Process Reengineering in the Dutch HealthCare

Focusing on the CARE qualities

Eddy Voogd

UMCG, Sector E
University of Groningen, Faculty of Economics & Business, Operations & Supply Chains

Groningen, 26 november 2009

Studentenbureau UMCG/afstuderen

Universitair Medisch Centrum Groningen

Process Reengineering in the Dutch HealthCare

Focusing on the CARE qualities

Groningen, 24 november 2009

Auteur	Eddy Voogd
Studentnummer	1468049
Afstudeerscriptie in het kader van	Operations & Supply Chains Faculty of Economics & Business RuG
Opdrachtgever	Ir. A.P. Goudswaard Hoofd Zorglogistiek & Innovatie, Sector E UMCG
Begeleiders	Dr. M.P. Mobach Dr. T.J. Van der Vaart Faculty of Economics & Business RuG
Begeleider UMCG	Dr. J. Pols Studentenbureau UMCG

ISBN 978-90-8827-062-8
NUR 804 Productie, Inkoop, Logistiek
Trefw Logistiek, voorraad, capaciteit, taken, processen, communicatie

Omslag: Wenckebach Instituut, Universitair Medisch Centrum Groningen

- Abstract (En) –

This research is initiated by the logistical management and the management of the operations center of the University Medical Center Groningen. This hospital is confronted with changing demands of the healthcare market and planned changes in the internal hospital structure. The introduction of the new health care system and the DBC case-mix system in the first place obliges hospitals to change their strategies. The costs of the care process should be lowered and the quality of the process should be raised. Besides that, there also is a growing demand for a better understanding of the origin of the costs and quality. The UMCG is, in the second place, also confronted with planned changes in their internal structure. Elaborate saving plans should lead to a greater effectiveness and efficiency of the logistics, economically depreciated infrastructure at the sterile processing department and operations center require new investments and spare capacity at the logistical center at The Eemspoort demands for extra work. The combination of these internal – and external perspective resulted in this research towards the organization and structure of the logistical processes between the sterile processing department and an operation room and the logistical center The Eemspoort and an operation room.

Based on an elaborate theoretical discussion we have argued that the foundation for an improvement of the mentioned logistical processes is a **focus on the core competences**. Nash and Bryce **[**1996**]** presented the core competences that healthcare providers should master in order to create customer value. Among others these are effective management of health and wellness and effective care delivery. Nash and Bryce **[**1996**]** however also stated that to be able to create customer value with their core **care** competences, hospitals should organize their supply systems as efficient as possible. Healthcare systems may be able to achieve significant cost savings by **reengineering their supply systems** around patient needs instead of around traditional functional departments. This will allow hospitals to remain viable, even within a fast changing internal and external environment.

Business Process Reengineering is a radical breakthrough way of generating improvement in an organization. Process reengineering is a combination of different operations management techniques as just-in- time, process flow charting, critical examination in method study, operations network management and customer-focused operations. Underlying the process reengineering approach is the idea that operations should be organized around the total processes which add value for the customers, rather than the functions and activities which perform the various stages of the value-adding activity. Approaches such as process reengineering recognise that business performance is ultimately dependent on the optimisation of core and support business processes. Processes are comprised of sequences of linked activities which cross the vertical and functional boundaries existing in most organisations. Hence the reengineered organization transforms itself from a structure based on departmental roles to one based on directly servicing processes. Reengineering focuses on realigning the internal processes of an organization. It assumes that the enterprise has already made appropriate choices about overall purposes and about where to put the energy to achieve its purposes. The problems being solved through these initiatives are how best to do the work, how to improve speed, how to maximize resources and how to improve quality. Based on the BPR concept we were able to define six different research directions that examined the current organization of the logistical process in the direction of an operation room.

We first of all studied the current organization and structure of the logistical processes in the direction of an operation room. For the understanding of total research it was necessary to

analyze the different persons and departments that currently are involved at the logistical and surgical processes, the amount – and sort of process steps, the transition point from logistical to care related tasks and the insight in the different process steps. We showed that different kinds of medical resources and different kinds of logistical processes can be distinguished. Each logistical process consists of several process steps whereby great distances and also different floors are crossed. At each process also different persons and departments are involved. The limited amount of supply rounds, suboptimal loading of containers, not attaching opening hours, lack of signals and lack of transfer of information all are indications that the different persons and departments currently are operating in functional silos with mainly an internal focus. This lack of an external focus results in a suboptimal organization of the logistical processes and a suboptimal division of tasks. This is especially visible in the current division of ownership, the existence of two different but actually identical logistical departments and the quality of the insight in the different logistical processes. Especially the lack of insight results in cost, speed and quality problems. The exact height of the inventory currently for example is not known and not visible. It furthermore only is possible to trace the amount – and the location of materials at the four process steps of the sterile processing department. At all the other described process steps it is not possible to trace the amount – and the location of necessary or ordered materials and instruments.

The result of our first research theme was an elaborate description of the different logistical and care related tasks and an overview of the involved employees and departments. To be able to analyze the quality of the current organization and to be able to provide reengineering possibilities, we secondly studied the current relationships between the different involved persons and departments. Different sorts of relations, analyzed in terms of interdependencies, are possible. The strength of the interdependency is influencing the quality, speed and costs of the logistical – and care related processes and determines the optimal lay-out, structure and organization of the different processes in the direction of an operation room. We showed that the current interdependency is not of sequential -, as it was on paper, but of reciprocal form. The great amount of emergency appeals for stock items, non stock items and reusable items indicated that the current organization of the logistical process is of suboptimal form. The great amount of involved persons and departments, the great distances, great amount of transfers (of information and materials) and the low quality of the insight are, among others, responsible for this great amount of emergency appeals. This leads to a great amount of telephone calls, orders, conversations and meetings with persons and departments upstream and downstream in the logistical process. The eventual consequences are extra costs (inventory, couriers), extra required time (postponement of surgeries) and a decrease of the quality of the delivered care (forced usage of other materials). The main conclusion however was that the current structure and organization of the different processes in the direction of an operation room are not adjusted to the characteristics of the logistical process. A sequential process with frequent interactions demands, among others, for horizontal communication and locating units close together. This all is missing in the current organization.

During our discussion of the first sub question we showed that the transition point from logistical tasks to care related tasks is currently placed at the surgical assistant function. They currently are the most prominent actor in the organization of the logistics at the operations center. Surgical assistants are responsible for a great amount of logistical related tasks. Their core tasks, however, are care related tasks in an operation room. In view of the importance of the surgical assistant in the execution of the surgical process and the current shortage of surgical assistants in The Netherlands it was important to create an overview of the current work processes and task diversity of a surgical assistant and the related influence of placing the transition point at the surgical assistant function.

We showed that the content of the surgical assistant function currently indeed contains a great amount of logistical related tasks that interfere with their core care related tasks. As was evidenced by the different logistical studies in this research, the preparation of necessary materials, collection of missing materials, administrative tasks, laying out of materials and stock management takes a lot of time from the surgical assistants. The consequence first of all is that there is less time remaining for their core care tasks and that complete surgical assistant fulltime equivalents (*fte's*) are released for logistical related tasks. A second consequence is that the logistical tasks are executed with less speed and quality. This has a negative influence on the costs, quality and speed of the delivered care process. In line with the previous statement about the current suboptimal organization of the logistical processes, we also showed that the transition point from logistical – to care related tasks is placed at the wrong function. Placing the transition point at the surgical assistant function leads to a suboptimal execution of the logistical tasks, but also negatively influences the core care tasks of the surgical assistants. An even worse effect is visible on the health and stress experience of surgical assistants. A survey showed that high percentages of surgical assistants show serious health complaints and show clear signals of a burnout. These effects were also personally supported by the surgical assistants. They first of all appreciated the surgical assistant function with a grade which is lower than the average appreciation of professions in The Netherlands. They secondly also valued the current organization of the logistics with a serious low grade. They not only dislike the current organization of the logistics, but also do not enjoy executing logistical tasks and think that logistical tasks should be executed by logistical employees instead of surgical assistants.

Our fourth research theme stressed the main input to the organization of the logistical – and care related processes. This is the demand for surgeries and the resulting demand for materials and instruments. To be able to provide recommendations for a reengineering of the total process, it was necessary to create an overview of the different characteristics of the demand and how they are influencing the possible organization, structure and lay-out of the total logistical – and care related process.
We showed that the current demand for reusables and disposables (towards suppliers) is not based on the demand for surgeries. Instead of pulling the resources to an operation room, the materials are currently pushed to the warehouses. Instead of using *time* as a buffer, the UMCG is using *inventories* (close to the operations center) as buffer. Switching to a pull based strategy can however lead to lower inventories (on different locations). Most health care providers however are hesitant against implementation of a just in time system because of a common feeling of not being able to predict the production capacity and scheduling. An often heard argument is that hospitals are facing a great amount of short term emergency demand and that there just is not enough time to implement a just in time strategy. Based on our research and analysis we however showed that the current demand indeed is variable, but that the excessive usage of inventories on locations close to the operations center is unnecessary. We have shown that only 4.03% of the surgeries cannot be buffered with the available time until the moment of surgery. In view of the fact that the UMCG currently is using high inventories as buffer, it thus is possible to significantly reduce the amount of stock and use the available extra time until a surgery as buffer.

Based on characteristics of the demand, the organization of the logistical – and care related processes and the insight into the different process steps, it is possible to formulate an inventory management strategy. The management of the inventories is vital to hospital performance and patient care quality. Hospitals need to store a great variety of medical and surgical supplies which are required to be available in sufficient quantity and quality for the staff to use at all times. The formulated inventory management strategy has a significant influence on the costs, speed and quality of the total process.

In this fifth research theme, we showed that there actually is no inventory management strategy at the operations center. The different logistical employees just are doing those things of which they think it will lead to a sufficient amount of inventory. Important determinants of an inventory management strategy as characteristics of demand, characteristics of the total surgical process, involved persons and departments and the logistical concept/strategy are not taking into account and applicable concepts out of the environment (assistance of information systems, calculations of inventory parameters, usage of scanning systems) are not used. This leads to a suboptimal execution of the different logistical tasks (clearing away of ordered disposables and reusables, control of stock in hand and ordering replenishment stocks, ordering new products, control of sterility dates and management of the warehouses). Stock outs, postponements, emergency orders, disturbed relations, stress and uncertainty are therefore the order of the day. We furthermore also showed that in the current organization of the logistical process, not the logistical employees but the care related employees are the leading party. All the inventory related practices are adjusted to – or determined by the care related employees. They actually are the most important party in the management and organization of the inventory. The logistical employees are only facilitating this situation. It therefore hardly will be possible to create an effective and efficient inventory management policy.

The formulated inventory management strategy is, in combination with the characteristics of the demand, the organization of the logistical – and care related processes and the insight into the different process steps, determining the amount of locations (lay-out) of resources and warehouses in the total hospital supply chain. The chosen amounts are significantly influencing the costs, speed and quality of the total process and thus were the subject of our sixth and final research theme.
We showed that the current lay-out is totally adjusted to the used logistical strategy at the operations center. Since the surgical assistant function currently is the transition point from logistical tasks to care related tasks, the layout is totally adjusted to the different work places of the surgical assistant. This has lead to a great amount of warehouses at different locations in the supply chain. At the operation center we for example already counted a total amount of fifteen (15) central/large warehouses. Besides these central warehouses there also are different stock points at the patient care units and points of care. This leads to very high costs (great amount duplicate items), low speed (extra time with preparing surgeries and clearing away instruments) and low quality (passed sterility dates and frequent out of stock situations).

Based on the results and analysis of our six research themes we were able to conclude that the current organization of the logistical – and care related processes in the direction of an operation room needs significant changes to be able to improve the quality and speed and decrease the costs. This change has to be applied to all the different subjects that were discussed. A reengineering of the total process should ultimately lead to a different organization of the total process, improved insight in the processes, improved communication and cooperation, a process that functions in sequential way, a different location of the transition point, improved consideration of the characteristics of demand and finally an effective and efficient inventory management strategy and organization and layout of the warehouses and operations center. To be able to reach this improved situation we have developed the following main interventions/recommendations for the UMCG:

1. Extent the current visibility of the logistical processes by increasing the amount of scanning moments and places (introduce a digital scanning system). It is advises to first of all extent the scanning of instruments and instrument sets (inclusive weighing). When this is working properly, it is possible to start scanning at all process steps for the used disposables. It then also is necessary to inventorise at which process steps materials must be scanned and until which purchasing price disposables are scanned

2. Create *integrator functions* and *task forces* to improve the communication between different persons and departments to be able to improve the total logistical process in the direction of an operation room (instead of departmental sub optimizing)
3. Change the organizational structure of the logistical departments. Create one responsible manager for the total logistical process in the direction of an operation room. Add the responsibility of the logistics at the operations center to the responsibility of the logistical manager UMCG
4. Deliver and clear materials away during the nights (or after the surgeries) / adjust the working times of the LCE employees and logistical employees to the surgical production schedule
5. Create a better and more obvious ownership of the different sorts of medical resources
6. Create a connection between the planning of the surgeries, preparation protocols and the inventory management system
7. Decrease the agreed decontamination time of 12 hours
8. Create a hard cut between supporting functions (including logistics) and the core care functions (including surgical assistants).
9. Extent the usage of procedure trays
10. Place the transition point on the logistical employee function
11. Use more time buffers instead of the frequent usage of inventory buffers
12. Stop with the dispersed responsibilities of logistical employees at the operations cente
13. Implement an inventory management system
14. Extent the usage of Chipsoft (the program has many extra functionalities)
15. Expand the tasks of logistical employees and create an ***integrated logistical service center*** (locate the sterile processing department and the operations center (including central warehouse) nearby each other whereby tasks instead of responsibilities are dispersed

- Preface –

By finishing this research I have completed my study Business Administration and my master Operations & Supply Chains. The result of this research is this master thesis named *"Process reengineering in the Dutch HealthCare – Focusing on the **care** qualities"*. Considering the changing market – and internal situations, Dutch hospitals are forced to change their strategies and structures. To be able to deliver a care process of lower costs, higher quality and higher understandability it is necessary that different processes are reengineered. Hospital employees are advised to keep focus on their core (or care) qualities, i.e. medical related tasks. For the future affordability of the Dutch healthcare, it is necessary that non medical related tasks are executed as efficient and effective as possible without hampering medical employees and the execution of medical related tasks. This research has applied this vision to the different processes in the direction of an operation room at the University Medical Center Groningen.

