen bleef stellen over dit of dat data veld. Veel gesprekken die ik met jullie heb gevoerd zullen mij altijd bij blijven.
Ook dank aan vele mensen in het Slingeland die mij in de keuken mee lieten kijken. Het meelopen met artsen, verpleegkundigen, operatiekamer assistenten, anesthesie

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Daarnaast waren er diverse mensen die stukken van het promotie traject mee liepen en mij voedden met ideeën, reflecties en meningen over de thematiek van dit proefschrift. In de eerste plaats dank ik Henri Boersma voor zijn hulp bij het eerste artikel en de boeiende gesprekken over onze eerste stappen in het promotietraject.

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Gedurende de promotie hebben diverse mensen me geholpen met allerlei hand en span diensten. Brigitte Caenen, ontzettend bedankt voor het regelen van afspraken en administratieve zaken rondom dit onderzoek. Barbara Greenberg, dank voor de proofreading van alle artikelen en het regelen van native speakers Casey O'Dell en Pushba, die het proefschrift vanuit India tegen lazen. Dank aan Tiny Wouters voor de opmaak van het proefschrift. Dank ook aan Roelant Siekman voor de mooie 'oneliner' illustratie van het Slingeland ziekenhuis. Dank aan Erwin Frederiksen die er in Photoshop een mooie boekomslag van gemaakt heeft.

Tenslotte voel ik grote dankbaarheid naar mijn samengestelde familie. Sander de Moel, ons leven is nu anders 'geïntegreerd en gedifferentieerd' dan toen dit promotie onderzoek startte. Dat het óók nu nog goed functioneert, daar ben ik je enorm dankbaar voor. Marit de Moel en Bjorn de Moel, dank jullie wel voor jullie open blik, nieuwsgierigheid, vrolijkheid en humor. Die zijn voor mij een bron van veerkracht en plezier. Op een moederdag knutsel cadeau met 'mijn allerliefste wens voor mijn moeder is dat ze haar artikel haalt' kan je wel weer even teren.
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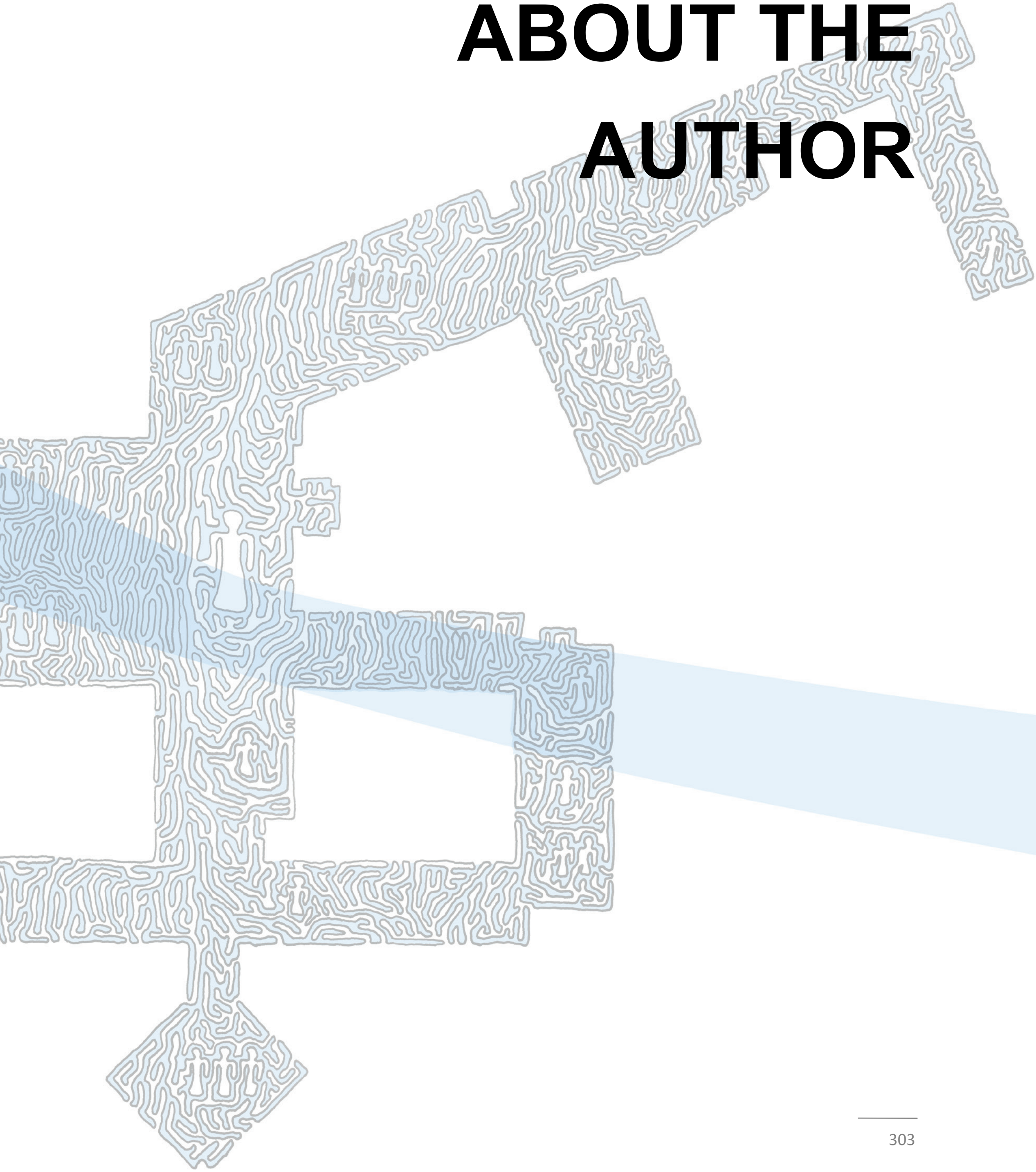
En zonder Erwin Frederiksen had ik deze weg niet durven bewandelen; jouw vriendschap, verwantschap en liefde hebben mij vleugels gegeven.