It already is more than five years ago that I have set my first footsteps in the college world of Groningen. During these years I have received the possibility to develop myself in a social and an intellectual way. It was a chapter of my life full of experiences: both study and non-study related. I remember the nice activities, trips and evenings with my fellow students, my activities for the faculty associations BIG, EBF and RISK, the board membership during the organization of the Business Conference Groningen 2008 and of course my last college year which I have experienced as the nicest and best of the total Business Administration education.

Looking back at the last nine months of my college days and of this research at the UMCG, I have to conclude that I have seen, witnessed and learned a lot. Different conversations with various employees, different practical situations in different hospitals and the access to different sorts of information have contributed to this final result. They besides that also have strengthened my desire to start a career in the medical world. In my opinion this is a world which is always moving and which still is a playground for logistical educated people. I really hope that I can contribute to the maintenance of the current quality of the Dutch healthcare.

I really am proud of this research and especially of the results. I therefore would like to thank all the people without whom I could not have completed this research. The people below I would like to thank in particular.

First of all I would like to express my gratitude to Peer Goudswaard. It was the second time we cooperated during the writing of a thesis, and I have perceived it just as nice and successful as the first time. When there would be a third possibility, I definitely first of all would approach you as my supervisor.

Besides Peer, there also are three other supervisors which I really would like to thank for all the work they have put in this research. First of all Jan Pols, who was always ready for help or advices, secondly Taco van der Vaart who provided me different useful advices and suggestions during the final part of this research and last but certainly not least Mark Mobach which who I have spend several hours to discuss the progress of this research. I really would like to thank you for all the useful advices concerning the content of this research and the corresponding research methods. I also would like to thank you for all the advices concerning the structure and content of the final report. Without your help I would not have been able to present this final result.
A lot of people in the hospital have helped me with understanding the different processes in the direction of an operation room and with the execution of the data collection. I especially would

like to thank all the employees of the operations center. The persons I explicitly would like to mention are Judith de Priester, Anita Sportel and Melchior Oldenburger (of the Martini Hospital). I really would like to thank them for all the nice conversations and time they have invested in showing me around in the medical world.

I will always look back on my college life with a smile. It was a turbulent period with a lot of tops but also with one terrible period of illness of my girlfriend Gerdien. I am really glad and thank God that health has occurred in our lives again and that the future, how hard it maybe will be, is shining to us again. I really hope that our time of being together soon will begin - and will last forever!

Groningen, November 2009

Eddy Voogd

- Index -


2
4
6
8
10 CC
HYPO
ITALY

1.

- Introduction -

This research was initiated by the logistical management and the management of the operations center of the University Medical Center Groningen. This hospital is confronted with changing demands of the healthcare market and planned changes in the internal hospital structures and strategies, i.e. at the operations center, the sterile processing department and logistical center The Eemspoort. This research focuses on the creation of new structures and strategies of the processes in the direction of an operation room to be able to meet the changed demands of the external hospital market.

The first chapter of this research report aims to clarify the context and background of this research. First, the organization and the different concerned departments, where the research was executed, will be introduced. Subsequently, the background and motivation of this research will be described. It will be described as a reconciliation of the market situation and the internal situation of the University Medical Center Groningen. This chapter concludes with an overview of the content and structure of this research.

1.1 Introduction of the organization and concerned departments

This master thesis research is executed at the University Medical Center Groningen (UMCG). In the introduction, this organization will shortly be introduced to the reader. In particular the departments, where the research was executed, will be taken into account. These departments are the operations center, the sterile processing department (SPD) and logistical center "The Eemspoort" (LCE).

1.1.1 University Medical Center Groningen (UMCG)

The University Medical Center Groningen is a very large organization. It is one of the largest hospitals in the Netherlands and also one of the largest employers in the north of the country. Since January 2005 the Academic Hospital Groningen (AZG) and the Medical Faculty are combined to form a new organization named the University Medical Center Groningen (UMCG). The UMCG has got almost 10.000 employees, more than 1.300 beds, over 300.000 days of care and almost 70.000 operations per year. Daily, almost 1.000 different patients are admitted.
The hospital has, besides the core care tasks, also an education and research task. The UMCG is the largest medical educational institute in the Netherlands. It offers different studies and educations which are populated by almost 3.400 students. Through the integration of care,

education and research tasks, the UMCG is trying to deliver a contribution to qualitative superior care for the future [The UMCG, ww.umcg.nl].

1.1.2 Operations Center

The operations center of the UMCG is the location where daily more than 160 employees of different disciplines are cooperating in the care and cure of patients. Together, these employees form multidisciplinary teams of surgeons, surgical assistants, anaesthetists, anaesthesia employees, recovery employees and (in case of heart surgery) perfusion employees.
The operations center of the UMCG is separated in three surgical sectors and the sectors administration, sterile processing department and logistics (figure 1). The arrangement of the three surgical sectors is based on the similarities in tasks and requirements during an operation (table 1).

Sector	Specialism	Abb.
Sector 1	Cardiothoracic surgery	THO
Sector 2	Throat, nose and ear surgery	KNO
	Plastic surgery	PLA
	Neurological surgery	NEU
	Eye surgery	OHK
	Mouth surgery	MHK
Sector 3	Gynaecology	GYN
	Orthopaedics	ORT
	Vascular surgery	VAA
	Traumatology	TRA
	Urology	URO
	Child surgery	KIN
	Transplant surgery	TRA
	General surgery	ALG
	Hepatobiliary surgery	HEP

Table 1, *The arrangement of the three surgical sectors*

The operations center consists of 22 theatres which are spread over two different departments. These theatres are distributed among the different specialisms on the base of the demand for the specific surgeries. This results in daily changing allocations and theatre usage.

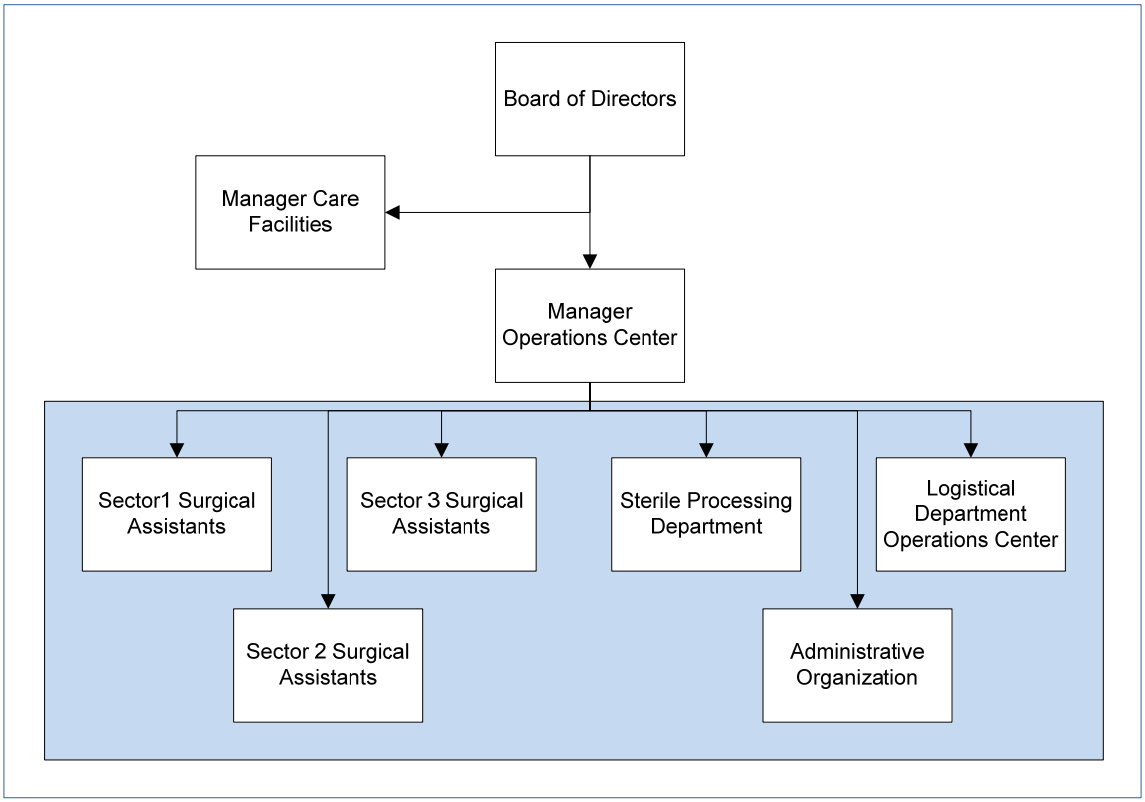


***Figure 1**, Organization chart of the operations center*

1.1.3 Sterile Processing Department (SPD)

The sterile processing department of the University Medical Center Groningen decontaminates (cleans, disinfects and sterilizes) reusable medical resources. The consumers or customers of these medical resources are all the different departments where medical, paramedical or nursing activities are taking place. Among these customers are the operations center (22 theatres), the surgery day treatment center (4 theatres), the policlinic (9 clinics) and the functional center urology.
Since the end of 2004, the sterile processing department is an independent department within the UMCG to be able to create a more direct management of the operative care process. Because of different reasons, the sterile processing department is established at a location not close to the operations center.
Because the sterile processing department now is an independent department, it also is independent in budget. The SPD will be discharged by production costs and has to deal with increasing competition by external service providers. The SPD therefore has the ambition to accomplish the sterilization process against the lowest possible costs with the highest possible quality. The activities during the decontamination process are presented in figure 2 **[**Pool, 2007**]**.

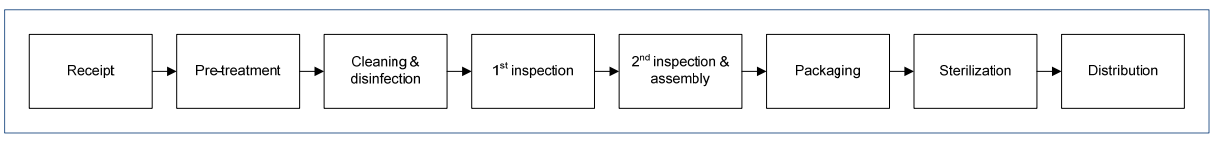


***Figure 2**, The activities during the decontamination process*

1.1.4 Logistical Center the Eemspoort (LCE)

Since May 2008, all the goods for the Martini Hospital and the University Medical Center Groningen are received and stored at a logistical center at industrial center "The Eemspoort" in Groningen. The storage, handling and supply of the two hospitals will be arranged from this new distribution center. The UMCG is the owner and the Martini Hospital rents around 900 square meters of the total 5.000 square meters storage location. The building comprises three floors with different sections, a conveyor of 300 meter pallet shelves for 1.300 pallets, a reach truck and a comb truck, roll through shelves and a modern sterile warehouse. At the moment, the building has a spare capacity of forty percent.
By transferring the completion and storage of the diverse goods to a more central location outside the hospital area, the flow of goods can be further optimized. The location is perfectly accessible for suppliers and offers a direct connection with the two hospitals. The centralization and modernization of the material logistics is a response of the UMCG to the social developments in improving the efficiency of hospital care **[**Logistiek Centrum Eemspoort, www.logistiek.nl**]**.

1.2 Background and motivation of this research

The background and motivation of this research originate from two different perspectives (*Appendix Book I*): the market situation in the Netherlands and the internal situation of the University Medical Center Groningen. Different hospitals in The Netherlands are currently experiencing great changes in their market – and internal situations. The introduction of the new health care system and the DBC case-mix system obliges hospitals to change their strategies. Together with their specific internal situations this has lead and will lead to new strategies, structures, relations and processes in the Dutch Health Care.

1.2.1 Market situation

The Netherlands have a long history of operating within a free market economy. Our entrepreneurial spirit has already been part of our culture since 1602, the year that the East India Company was established. Until recently, however, this entrepreneurial spirit was not visible in our health care system **[**Perrot, 2008**]**. The health care system was primarily a government-funded model with few entrepreneurial, free market characteristics. The used model still had its origins in the social reforms and socialized medicine concept proposed by Otto von Bismarck in the 19th Century **[**Wansink, 2005**]**. It was a two-tiered system comprised of a government-funded socialized medicine model and an individual-funded insurance model. While the model had effectively provided universal health care coverage, there were a number of challenges that were confronting long-term sustainability. The two main challenges were the rapid increase of the costs and the absence of an evaluation mechanism.

As with many industrialized nations, rapidly increasing health care costs alarmed the government. In between 1953 and 2003, the costs of the Dutch health care rose from around three percent of the Gross National Product to more than ten percent of the GNP (48 billion euro) **[**Dossier zorgstelsel, www.nos.nl**]**. With the aging population, there were projections that health care soon would consume at least 14 percent of the GNP.

The second challenge was the quality of the delivered care. While the majority of people felt that quality was adequate, there were no mechanisms to evaluate or compare care. For health care providers (hospitals, physicians, etc.) the system provided no incentive to improve quality of care.

Health care reforms thus were needed to provide transparent quality indicators and stimulate competition among providers. All with a goal to improve the quality of delivered care.

The Dutch government therefore began a comprehensive health care reform process in 2004 which consisted of moving from the highly socialized, two-tiered system to a regulated, free market health care model **[**Enthoven, 1988; Perrot, 2008**]**. This was to be achieved by giving consumers free choice of health insurer, by giving a more active role to insurers (as the representatives of patients' wants) and by increasing the competition between providers and between insurers **[**Oostenbrink and Rutten, 2006**]**. The familiar and more or less granted way whereupon the budget of healthcare organizations was composed has thus been disappeared. Financing should in growing extent be earned by correct care performances, in sufficient extent and for a competing price. Healthcare organizations no longer receive a firm budget, but will be compensated per delivered care product. This means that the accurate performing hospitals will be rewarded.

A further element of the new health care system is a release of the obligation for insurers to conclude contracts with all hospitals. This means that care for a patient will only be reimbursed when there is an agreement between the insurer of the patient and the care provider. It will also be possible for the insurer to be selective in his choice. *The price* will most likely be decisive in these situations **[**Goudswaard, 2006**]**.

The above mentioned reforms of the health care sector are supported by considerable changes in the financing, budgeting and reimbursement of health care organizations. During the last decades, budgeting and reimbursement systems were mainly directed at the control of health care expenditures **[**Schut and Hassink, 2002**]**. Incentives to increase production or to drive efficiency were missing for the greater part. Therefore in February 2005, a case-mix system based on "diagnosis treatment combinations" (DBCs) was introduced for the registration and reimbursement of care provided by hospitals and medical specialists (*Appendix Book II*).

> **DBCs** are defined as the whole set of activities and interventions of the hospital and medical specialist following from the first consultation and diagnosis of the medical specialist in the hospital. This means that a DBC covers the entire treatment episode related to the same diagnosis, including the hospital admission, medical interventions and preceding and subsequent outpatient visits **[**Oostenbrink and Rutten, 2006**]**.

An important adjustment that comes with the change of the health care system and the introduction of the DBC system is selective contracting. In the old system (and which still is the case for care covered by list A DBCs), the choice of the medical center was left to the patient. In the new situation, insurers are no longer forced to contract all medical centers for list B DBCs. This choice will be dependent on the *price* and *quality* of the medical interventions.

An important consequence for hospitals of the new health care system and the introduction of the DBCs is that a distinct insight in the different costs of different DBCs is necessary. The transition from supply regulated care towards demand controlled care (combined with liberalization of the supply-side) will mean that hospitals need to become (social) entrepreneurs. It therefore is expected that management accounting and control and cost-price calculations will take a more prominent position in the future conduct of business. It is possible to mention a few expected modifications **[**Schaepkens, 2002**]**:

- Hospitals will not charge the obliged rates, but will negotiate with health insurers about the prices of their products. This means that cost-prices of DBCs should be calculated as starting point of these price negotiations.
- Because controlling of costs becomes important, hospitals need better understanding of the relations between activities on the one hand and cost on the other hand. Besides that, hospitals will try to avoid activities that will not add value. This will lead to the application of Activity Based Costing and Management.

An important criterion for a successful implementation of Activity Based Costing and Management is an in depth understanding of the origin of the different costs. This especially is applicable to the different overhead costs (*Appendix Book III*).

The market situation of the UMCG is visually summarized and presented in figure 3. It is possible to see that the broad understanding is translated in some *general performance objectives*.

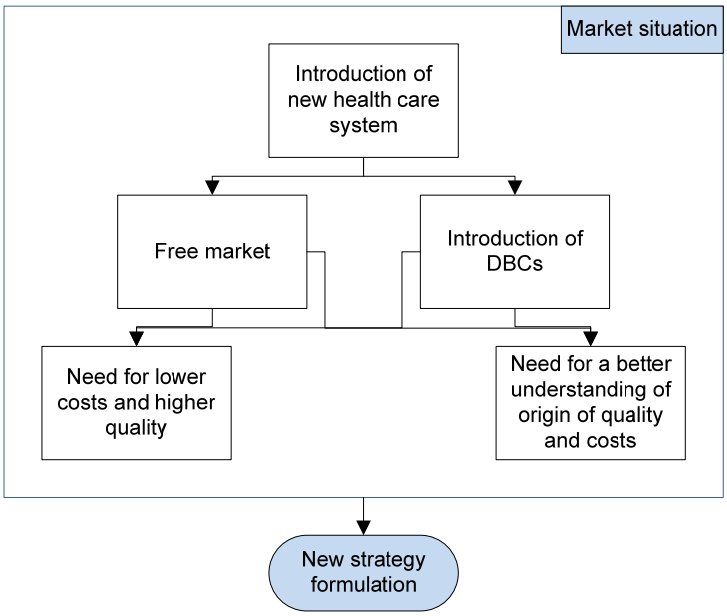


***Figure 3**, The market perspective analysis of the UMCG*

1.2.2 Internal situation

The internal situation of an organization is clearly an area within the operations function's traditional area of responsibility. Here it is not the totality of the market but the totality of the resources owned by or available to the operation, the way they form the operations' processes and the consequences for the internal situation which are important. Similarly as the broad understanding of the market was translated into general performance objectives, it is possible to translate the understanding of the internal situation into specific and concrete operations strategy decisions **[**Slack and Lewis, 2002**]**.

OPERATIONS STRATEGY can be defined as the procurement and allocation of resources for the development of operations capabilities such as low costs, superior quality, prompt, dependable and innovative service delivery, and flexibility. The objective of operations strategy is to support the organization's mission and business strategy, and to gain competitive advantage in the marketplace **[**Butler et al, 1996**]**.

The University Medical Center Groningen is facing different challenges and changes in their internal situation. To be able to keep providing care of great quality and diversity in the future, it had to start an elaborate saving plan of 40 million euros. Although the financial results over the last three years were positive, it is necessary to cut down the costs to be able to continue the investments in innovative health care of better quality and lower costs. All the different organizational departments therefore are forced to decrease costs and increase profits. The University Medical Center Groningen expects to realise a great part of the savings with measures aimed at effectiveness and better logistics (standardisation and purchase advantages) **[**Jaarverslag Universitair Medisch Centrum Groningen 2007, www.azg.nl**]**.

Besides this obligation to work more effective and efficient, there are also some other internal modifications at the different departments that are relevant in line with this research. Mainly the operations center and the sterile processing department are on the eve of necessary changes. The operations center is ready for a profound rebuild. The current infrastructure does not meets the needs of the current health care demand. It therefore is necessary to restructure the operations center to be able to execute operations against lower costs and better quality.
Also the sterile processing department is forced to make internal changes. The current infrastructure (machines and materials) is more than fourteen years old and is economical depreciated. To be able to keep a high quality and safety of the cleaning and sterilization process, it is necessary to replace the infrastructure at short notice.
It finally also is important to look at the internal situation of the logistical center at the Eemspoort. The logistical center is in use for a short period (since 2007) and therefore is still working with a spare capacity of 40 percent. There is a desire to fill this capacity with inventory activities from the UMCG or other medical centers in the region.

It is possible to conclude that the internal situation thus actually is a combination of resources, capabilities and processes. The operation's strategy is directed at the arrangement of these different aspects. These arrangements are based on decisions. These decisions can be divided in four categories named decision areas **[**Slack and Lewis, 2002**]**:

1. *capacity*: The ability of an operation, or business, to achieve a particular level of activity or output
2. *supply networks*: No single operation exists in isolation. All are an element of an interconnected network of other operations (customers, customers' suppliers, suppliers, suppliers' suppliers, distribution operations, etc.) All operations need to regard their position in this network, both to understand how the dynamic forces within the network will concern them, and to determine what role they wish to play in the network
3. *process technology*: There are two categories of process technology. The first category is the equipment, machines and processes which act on transformed resources to convert them into finished products and services. The second category is a kind of process technology, which may not directly produce core products and services, but helps the transformation process. This is information processing technology
4. *development and organization*: The set of broad – and long-term decisions which must be made governing how the operation is run

The internal situation of the UMCG is visually summarized and presented in figure 4. The understanding of the internal situation is translated into the mentioned operations strategy decisions. These strategy decisions are the input to the development of the theoretical framework in chapter 2.

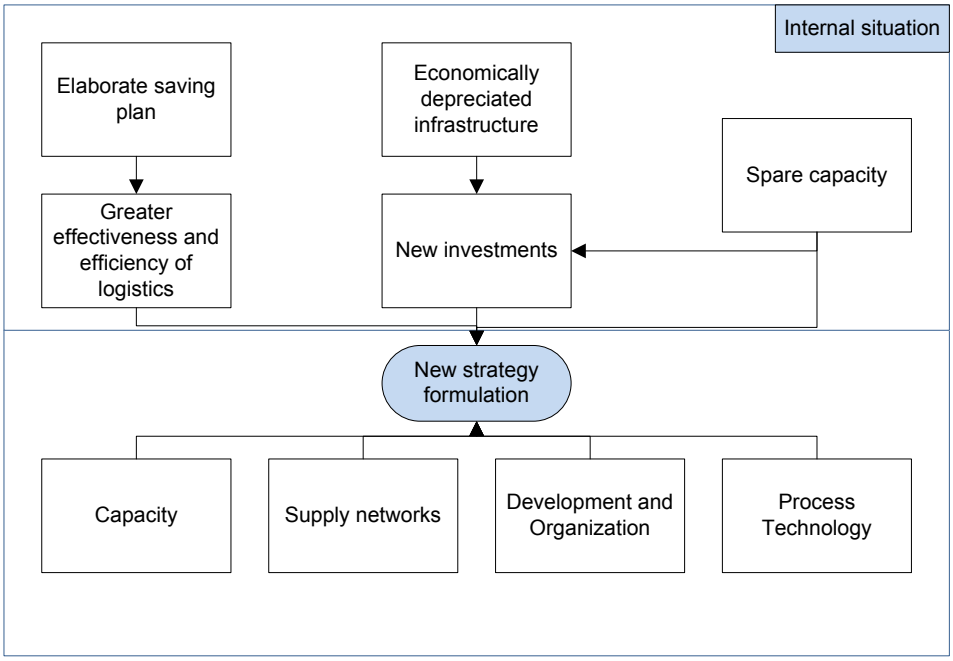


Figure 4, *The internal perspective analysis of the UMCG*

Considering the above described market situation of hospitals in The Netherlands and the specific internal situation of the UMCG it now is possible to formulate the *main problem* that is relevant for this research:

> The current organization and structure of the processes in the direction of an operation room are not adequate enough to be able to meet the changed demands of the hospital market. The current quality of the logistical process is too low, the costs are too high and the origin of the costs and quality are not understandable.

Based on the formulated main problem, it is possible to formulate the following *research objective*:

> Provide insight in how the UMCG needs to change the organization and structure of the logistical processes in the direction of an operation room to be able to meet the changed demands of the market (the need for lower costs, higher quality and a better understanding of quality and costs) thereby taking into account the specific internal situation of the UMCG.

This research objective is a second input into the development of the theoretical framework of this research. The research objective makes it possible to choose for one or several of the above mentioned strategy decisions.

1.3 Content and structure of the research

To be able to create a structure and delimitation of this research, a theoretical framework will be developed in chapter 2. This theoretical framework provides the scientific motivation and arguments of this research. It is based on the notion and perspective that quality and cost of care are related to an integrated supply chain and appropriate resource utilization. Chapter 2 will be concluded with a summary whereby also the research question and different sub questions will be formulated.
Chapter 3 subsequently will describe the methodology of this research. This chapter will define how the formulated research questions were answered and how the data was collected. Chapter 3 will also provide the system and environment of this research. As with every research it namely is very important to make the right modeling decisions.
The results of this research will be described in chapter 4, and will be analyzed in chapter 5. Chapter 6 concludes with the answers on the different research questions and provides several important recommendations and directions for future research. Chapter 6 will, moreover, also discuss the scientific value of this research. The structure of the research report is visually presented in figure 5.

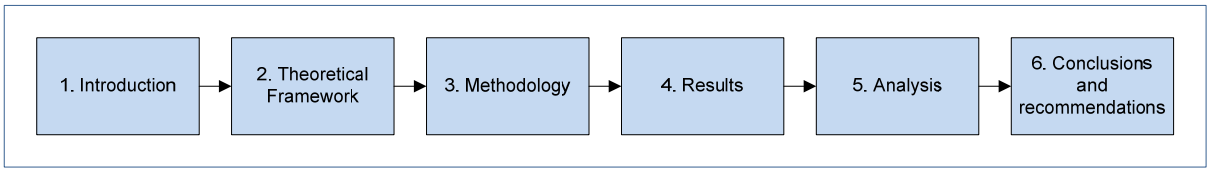
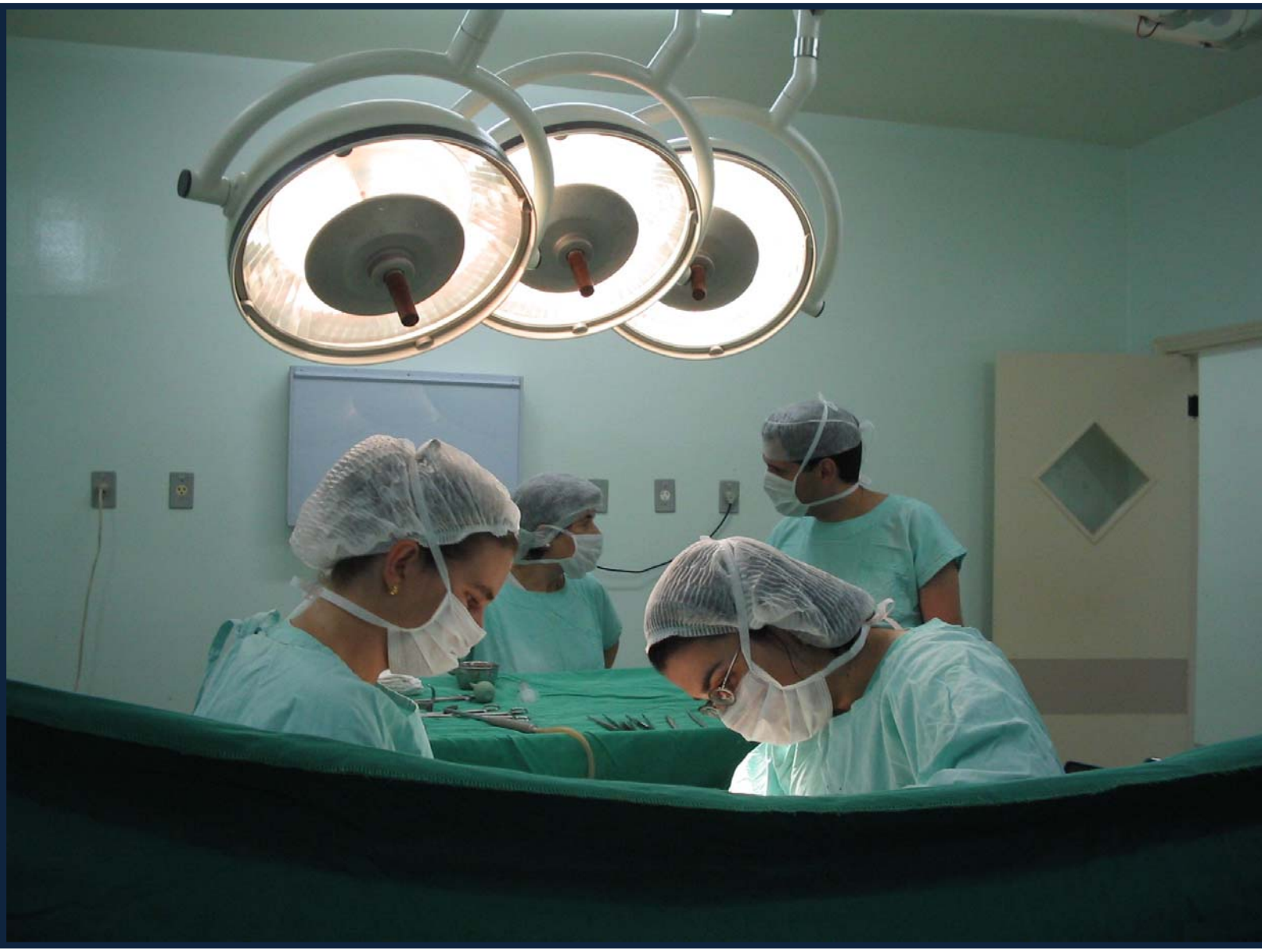


***Figure 5**, Structure of the research report*



2.