ABOUT THE AUTHOR



ABOUT THE AUTHOR

Annelies van der Ham was born on June 5 1975 in Utrecht, the Netherlands. After finishing her 'gymnasium' secondary education at St. Bonifatius College in Utrecht, she lived with a Scottish family in East Kilbride for a year, as part of a cultural exchange program. In Scotland she obtained her Highers and Advanced Highers at Duncanrig Secondary School in East Kilbride. After her year away she moved back to The Netherlands and obtained a Master's degree in Systems Engineering, Policy Analysis and Management in 1999 at the Technical University of Delft. Her thesis was about the optimization of information processes through computer simulation in Haaglanden Medical Centre in The Hague, the Netherlands.

Since 1999 Annelies has continuously worked on improving supply chains and networks. Between 2000 and 2006 she worked for TNO, a large independent research organization in The Netherlands. As a TNO consultant she advised airports, fruit traders, offshore companies, inland skippers and several other commercial businesses on logistical improvement and she designed supply chains and information architectures. She returned to healthcare in 2006 by joining consultancy firm YNNO and started consultancy firm SQwin in 2009, together with five YNNO colleagues. SQwin offered very specific knowhow to healthcare providers on the design, development and implementation of new buildings, information systems and logistical concepts. In 2020 she became an independent consultant, working for hospitals from her own consultancy firm SQurious. From September 2021 she is associated with Turner, a consultancy firm specialized in strategy execution.

In 2015 Annelies initiated the PhD research and has been an external PhD candidate to the Department of Health Services Research, Care and Public Health Research Institute (CAPHRI) at the Faculty of Health, Medicine and Life Sciences of Maastricht University. Her main interests are health care logistics, IT, eHealth and organizational development. In the upcoming years Annelies will continue to work on these topics, both as a postdoc researcher at CAPHRI and as a consultant.

LIST OF PUBLICATIONS

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