- Theoretical Framework –

2.1 Introduction

One of the oldest books about business in hospital environments is the greatly valued book of John Hornsby and Richard Schmidt named "The modern hospital, its inspirations, its architecture, its equipment, and its administration." Although the book was already published in the year 1913, it still consists of many usable wisdoms. In the preface the authors for example mention the many shortcomings of the book due to "the scarcity of hospital literature and the many rapid changes that are taking place in the science of hospital administration, that would render the literature of today valueless for tomorrow" **[**Hornsby and Schmidt, 1913**]**.
This statement is, despite his age, still relevant these days. The environment of healthcare organizations is, as already described in chapter 1, rapidly changing and more and more literature, for a great part coming from a business perspective, is published recent years (*Appendix Book IV).* The changing internal and external situation has resulted in a growing demand for improvement philosophies and methodologies from an operations management perspective to address the different challenges the industry is facing.

The result of the discussion in chapter 1 was an overview of the changed market situation and internal situation of the UMCG, and the resulting management problem. The solution to the management problem can be found in one of the mentioned strategy decisions. This chapter will make a case for the choice for two of the four strategy decisions and develops this choice to the theoretical framework of this research. The results of this theoretical framework are the conceptual – or research model and the corresponding research questions.

2.2 The operations strategy matrix

When the market situation and the internal situation of the UMCG are brought together it is possible to form the two dimensions of a matrix. This matrix is presented in table 2 and describes the operations strategy as an intersection of the UMCG's performance objectives and its decision areas.
When regarding the different performance objectives, it is suggested that an organization should make a determination as to which performance objectives are order qualifiers and which performance objectives are order winners **[**Hill, 1989**]**. Based on the market situation, the UMCG is forced to improve the performance on the performance objectives *cost* (amount and insight) and *quality*. It can thus be stated that these performance objectives are the order winners in the current market situation. Flexibility, reliability and speed can be viewed as order qualifiers. Hill

[1989] further recommended that relative weights have to be assigned to the order winners so that resources and energy can be appropriately directed and performance can be improved.
To be able to obtain this improved performance, a new strategy has to be formulated. According to Ginn [1990], operational issues are one of the keys to strategic change. This is confirmed by Butler [1996], who adds that it is wise to change the role of the operations manager from a reactive ("can't say no") to a proactive and involved role in strategic decision making. Changing the operations strategy could thus improve the performance of the UMCG on the order winning performance objectives cost and quality. The main question, however, is which specific decision area, or combination of several decision areas, has to be chosen? We therefore first of all will analyse the literature about the order winning performance objectives in this healthcare environment: costs and quality.

	Quality	Speed	Dependability	Flexibility	Cost
Capacity					
Supply networks					
Process technology					
Development and organization					

***Table 2**, The Operations Strategy Matrix*

Costs

Cost containment still is a major operational issue and research agenda item in hospital management. Smith et al [1981] presented the initial comprehensive work on the issue of cost containment from a research and strategic perspective in health care environments. Cost containment in the health care field is viewed as a localized problem and responsibility for every health care administrator, instead of being perceived solely as a public policy issue. As a result they presented a framework which describes, among other things, inter-organizational and intra-organizational actions management can take to achieve cost containment.

The creation of an efficient record system is the first step toward cost containment in health care organizations. Administrators first must know which costs they are facing before programs can be developed for solving problems. Improved budgeting and budget control systems are thus important and required.

A second, important mode of cost containment in different industries is inventory management. Hospital inventories often are an ignored topic. Most of the health care inventory literature focuses on service levels and neglects costs [Pierskalla and Wilson, 1989]. Important attributes of hospital inventories are the high stock out costs and holding costs, as well as the heterogeneous nature of the inventories and supplies. In order to contain costs and maintain high service levels, some hospitals are using a "stockless" inventory system where necessary equipments are delivered directly and just in time to nursing units and operating rooms [Freudenheim, 1991].

Third, the health care organization can engage in various types of internally or externally oriented, intra-organizational or inter-organizational cooperative arrangements with other departments or health care organizations. This might include a shared service arrangement, contracting out all or a part of the functions of the organization or a joint venture with other health care organizations to form a multi-institutional system. This strategy represents an attempt to alleviate some of the external pressures for cost containment through the establishment of favourable external relationships [Fottler et al, 1982].

Quality

While the public forces health care administrators to reduce costs, there is an equal pressure to improve quality. Health care administrators must pursue both efficiency and effectiveness goals. These outcomes are often countervailing in nature, resulting in sub optimization of one or both goals compared to the level of attainment as were they separated. This is not a new problem in the health care field. The emphasis on good performance has in the past however been so over weighted towards quality of care issues that efficiency until now has received little priority.
Consequently, not much literature that studies the relationship between these two variables is present. Harkey and Vraciu **[**1992**]** were one of the firsts and few to found a positive relation between quality and profitability in that hospitals with higher quality services hold greater market share and operated more efficiently. But also more recent work mentioned this relationship **[**Farrel et al, 2007; Jiang et al, 2006**]**. It can thus be stated that when a health care organization is following the right operations strategy, cost containment and quality improvement can go hand by hand.

As already stated, there are four different operations strategy decisions which a management can choose to achieve cost containment and quality improvement. Based on the specific situation of the UMCG (mainly the three involved departments) and the above mentioned possible actions, it is expected that significant cost containments and quality improvements can be achieved by reconsidering the decision area *supply networks*. The three concerned departments are currently operating in too much isolation. A more integrated supply network may lead to improved cooperation and understanding and thus to lower costs and higher quality. This is supported by research of Kocakulah et al **[**2001**]**. They mention the significant relation between quality of care, integrated supply chains and appropriate resource utilization.

This research therefore mainly will be focussed on *the relationship between the supply network of the operations center, the logistical center at the Eemspoort and the sterile processing department and the performance indicators quality and cost*. This results in the complete operations strategy matrix in table 3 and figure 6.

Because it is impossible to study supply networks without taking into account the *process technology*, this decision area will also be indirectly studied. And because different process times of the supply network are of considerable importance when studying actual quality and costs, the performance objective *speed* will also be indirectly studied.

	Quality	Speed	Dependability	Flexibility	Cost
Capacity					
Supply networks					
Process technology					
Development and organization					

	Studied
	Indirectly studied

***Table 3**, The Operations Strategy Matrix*

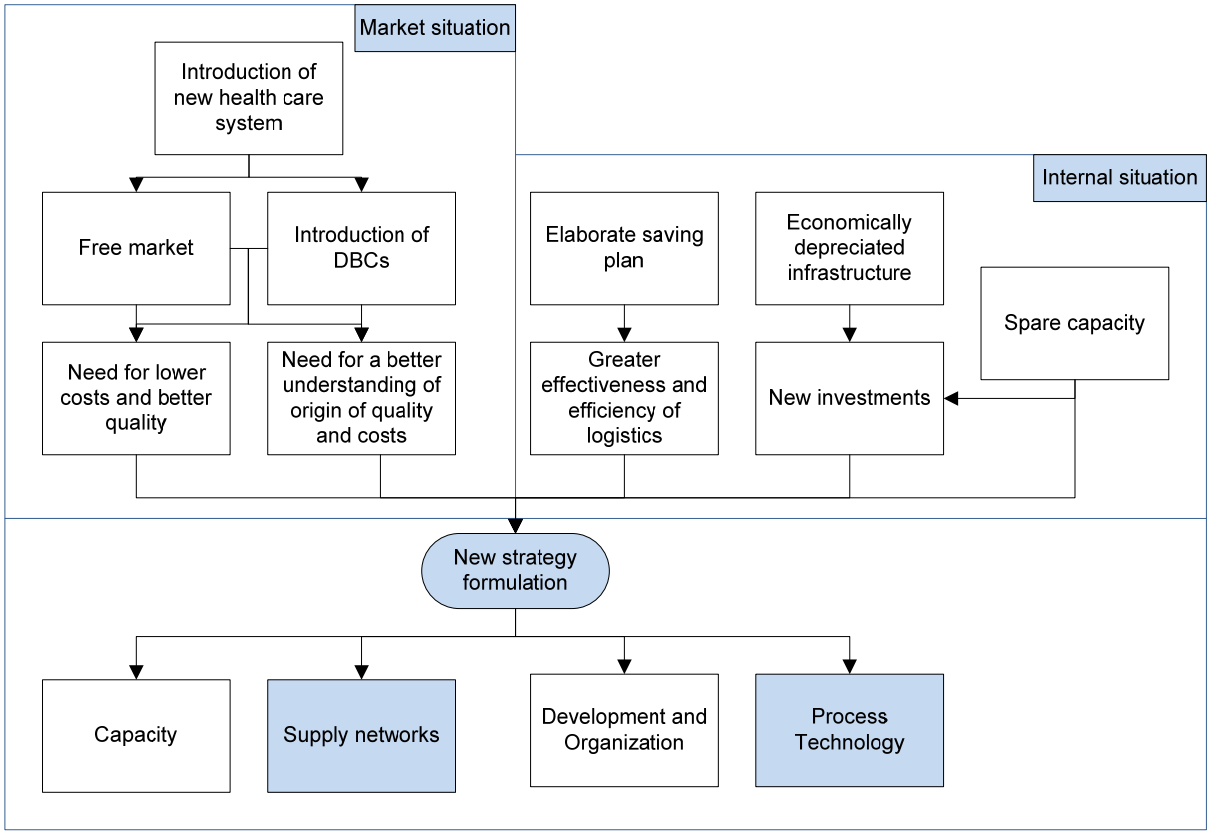


***Figure 6**, The combined internal perspective analysis and market perspective analysis of the UMCG*

This chapter continues with the further development of the theoretical framework by which the decision areas *supply networks* and *process technology* are the main input. The question then, however, is where to start and what to do? How can the UMCG change his strategy? The answer, as already mentioned, is the cure that many managers have been too distracted to attempt: detailed, day-to-day attention to operations and logistics. Hospitals are being compensated in almost the same way as manufacturers and will rise or fall largely on the strength of operational performance. Stocks and flows, queuing theory, just in time processes, all concepts associated with the factory floor, are exactly what the modern hospital needs. Manufacturing industries already have used these ideas for decades. More recently, service industries such as retail banking, fast food and telecommunications have followed. Now it is time for the hospitals to start implementing the details **[**Mango and Shapiro, 2001**]**.

This focus on operations and logistics is already gaining more and more popularity in the health care industry in The Netherlands. Dutch hospitals, however, still are mainly designed around a *functional structure*. This means that their activities are not based on the demand of care, but are based on the supply of care, organized in specialized departments. Within this organizational structure the emphasis is on the connection between patient flows and capacities within a single department. There are only marginal connections with other departments. This structure is very effective when there is little need for horizontal coordination. It however leads to high inefficiencies because of, for example, the high inventories at the distinct departments **[**Daft, 2004**]**. This, in other words, will lead to "fat" organizations. As a rule, however, they are not born fat. To the contrary, more often than not, they began lean. The challenge for Dutch hospitals now is to become lean again **[**McConnel, 2005**]**. This also is one of the main challenges of the UMCG.

In the next paragraphs some modern solutions to improve the efficiency and effectiveness of the UMCG will be discussed. It first of all, however, is necessary and important to obtain some insight in the distinctive technology and internal organization of a hospital.

2.3 Technology and internal organization

Technology refers to the work processes, techniques, machines and actions used to transform organizational inputs (materials, information and ideas) into outputs (products and services) **[**Perrow, 1967**]**. Technology is the organizations' production process and includes work procedures as well as machinery. An organization's core technology is the work process that is directly related to the organization's mission. A non-core technology is a department work process that is important to the organization but is not directly related to its primary mission. In case of a medical center, the core process can be described as *curing patients* **[**Bouwen aan de toekomst van gezondheid, www.azg.nl**]**. It is important to realize that the core technology has a great influence on the organizational structure. Understanding the core technology can thus provide insight in how an organization should be structured for efficient and effective performance. An organizational structure is made up of different departments, whereby each may use a different work process (technology) to provide a good or service within an organization. The transformation process of a prototype organization is presented in figure 7.

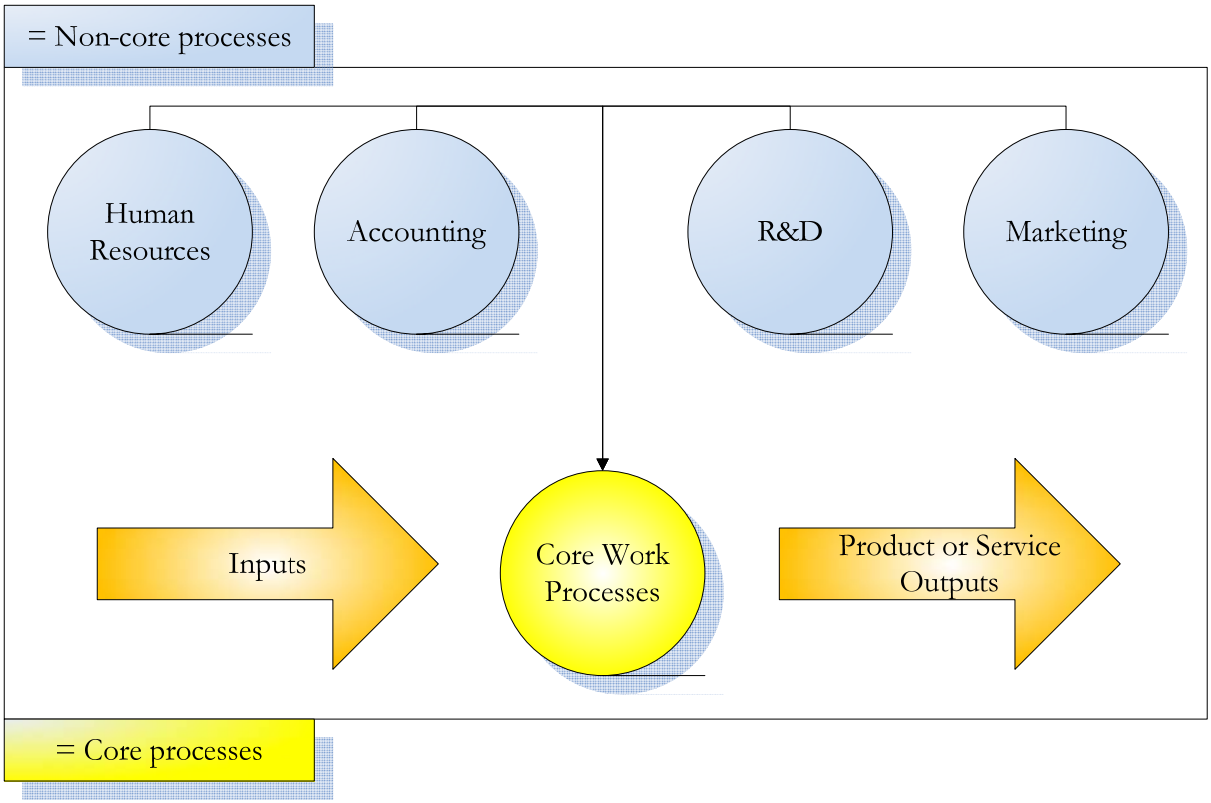


***Figure 7**, The transformation process of a prototype organization*

Besides looking at the technology of a prototype organization, it also is important to look at the specific internal organization of a prototype hospital. The internal organization of a hospital namely is very unique because it actually is a composition of two firms in one. One part is ran by the doctors and another part is ran by the hospital administrators. This split in authority has been emphasized repeatedly in the organizational literature, but remains a source of considerable

confusion in existing business models. It however turns out that it is important to consider this organizational schizophrenia when restructuring hospital structures and processes [Harris, 1977].

The result of the hospital schizophrenia namely is an organization separated in two distinct pieces, each with its own objectives, managers, processes and constraints. The hospital is a firm specifically designed to solve complicated decision problems: the diagnosis and treatment of illness. Because of the uncertainty of human disease processes, this task requires an organization which can adapt quickly to changing circumstances and new information: the "fire fighting aspect".

This "fire fighting aspect" of hospital care is critical to the firm's organization. In contrast to the standardized assembly line production processes in production firms, each patient receives customized attention. Such a regime of special cases requires a considerable degree of decentralization of decision making. Any organization designed to deliver care obviously also must have a certain amount of standby capacity. But in a hospital this is not merely a matter of stocking the appropriate physical inventories.

A hospital often is made up of an array of specialized suppliers and demanders. On the supply side, certain functional oriented departments stand ready to assemble and deliver a particular input. These inputs are called "ancillary services" and the suppliers are called "ancillary departments." On the demand side, various doctors decide which patients need which ancillary services and when. A doctor (demand side) for example orders an operation whereupon the logistical department (supply side) prepares the surgical suite and the necessary materials and instruments. The patient care process becomes, in effect, a sequence of demands and deliveries. This separation of internal supply and demand functions is really what distinguishes the hospital from other organizations. *In a hospital, the supply function has become too specialized for doctors to handle by themselves.* Hence, when a doctor places an order it thus creates an internal demand for an ancillary service, which then is supplied by different employees in the firm (the hospital's administration). This separation of functions is presented figure 8. The important point is that the administration does not make patient care decisions. The information it uses to plan capacity for ancillary and support services is derived basically from the set of internal demands of individual doctors [Lee, 1971].

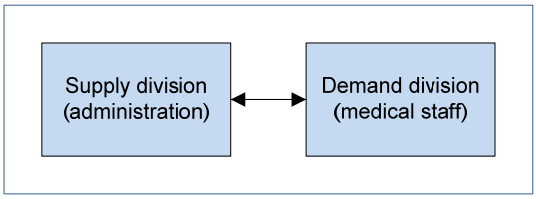


***Figure 8**, The internal organization of a prototype hospital*

2.3.1 Integration

When we then try to combine the above mentioned concepts (technology, internal organization and the earlier discussion about the increased focus on logistics) it is possible to create an integrated figure. This figure is presented in figure 9. In this figure it is possible to distinguish the demand division and supply division of the hospital, the different core processes and the different noncore processes. The combination of these three concepts leads to the creation of three distinct segments. The three different concepts all are responsible for the transformation of organizational inputs into outputs in a healthcare environment.

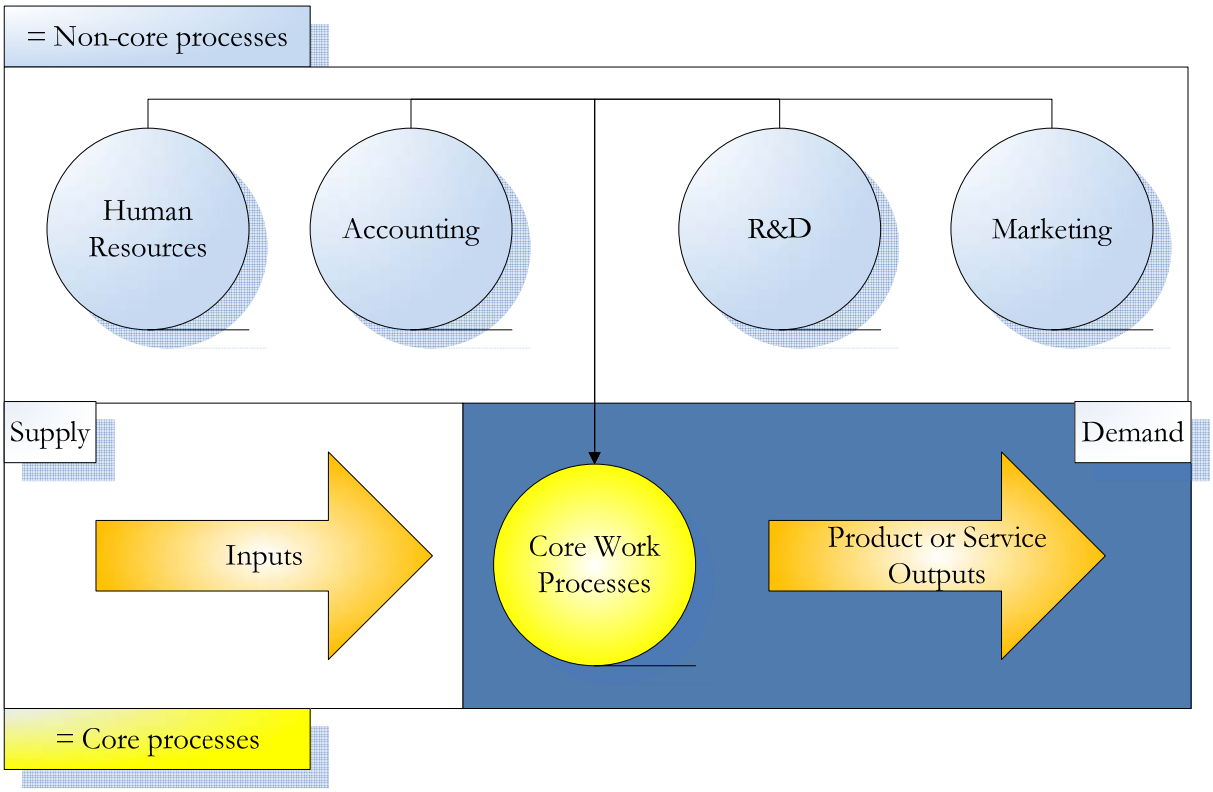


***Figure 9**, The integrated figure of a healthcare provider*

To be able to improve the efficiency of the transformation process, hospitals receive more and more attention for a business driven approach of health care organization. This approach focuses, in contrast with the earlier mentioned functional organization, more on the adjustment of patient flows and capacities across different departments **[**Vos et al, 2008**]**. Hospitals are more and more trying to reduce patient waiting times, slash inventories, prepare operating rooms faster and move patients fast, seamless and error free through a hospital stay or doctor visit **[**Wysocki jr., 2004**]**. This growing awareness of the need to re-operationalise health care environments, whereby costs will be lowered and speed and quality will be raised, has led to the adaptation of a well-known business concept: *focusing on core competences* **[**Jarret, 1998**]**. This management concept is applicable to the supply division and the demand division of the core operations processes (as presented in figure 9). Regarding the management problem of the UMCG, as described in chapter 1, this research will mainly be focused on the performance of the supply division of a hospital (figure 10).

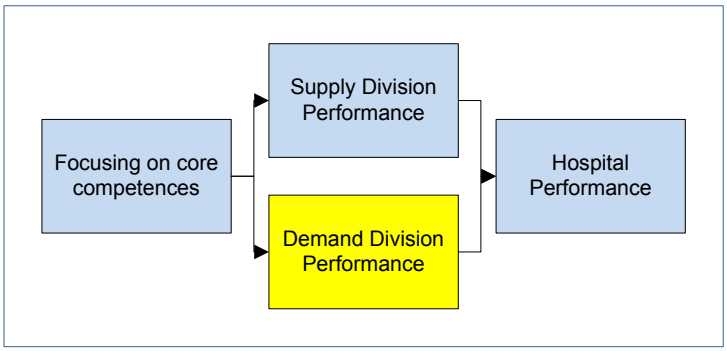


***Figure 10**, Focus on the performance of the supply division of the UMCG*

2.4 Focusing on the Core Competences

In today's world, more and more organizations are wondering what makes it possible for an enterprise to create products or services that are universally recognized as distinctive and valued. How is it possible that certain companies are able to develop products or services that appear to be a perfect match between the internal and external situation? One of the current theories in the management literature is that some organizations are better capable than others to understand and exploit their core competencies or capabilities. They perfectly know how to combine their talents, knowledge, technology, and culture to bear not just on the needs of the present, but to use them as a foundation for creating value and performance in the future **[**Jurrow, 1996**]**.

Over the last few years, three directions of practice have emerged in the academic literature, in response to the need for better performance of hospitals. These directions are restructuring, reengineering and redesigning. Each has its advantages and disadvantages. The key for choosing one of these methodologies to improve service performance should be a clear view of what the organization seeks to accomplish. Once the goals are set, the appropriate direction should be selected based on how *well its characteristics address the core competences* **[**Nutt and Hogan, 2008**]**.

Restructuring is a reconfiguration of organizational units with a focus on reducing the amount of staff employed to accomplish the work of the organization. Changes can appear in the size, shape and number of units and in the hierarchy required to manage the work. Employees are often expected to develop broader knowledge bases and areas of expertise, so that they can support what has been done previously through the efforts of multiple work units and a larger staff **[**Walston et al, 2004**]**.
Reengineering focuses on realigning the internal processes of an organization. It assumes that the enterprise has already made appropriate choices about overall purposes and about where to put the energy to achieve its purposes. The problems being solved through these initiatives are how best to do the work, how to improve speed, how to maximize resources and how to improve quality **[**Lin and Vassar, 1996**]**.
Organizational redesign is a rethinking of what an organization is trying to achieve, the programs and services to accomplish it and the organizational structure, processes and systems to best support it. Organizations often get distorted over time through a variety of means. Redesign offers the opportunity to reexamine the purposes of the organization and to design the most effective structure and set of processes and systems to carry it out. This means rethinking the shape and direction of the enterprise in light of current and emerging user needs.
An approach that can be an outgrowth of any of these three directions is outsourcing. This means looking upstream and downstream in the supply chain of which the organization is part of, and cutting of some traditional processes of the organization. Activities and tasks that are outsourced should be those that others can do more efficiently because of lower costs, greater scale or better performance. This should be activities and tasks that do not add to the core qualities which users and demanders consider important.

Before organizations can choose for one of the mentioned directions, a central issue to be discussed is what should be considered as core competences. This fundamental question is the strategic key to the choices that must be made. The answer to this question is what will allow hospitals to remain viable, even within a fast changing internal and external environment. Prahalad and Hamel **[**1990**]** offer three tests that can be applied to identify core competences:

- It provides long-term strategic advantage
- It contributes to customer benefits of the end product or service
- It is difficult for competitors to imitate

Leonard-Barton **[**1995**]** further refines this definition by distinguishing core competencies from supplemental or enabling capabilities. Supplemental capabilities add value to the core competence, but can be imitated by others. Enabling capabilities are those that are necessary to success, but which are not marks of superiority. Nash and Bryce **[**1996**]** present the core competences that healthcare providers should master in order to create customer value. Among others these are *effective management of health and wellness* and *effective care delivery*.

Nash and Bryce **[**1996**]** however also state that to be able to create customer value with their core care competences, hospitals should *organize their supply systems (in terms of figure 8 and 9) as efficient as possible*. Some healthcare systems may be able to achieve 10 to 20 percent in cost savings by *reengineering their supply systems* around patient needs instead of around traditional functional departments. It for example is possible to consolidate support service operations (such as routine laboratory and radiology services and sterile process centers) at one single location or to *outsource* other support services (as logistics, housekeeping and food service) cost-effective to organizations with specific expertise. **Healthcare providers then can focus all their attention and energy on their core care competences: *maintaining the health of covered populations*** **[**Nash and Bryce, 1996**]**.

It can thus be concluded that the appropriate directions for the restructuring of the UMCG, based on the earlier mentioned directions of practice, the above mentioned arguments and the earlier mentioned internal and external situation, are:

- Supply process reengineering
- Supply process outsourcing

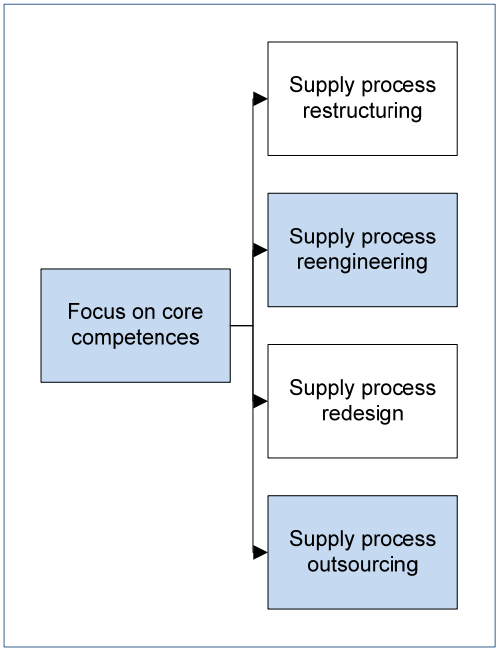


***Figure 11**, Development of the theoretical framework*

Based on the specific management problem of the UMCG, only the concept of supply process reengineering will be further discussed. For a proper understanding of this discussion it can be advised to read the short introduction to the supply chain of a prototype health care provider in *Appendix Book V*. The concept of supply process outsourcing will be shortly outlined in *Appendix Book VI*.

2.4.1 Process Reengineering

Typical of a radical breakthrough way of generating improvement in an organization is the Business Process Reengineering (BPR) approach. Process reengineering is a combination of different operations management techniques. Examples are just-in- time, process flow charting, critical examination in method study, operations network management and customer-focused operations. Underlying the process reengineering approach is the idea that operations should be organized around the total processes which add value for the customers, rather than the functions and activities which perform the various stages of the value-adding activity **[**Slack et al, 2004**]**.
Approaches such as process reengineering recognise that business performance is ultimately dependent on the optimisation of core and support business processes. Processes are comprised of sequences of linked activities which cross the vertical and functional boundaries existing in most organisations. Hence the reengineered organization transforms itself from a structure based on departmental roles to one based on directly servicing processes. In this view it shares much in common with Total Quality Management. It however differs fundamentally in the sense that objectives are achieved by fundamental and large step changes in processes rather than by incremental, continuous improvements **[**Fowler, 1998**]**.

> **BUSINESS PROCESS REENGINEERING** has been defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed. **[**Hammer and Champy, 1993**]**

Process reengineering is thus mainly focused on realigning the internal processes of an organization. This in contrast with supply chain management which (mainly) also focuses on realigning the external processes of an organization. Common areas between the process reengineering - and supply chain management philosophy may, at first glance, seem hard to find. When however studying the literature, relationships can be found. In both cases the *raison d'être* for management is the departure from only controlling the inputs into also controlling the processes and to significantly change the processes itself. The objectives of these two concepts are summarized by Jones **[**1989**]** who states that Supply Chain Management is about "achieving a competitive industry comprising of competitive businesses. The main strategy of Supply Chain Management is intra – and inter-organized synergy while the main strategy of Business Process Reengineering is lean, core process synergy."

> **SUPPLY CHAIN MANAGEMENT** has been defined as the management of material suppliers, production facilities, distribution services and customers, linked together via the feed forward flow of information and the feedback flow of materials. **[**Stevens, 1989**]**

The choice then is which terminology to use? Arguably, a reengineered business can be very efficient. To only take this view and not include the supply chain, in which the business operates, will however create a disaster. The internal improvements namely will quickly be made undone by poorly performing suppliers (and intermediary customers) that are still in the old mindset. Supply Chain Management and Business Process Reengineering can therefore be seen as two complementary philosophies. After full and successful business process reengineering, functional and internal integration will be the result. The move to external integration is then a logical next step **[**Evans et al, 1992**]**. In this research we therefore will focus on as well as the internal

processes (related to the directly involved persons and departments) as the external processes (also related to suppliers). The next paragraph first of all will discuss the concept of internal process reengineering based on two important directions: time based competition and the Lean philosophy. This discussion results in the first three sub themes of this research at the UMCG:

- Amount of involved departments and insight in the logistical processes in the direction of an operating room
- Interdependence between departments involved in the logistical process in the direction of an operating room
- Amount of tasks of employees involved in the logistical process in the direction of an operating room

This paragraph is followed by a discussion about external process reengineering. This discussion results in the second three themes of this research at the UMCG:

- The origin of demand for medical products
- The management of the inventory at the operations center
- The management of the locations and resources at the operations center

This theoretical framework finally will include a short discussion about the outsourcing of activities in hospital supply chains (presented in the *Appendix Book*).

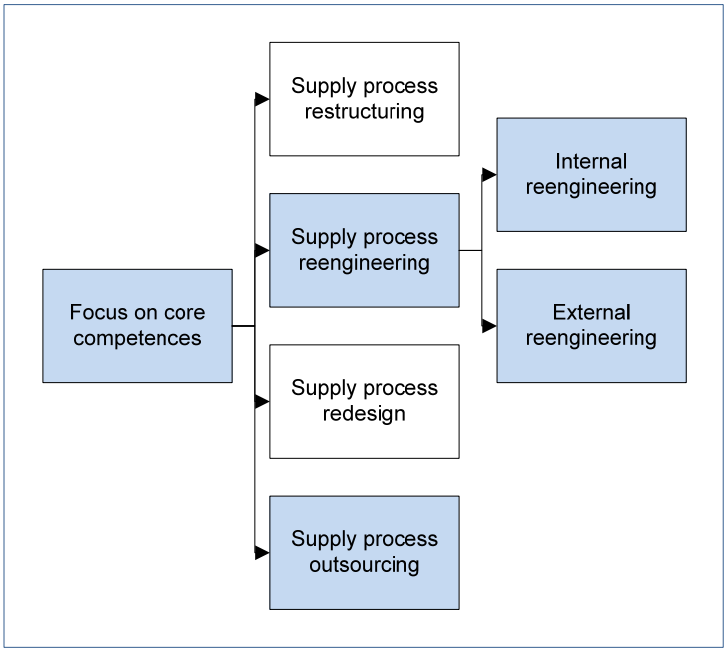


***Figure 12**, Development of the theoretical framework*

2.4.1.1 Internal Reengineering

While there are many different views of process reengineering and also many related approaches have been presented, a returning subject is the focus on the *sequence of activities which form the various processes involved in doing business*. In process reengineering, a business process is seen as a horizontal flow of activities. This while most organizations (and especially hospitals), as already mentioned, are organized in vertical functional groupings. This is sometimes referred in the literature as "functional silos" **[**Freeman, 1996**]**. We have distinguished two important directions in the literature concerning the concept of process reengineering: based on time based competition and based on the Lean philosophy.

2.4.1.1.1 Based on Time Based Competition

The first direction within the concept of process reengineering is based on time based competition. Stalk and Hout **[**1990**]** state in their book, about how time is reshaping global markets, that time is the most competitive weapon of the modern firms. They suggest firms to reduce the elapsed time involved in the performance *of and between* their key business processes.
Like much of the literature about business process reengineering, Stalk and Hout **[**1990**]** support with their findings the earlier fundamental research of James Thompson **[**2008**]**. In his well known book "Organizations in Action" he defines three types of interdependence that influence the structure of an organization: pooled, sequential and reciprocal. These interdependences are presented in table 4.

Form of interdependence	Demands on horizontal communication decision making	Type of coordination required	Priority for locating units close together
Pooled	Low communication	Standardization, rules, procedures	low
Sequential	Medium communication	Plans, schedules, feedback, task forces	medium
Reciprocal	High communication	Mutual adjustment, cross-departmental meetings, teamwork, horizontal structure	high

***Table 4**, Thompsons classification of interdependence and some organizational implications*

Pooled interdependence is the lowest form of interdependence among processes. In this form, work does not flow between units. Each process is part of the organization and contributes to the common goal of the organization, but works independently. Pooled interdependence may be associated with the relationships in a divisional structure. Thompson proposed that pooled interdependence would exist in firms with mediating technology. A mediating technology provides products or services that mediate or link clients from the external environment and allows each department to work independently (banks and real estate offices). Very little day-to-day coordination and communication is required among these kind of units.
Sequential interdependence is the medium form of interdependence among processes. When interdependence is of sequential form, parts produced in one department become inputs to another department. The first department must perform correctly for the second department to perform correctly. Sequential interdependence creates a greater need for horizontal mechanisms such as integrators or task forces. Thompson proposed that sequential interdependence would exist in firms with long-linked technology, which refers to the fact that each stage of production uses as its inputs the production of the preceding stage and produces inputs for the following stage. A higher amount of coordination is required among the linked plants or departments.
Reciprocal interdependence is the highest level of interdependence. This exists when the output of operation A is the input into operation B, and the output of operation B is the input back again to operation A. The outputs of departments influence those departments in reciprocal way. Reciprocal interdependence tends to occur in organizations with what Thompson called intensive technologies, which provide a variety of services in combination to a client. Intense coordination is needed between all the different processes.

Within healthcare, primary care physicians could be thought of as having pooled activities, whereas the patient's journey through a hospital follows a sequential set of activities with certain tasks needing completion before other tasks can be performed. Such patterns of interdependence are also familiar in supply departments where nurses, surgeons, anaesthetists, patients and

logistical employees interact in reciprocal ways in response to unpredictable scenarios in carrying out their professional activities [Leedal and Smith, 2006].

As already mentioned in table 4, processes with a reciprocal interdependence, but also important sequential processes, should be located nearby each other in the organization. It is remarkable that this idea was already applied on supply processes of hospitals at the beginning of this century by the already mentioned book of Hornsby and Schmidt [1913]. Because of the great amount of interactions between the operating theatre, the sterilization room and the supply departments, they advised hospitals to place these departments very close to each other (figure 13). Despite the age of their work, their ideas are still usable nowadays. Today there still are numerous interactions between the different warehouses, sterile processing department and operation rooms in hospitals. Locating these departments close to each other has a significant positive influence on the performance of the supply processes.

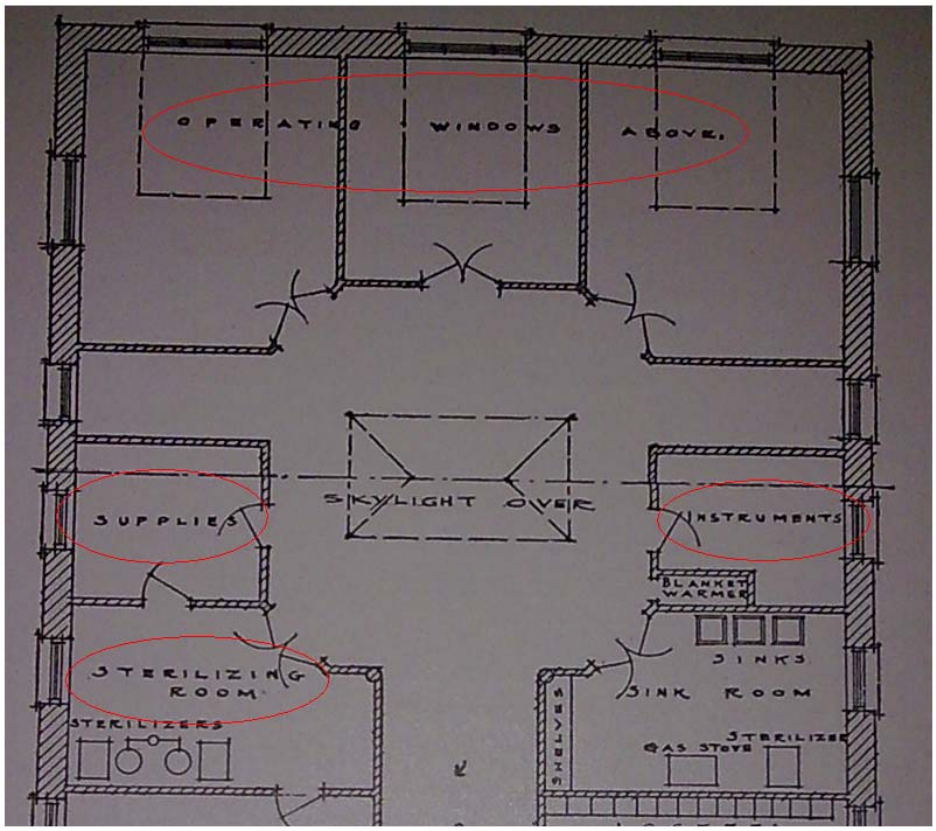


***Figure 13**, Floor plan of the supply side of the operating theatres, source: Hornsby and Schmidt (1913)*

Employees, first of all, need to bridge shorter distances. Departments are located closer to each other, which influences the speed and costs of the total supply process. Secondly, because of the shorter distances, there are less possibilities of mistakes and damages. This influences the costs, but also the quality of the supply process [Shiver, 2007].
Concluding it thus is possible to state that departments with sequential or reciprocal interdependence should be located close together. When looking at the internal and external situation and the above discussion, this also applies to the structure of the supply departments of the UMCG. To be able to raise the performance, it is advised to reengineer the different departments into an "integrated logistical service center."

2.4.1.1.2 Based on the Lean Philosophy

A second important direction within internal reengineering philosophy is based on the Lean production philosophy. An important part of this philosophy is "transferring a maximum amount of tasks and responsibilities to *those workers actually adding value* **[**Womack, 2005**]**. This transfer cannot be made without an understanding of how workers and processes operate. In the absence of such an understanding, no attempt can be made to identify performance and added value **[**Childe et al, 1994**]**. Process reengineering is thus not only a hard philosophy that changes structures, processes and tasks, but also a soft HRM philosophy that directly alters the feelings of (health care) employees. As already mentioned, business process reengineering is mainly focused on restructuring processes and departments within organizations. Something which often is overlooked is that process reengineering is not only changing processes in terms of the organization, but also work processes/practices in terms of the worker. Not taking this into account when reengineering an organization may lead to long term damages of human resources.

When reengineering processes, it is important to realise that the health care professionalism has limits on how far labour flexibility can go. Too much worker responsibility, multi-skilling and job variety does not lead to better performance and, maybe even more important, employee well-being. The introduction of the internal market, already lead to an improved focus on performance, efficiency and consumerism. This demanded increased responsibility and accountability of the health care professional. Initiating a process reengineering process poses again an implicit challenge to the health care professionals and again threatens their professional working. Process reengineering often is executed in combination with significant downsizing leading to an even further increase of job variety and intensification of work. This however does not automatically leads to increased employee performance **[**Grey and Mitev, 1995**]**. It is estimated that between fifty and seventy percent of these kind of reengineering efforts failed to achieve the goals set for them **[**Moad, 1993**]**. This mainly is due to job stress because of not taking the worker practices into account. It is suggested that job stress is composed of three basic factors:

- role ambiguity
- role conflict
- role overload

This supports the theory that not taking the work practices of the employees into account when reengineering organizations increases the possibility of reengineering failure. Involvement of employees when changing the physical and procedural layout increases the well being, commitment and performance of employees and thus the success of the reengineering operation **[**Majchrzak and Qianwei, 1996**]**. When reengineering an organization it thus is important to take into account:

- the amount of tasks of an employee
- the kind of tasks of an employee
- the separation of the tasks of different employees

In practice, in a reengineering situation, this then might lead to the following interventions:

- diminishing or increasing the amount of tasks of an employee
- diminishing or increasing the kind of tasks of an employee
- change the separation of tasks among different employees

In hospitals these interventions can be applied to the overlapping processes of the logistical employees and the surgical assistants. Some of the logistical activities namely have historically been the responsibility of surgical assistants. These tasks, however, need to be reassessed. Logistical employees and clinical staff are working together to achieve the shared goals of patient safety and quality outcomes. Together with their unique roles they rely on each other to provide exceptional patient care. In a time where demand for nursing resources far exceeds the available supply of nursing time, it is critical that the clinicians are set free of as many non-patient care tasks as possible. *By freeing the care personnel, they can spend more time at delivering care.* This maximizes both clinician time and is a major component in improving nursing satisfaction. Shifting the mindset and responsibilities for supply chain related tasks that are not clinically contingent to be performed by materials management can be a *labor cost saving*, a *nursing satisfier*, and *a strategic way of obtaining more nursing time without adding clinical FTEs* **[**Barlow, 2008**]**.

> *The workload has almost doubled which has had an impact on how stressed we feel. Added to this there is much more of a feeling of being on our own - more answerable for our own actions without the back up of the old nursing sister, who used to support us if there was ever a problem. You feel as if you have lost the support of your superiors – especially as they seem so much more upbeat about the changes, which in turn makes you feel more vulnerable and questions your own commitment, not in terms of the patient but certainly in terms of work generally* **[**Leverment et al, 1998**]**.

The above discussion on process reengineering has lead to the following changes in the "conceptual model" of this research (figure 14):

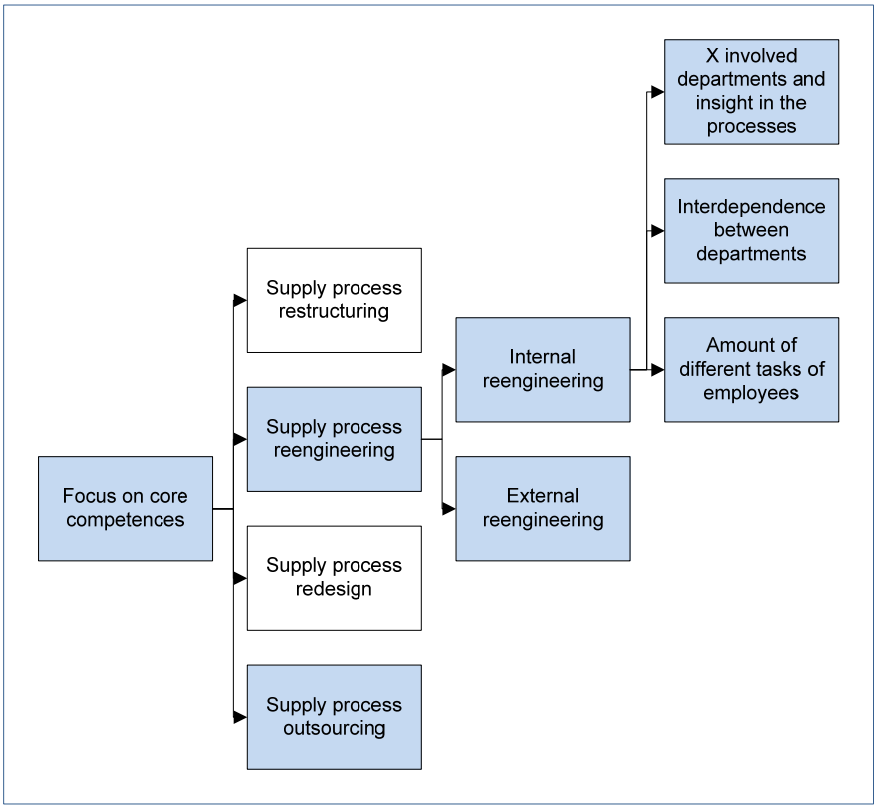


***Figure 14**, Development of the theoretical framework*

2.4.1.2 External Reengineering

Many successful process reengineering efforts have been reported to significantly increase performance. However, some process reengineering programs have resulted in negative effects

on other organizational processes. There also have been many reports of overall program failure [Hammer and Stanton, 1995]. This lead to the need of investigating the relationship between process reengineering and other change initiatives, that may occur simultaneously. As already mentioned, only looking at internal reengineering and not taking into account the external supply chain, will create a disaster. Internal improvements will quickly be made undone by poorly performing suppliers that are still in an old mind set. This resulted in an increased interest in external reengineering or supply chain management [Stebbins et al, 1998].

Push - and pull based supply chain strategies

A supply chain is generally viewed as a network of organizations or departments that perform the procurement of (raw) materials with the use of two major control philosophies: the "push" strategy and/or the "pull" strategy. With a push strategy there is a single wholesale price and the customer, by ordering his entire supply before the demand arises, bears all of the supply chain's inventory risk. With a push-based supply chain, products are pushed through the supply channel, from the production side up to the retailer. The supplier sets delivery at a level in accordance with historical ordering patterns from the customer.

With a pull strategy, on the other hand, the supplier bears the inventory risk because only the supplier holds inventory while the retailer replenishes as needed during the season based on customer demand. In a pull-based supply chain, procurement, production and distribution are demand driven so that they are coordinated with actual customer orders, rather than forecast demand [Cachon, 2004].

It takes longer for a push-based supply chain to respond to changes in demand, which can result in overstocking, bottlenecks, delays, unacceptable service levels and product obsolescence. This is mainly due to the cause mostly known as the bullwhip effect. The bullwhip effect is a much-studied feature of supply chains. It describes a situation whereby orders at the higher (upstream) levels of the supply chain can exhibit more variability than those at customer (downstream) level. Svensson [2005] gives four reasons for the origination of the effect. The first is demand signal processing, whereby demand increases and further increases are anticipated. The second is the rationing game whereby more is ordered if shortages are anticipated. The third is order batching, where fixed costs lead to the batching of orders, so that more tends to be ordered than is immediately required. Finally, manufacturer price variations encourage bulk orders. The effect is increased if demand variability changes.

To be able to decrease the negative consequences of a push based supply chain strategy, many organizations recent years have adopted the pull based supply chain strategy. This pull strategy mainly finds his origin in the just in time management system, which is an element of the lean management philosophy. The main goal of a just in time strategy can be stated as producing and/or stocking only the necessary items in necessary quantities at the right time. This strategy should be applied to the entire external - or supply chain of an organization [Tae-Moon, 1985].

External reengineering in the health care environment

As already suggested by Womack and Jones in their book Lean Thinking [1996], it is necessary to extend the concept of Lean manufacturing not only to production organizations, but to all kinds of service organizations including health care [Winter, 2004]. Generally, service organizations are likely candidates for just in time if their operations are repetitive, have reasonably high volume and deal with tangible items. Services must be "manufacturing-like" operations. Many health care services meet these criteria. Implementing just in time concepts may then lead to a significant improvement of the supply chain. If hospitals apply just in time techniques to reduce non value-added activities, they will have more time to focus on value-added activities, which will improve the service to their patients and provide higher margins for the organization. Despite these

advantages, most hospitals are hesitant and play a waiting game against the implementation of a just in time strategy **[**Whitson, 1997**]**.

The main reason why most health care providers are hesitant against the implementation of just in time is a common feeling of not being able to predict the production capacity and scheduling. Many companies in comparable industries have, however, been able to accomplish just in time through the adaptation of some flexible techniques. Examples are utilizing small lots, direct-line deliveries and pull inventory controls. This philosophy should also be adopted by health care providers in designing their supply chain. Just in time is exactly the opposite of the approach traditionally practiced in the health care supply chains, which is to order and store large quantities of products at one time. Just in time attempts, as already mentioned, to minimize the inventory costs by receiving supplies just in time for a "production run." Small quantities of supplies are received at a time. The supplier's truck will arrive at the hospital several times a day. Just in time is designed to eliminate waste, increase productivity and improve quality throughout the supply chain **[**Ansari and Modarress, 1986**]**.

As an overall accepted tool, just in time aims for a fundamental improvement of supply chains and embodies all of its goals: to be efficient, cost effective and to provide responsive fulfilment of materials and instruments. Just in time is the essence of fluid, fast and efficient customer service. In its most basic form, just in time is producing the required medical supplies at the right quality, and in the exact quantities, precisely when they are needed.

In the care of patients, the supply departments cannot accurately predict the precise materials and instruments and volume of products that will be needed on a daily basis. Therefore the just in time system will have to permit for a restricted buffer stock of a certain amount of days or operations. With these kinds of demands placed on the supply chain, intense integration and partnership is required. Besides that, it also is very important that the entire hospital organization goes through rapid and drastic change. As already mentioned, just in time is not a strategy that leaves the rest of the organization unharmed. The entire hospital must undergo operating and cultural changes. For a just in time programme can succeed, the following directions, besides the already discussed internal processes, need a radical change **[**Chen, 1997; Monczka and Morgan, 1998**]**:

- Demand Management
- Inventory Management
- Resource - and facility location Management

These directions will be discussed in the following paragraphs. The discussion will be applied on the system of this research: the sterile processing department (internal processes), the operations center (internal processes) and logistical center the Eemspoort (external processes).

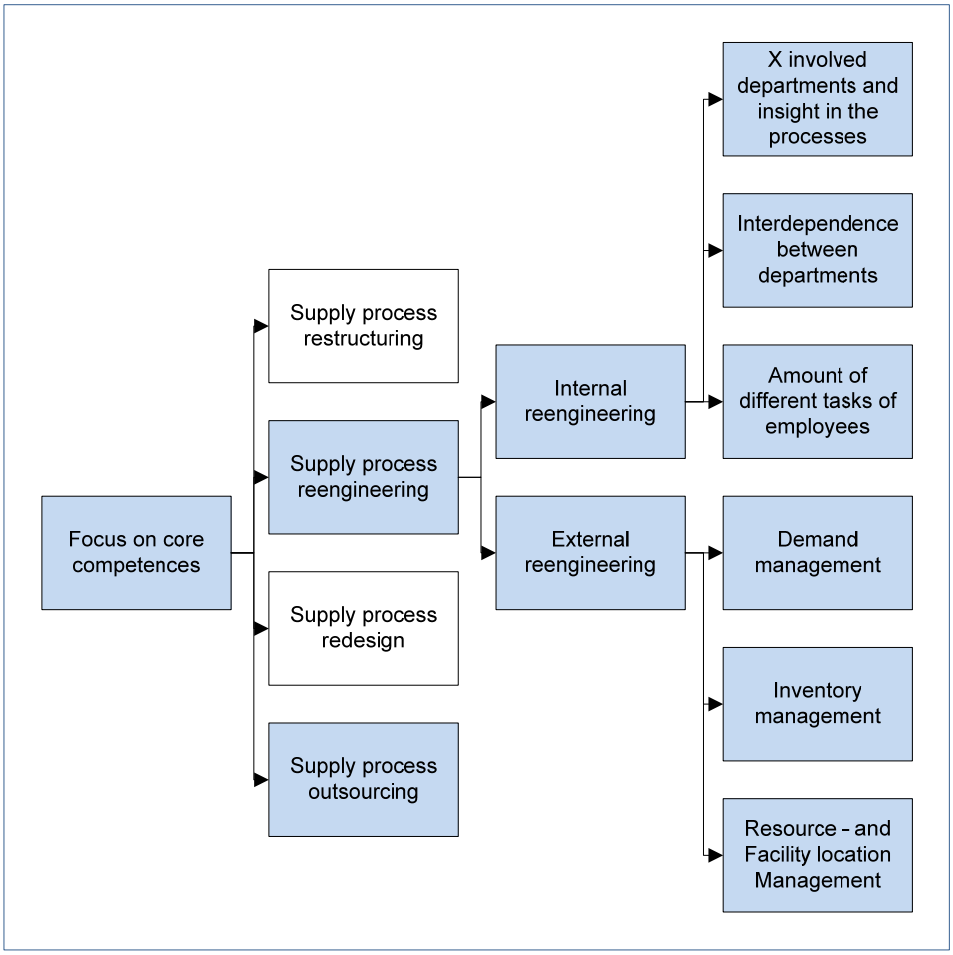


***Figure 15**, Development of the theoretical framework*

2.4.1.2.1 Demand Management

Demand management, which is the initiatory function of supply chain management, can be defined as the focused efforts to estimate and manage customers' demand, with the intention of using this information to shape operating decisions **[**Blackwell and Blackwell, 1999**]**. In service organizations, the successful management of demand is vital due to some difficulties that arise from the unique characteristics of services. The main influencing characteristics are the unpredictability and variability of demand and having no possibility of storage of final products **[**Baltacioglu et al, 2007**]**.
This unpredictable and variable demand often leads to the criticism that just in time management cannot be applied to the hospital supply chain **[**Shah et al, 2008**]**. Sceptics state that demand must be extremely consistent because following customer demand would otherwise be greatly inefficient. In reality, however, setting a pace (instead of chasing demand) is exactly what Toyota does to smooth demand. This means that they set the takt time based on an actual backlog of orders and then adjust it from time to time. Besides that, it sometimes also is possible to satisfy the demand during the time that is left to the moment of delivery; which in this research is the surgery (during the takt time).
The essence of this discussion about variability in demand is that variability leads to higher costs for an organization. This variability can take many forms like variable process times, delivery times, yield rates, staffing levels, demand rates, etc. Anything in the system that is not absolutely regular and predictable exhibits variability. The reasons of variability can be classified into internal factors (like setups, downtime, operations-induced fluctuations in production rates, yield

loss, rework, change of orders, etc.) and external factors (like irregular demand, product variety to meet market needs, customers change orders, etc.). External variability often is the result of the strategy of a firm. Offering for example high levels of product variety also leads to more internal process variety.

Irrespective of its origin, all variability will and can be buffered. There are three fundamental types of variability buffers: inventory, capacity and time. Safety stock, for example, represent inventory buffers against variability in demand and/or production. Excess capacity can also provide protection against fluctuations in production or demand. Finally, safety lead times provide a time buffer against production variability. While the exact mix of buffers is a decision of the management, the decision whether or not to buffer is not. When variability exists, it will be buffered somehow **[**Hopp and Spearman, 2004**]**.

The demand in this research originates at the operations center of the hospital. Hospitals perform surgeries either in response to an urgent or emerged need or on an optional basis. The term optional does not mean that the operation is elective, but rather that its scheduling may be delayed to accommodate patient and provider suitableness, as well as other more important cases. In the optional case, the need for surgery is often identified after consultations with a patient's primary care physician and possibly one or more specialists. In contrast, urgent need may arise as a result of an unforeseen acute episodes. These kinds of emergencies are often associated with motor vehicle accidents, acute traumas or medical conditions (stroke or heart attack) that create a life threatening situation for a patient **[**Gupta, 2006**]**. On the one hand, demand for surgeries is thus predictable and stable. On the other hand it can be classified as unpredictable and variable.

These different kinds of demand for surgeries lead to a new demand: demand for different sorts of demand for necessary materials and instruments. These materials and instruments can roughly be categorized in surgical instrument sets (reusable and/or not reusable) and covering material. Each surgeon has his or her own preferences and demands when it comes to the surgical instrumentation **[**Bonvissuto, 2007**]**. The demand for the covering material is, in general, identical. This demand pattern (from patient to surgery, to instruments and to buffers) leads to a very comprehensive and costly process (figure 16).

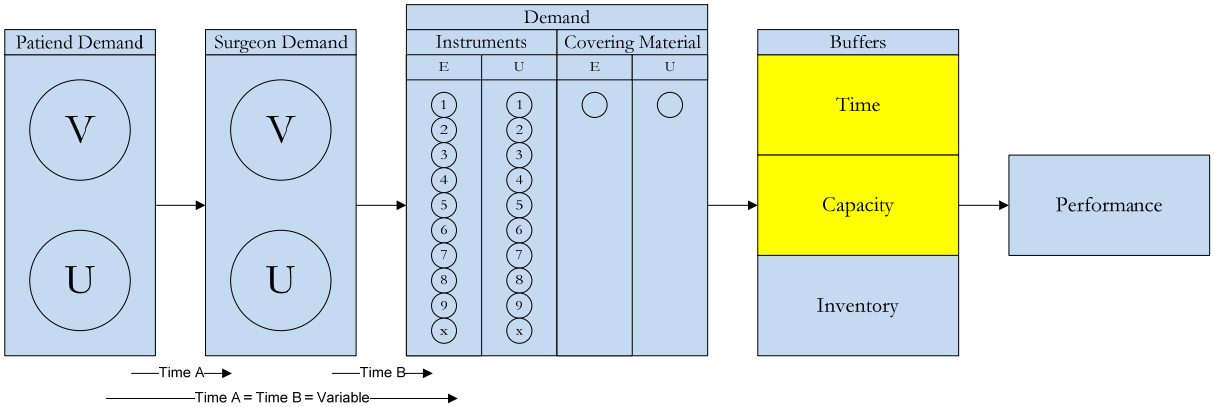


***Figure 16**, Demand pattern for surgical instruments and covering materials*

It is possible to see that because of the possibility of short term, variable (V) demand and the different demands of surgeons (1 till x) for instruments, it is necessary to create a large inventory buffer near to the production location, the operations center. In case of a short term emergency it then is possible to gather all the different instruments necessary to satisfy the two sorts of demand: the kind of surgery and the wishes of the specific surgeon. The consequence then is, however, that a great amount of inventory needs to be stocked close to the operations center.

And because surgeons classify the bulk of the operations at the surgery center as unpredictable, the amount of inventory grows even higher. (*The specific ins and outs of inventory management and the consequences for the hospital will be discussed in the next chapter.*)

The surgical demand for specific devices and instruments represents a significant challenge for material management and supply divisions. Besides that, it also leads to great expenses for the hospital. It thus can be seen as an element of possible savings. Surgeons need to understand that their specific demands lead to great costs for the hospital. It is necessary that they create a collective demand for the instrumentation, instead of all the different, individual demands. These collective demands can be standardized in protocols *(Dutch: klaarzetboeken)* per surgery, instead of protocols per surgery and surgeon. Surgeons need to understand that it is impossible to improve quality and reduce costs without having protocols in place. Variances are going to occur but they have to be the exception and not the standard. Research has shown that the more variances you have the lower quality and the higher costs you deliver **[**Barlow, 2007**]**.

> *Each surgeon will want a lot of things of his own, special instruments and special techniques.* **[**Hornsby and Schmidt, 1913**]**

Examples of working with standardized protocols are already shown at the "Onze Lieve Vrouwen Gasthuis" in Amsterdam and the Medical Center Leeuwarden. These protocols show the different necessary instruments and covering materials per operation. Within these protocols there only are marginal differences for different surgeons. This standardisation of demand leads to less variability in demand for materials and instruments, which has a positive influence on the cost – and quality performance of the hospital. Besides that it also facilitates the transition from a push based supply strategy to a pull based supply strategy, one of the conditions of just in time management **[**Van der Meer and School, 2008**]**.

2.4.1.2.2 Inventory Management

Inventory management professionals within the supply chain profession are vital to hospital performance and patient care quality **[**Barlow, 2008**]**. Hospitals need to store a great variety of medical and surgical supplies, which often are very critical and therefore required to be of sufficient quantity and availability for the staff to use at all times. Among these products are some which are used on a regular basis and some which are used on an irregular basis. The regular used products, the earlier mentioned standard requirements, have a known distribution of demand and should always be available. Under no circumstances should an item that costs only a few euro's be allowed to delay the health care process. Inventory management releases procurement orders very early, with ample margins as to quantity and time. This increases the storage costs only marginally, since the items are inexpensive ones. For these products it is possible, for any period of time, to generate a stock level which provides a maximum service level.
The irregular used products have an unknown distribution of demand. On beforehand it is not predictable on what time and in what quantity products are needed. For these products it is necessary to implement a "tailor-made" inventory policy, taking into account the restricted storage space and labour in a hospital, thereby meeting the demands of different stakeholders.
As we then continue to see the raising costs of healthcare, the financial resources available to hospitals to maintain quality operations continue to diminish. It has been estimated that materiel resources, such as surgical instruments, can easily consume over forty percent of the hospital's operational budget. For that reason, effectively controlling and managing hospital inventories is very critical. Understanding and applying the core concepts and principles of inventory management will have a positive impact on the bottom line and will help preserve an organization's ability to deliver quality services and prosper through these turbulent times. It

therefore is necessary to adjust the service levels and the frequency of deliveries to be able to store all the products (each with different volumes) within the available space of the hospital and to be able to satisfy the demands of the different stakeholders [Yokl, 2008].

When changing the inventory management policy, there are four main stakeholders in the decision making process whose views need to be incorporated. The first is the inventory management department. They are looking to provide service level agreements as cost-effectively as possible, thereby reducing delivery costs while ensuring materials are not being overstocked or becoming obsolescent. The second and third are the medical staff and the patients. They are searching for as high service levels as possible across all the necessary instruments and materials and the confidence of not running out of stock. They further require that there is no delay in getting the appropriate products. Finally, the department managers and accountants require visibility of the cost for the stock being held, used and distributed [Little and Coughlan, 2008].

This leads to the following two important requirements of inventory management in a hospital:

- The required service level
- The visibility of consumption

Required service level

The first important inventory requirement, based on the demands of medical staff and patients, is the required service level of materials and instruments Because of the earlier mentioned anxiety of supply stock outs, material staff often prepares for such events by stockpiling supplies. In this way they are assured of a *probability of stock out* of zero percent. The probability of stock out is the probability that a stock out will occur during each order cycle before a replenishment order arrives. A probability of stock out of zero percent automatically leads to a service level of 100 percent. The service level can be defined as the percentage of order cycles that the firm will go through without stock out, meaning that inventory is sufficient to cover demand. A classical hospital will thus keep warehouses full of all the different materials and instruments that could be required during a surgery. This of course leads to high inventory costs. This are all the costs incurred in connection with holding inventory. Normally this is compiled of:

- Ordering costs
- Carrying costs
    - The costs of financing (capital costs)
    - Storage infrastructure costs (buildings, installations, warehouse employees, insurance, etc.)
    - The risk of depreciation
        - Technical obsolescence
        - Perishability
        - Damage, spoilage or destruction

It is not unusual for the carrying cost rate to be in the direction of 20 percent. For goods with a high risk of depreciation, it may even reach 30 percent and higher [Schönsleben, 2007].
The above mentioned fear has thus limited the attempts of health care organizations at the development of an effective and efficient inventory management strategy. This has lead to a lack of inventory management protocols. In practice this finds expression in ordering at different vendors, ordering done by different (not qualified) persons, unnecessary high inventories and outdating of stock. This of course leads to a very costly situation for the hospital and more work than necessary for the hospital staff. Besides that, the inventory process is not transparent anymore. It is not clear how much and where supplies are stocked. In many cases the same supply items are stored at several different locations. There finally also is a lack of control whether the medical staff is actually using the demanded supplies. Practice shows that a great part

of the demanded materials and instruments is not used. The solution can be the adoption of a Lean based inventory management system, taking into account the earlier mentioned notions of the inventory management department **[**Langham, 2007**]**.

Visibility of consumption

The second important inventory requirement, based on the demands of the department managers, is the visibility of consumption of materials and instruments. The above mentioned lack of inventory management policy namely often leads to invisible consumption in many hospitals. Charge transactions of used materials and instruments are manually keyed (often by nursing staff) which turns out in unclear usage statistics and imprecise billing practices. This not only leads to unfair and unclear invoices, but also to inventory which lays idle on shelves or is not available as a result of inconsistent replenishing processes. This of course is a situation which may never occur in a professional hospital.

To improve the visibility of consumption, hospitals need to implement a digital inventory control system (instead of a manual based system). This system can, for example, be adopted from the retail or grocery industry by scanning products out of inventory and automatically ordering replenishment stock as they are used in patient care. Creating a unique barcode for each surgical case based on the physician, the procedure and the patient further provides enormous capabilities in reporting procedures.

When using such a system it also is very simple to implement the different preferences of the physicians. These can be electronically viewed in the OR suite and the warehouse. Items can be easily taken or added from either open or closed carts with a simple barcode scan or by the touch of a screen. Not only are the supplies then automatically accounted for, the items also are reordered and tracked back to a specific patient case. With such a system in use, it is almost impossible that a hospital runs out of stock, one of the worst nightmares of nursing staff.

A final advantage of an electronic system is that logistical staff can now focus on picking and auditing carts, allowing the clinical staff to focus on their respective areas of expertise (their core competences): health care. This not only leads to an improvement of the quality of health care, but also to a significant decrease of costs because of improved efficiency and inventory turnover **[**Jones, 2008**]**.

When the demand and inventory policies are structured and made clear and understandable, it is possible to take another step at the road to a lean supply chain. It then namely is possible to restructure the resource and facility management policies or even choose for outsourcing of certain supply chain processes and/or practices.

2.4.1.2.3 Resource - and Facility location Management

Resource management can be defined as the efficient and effective deployment of organization's resources at the moment they are needed. These resources may include financial resources, inventory, human skills, production resources or information technology. In the light of this research, the main focus is on the inventory of materials and instruments **[**Galbreath and Galvin, 2004**]**.

Facility management on the other hand can be defined as the integration of multiple disciplines necessary for the ensuring functionality of the land, buildings, infrastructure and equipment of an organization. It is the role of the facility management department to coordinate the safe, secure and environmentally sound operations of these assets in a cost effective manner aimed at long term conservation **[**Liyanage and Egbu, 2008**]**.

When regarding these definitions it is clear that there is a certain amount of overlap between these two management areas. Although the facility manager is more focused on the strategic lines of an organization and the resource manager more on the operational lines, it is impossible to

treat them separated. This is even more important when an organization is on the road to a lean supply chain. Part of this road namely is the reconsideration of an important part of the structure of the supply chain: the warehouses and resource locations.

When looking at page 10 of the *Appendix Book*, it is possible to conclude that the supply chain of a classical hospital consists of many different stock locations (echelons). Some are outside the hospital, others are inside the hospital. Some stock locations are necessary and indispensable, others are duplicates and removable. The most obvious example of a duplication of storage locations, especially in case of a lean supply chain, is maintaining a bulk storeroom and a separate distribution storeroom. This leads to a double handling of the same goods. And because each touch point in the supply chain adds costs, this is an expensive situation for a hospital.
A second, even more common, example of multiple storage locations occurs within the hospital at the patient care units. Here it is possible to find stock in large central warehouses. Especially the surgical areas are maintaining a too great amount of stock at sub warehouses and in each of the surgical suites. *This is a recipe for a supply chain disaster* **[**Rivard-Rover et al, 2002**]**. It results in:

- Excess inventory holding costs; many "low use" materials and instruments are kept in several locations which results in a very low turnover rate of these individual items
- Significant waste; from both expiration of outdated items and excessive quantities of obsolescent materials and instruments left after practice and preference changes of surgeons
- Waste of time; when medical staff or logistical employees have to search in multiple warehouses for an item
- Unnecessary emergency orders; when materials or instruments that are on hand somewhere else are not in stock at one of the usual locations

One of the key tasks of resource and facility management is to determine the most efficient and effective structure of the supply chain. An important element is determining the amount – and the locations of the different warehouse points. Relevant is also the examination of the corresponding warehouse costs and the costs of alternative solutions. Regarding the current structure of hospital supply chains, it is possible to distinguish a great amount of separate warehouses, leading to a great amount of excess inventory holding costs, significant waste of outdated and obsolescent materials, waste of time and unnecessary emergency orders.

A reasonable simple solution to this situation would be the removal of the separate warehouses at the distinct patient care units, leading to a modern in-house two echelon supply network, instead of an in-house three echelon supply network. In this new situation, the necessary materials and instruments are delivered *just in time* at the points of care. In general, the decision to choose for a two echelon supply network instead of a three echelon supply network is justified by ensuring that materials and instruments are provided more efficient while maintaining the same basic level of quality.

A classis in-house three echelon supply network would review the inventory level at each unit of care at the beginning of a new interval. The difference between the units par level and inventory on hand is ordered from the central warehouse. Orders from the unit of care are transmitted to the central warehouse instantaneously and they are executed as received. After fulfilling these orders, each central warehouse, in turn, reviews the difference between the par level and the inventory on hand and places an order with the distributors. Once again, these orders are transmitted instantaneously and executed as received. In this situation, the demand of the surgeons is not really taking into account.
In a new in-house two echelon supply network, each unit level of care orders materials and instruments based on the demand of a certain period. The central warehouse is removed and the

materials and instruments are delivered just in time by means of for example case carts. These carts are filled with materials and instruments that are needed for the concerning period of demand. In this situation, the maximum amount of order picking time, case cart preparing time and distribution time, is determined by the takt time of demand.

The decision to remove an echelon of the supply network is primarily driven by three factors. First inventory expenses are substantial and are estimated to be between 10 and 18 percent of net revenues. Thus, any cost savings which can be generated through more efficient inventory management, can lead to direct cost reductions. Second, health care providers focus on quality of service both from an internal and external perspective. The move from a three echelon – to a two echelon supply network will, as already argued, lead to improved internal performance. Improving internal performance also positively impacts patient care and this should lead to increases in the external measures of patient satisfaction and patient perceptions of service quality. Third and finally, there has been an increase in the expertise and in the number of health care providers who removed an echelon of the supply network. These providers have substantive evidence of their successes. These success stories are a key driver of the current trend to restructure supply chains in healthcare settings **[**Nicholson et al, 2004**]**.

An important development in line with the supply chain structure decision is the declining amount of available square meters in hospitals. Since a normal warehouse has a size of around one and a half square meter per hospital bed, the size of a warehouse of a standard hospital is around eight hundred square meters. When removing the redundant warehouses from the hospital, a great amount of valuable square meters then can become available. This space could be used for the primary function (core competence) of a hospital, delivering care. Besides that, it is also important to take into account the accessibility and parking lots of hospitals. Maintaining a central warehouse inside the hospital, results in several deliveries of different suppliers every day. Different facilities and space need to be created for this. Removing the central warehouse to a location outside the hospital provides opportunities for effective and efficient restructuring of the facilities and space. Besides that it then also is possible to restructure the warehouse on the base of the current logistical and warehousing knowledge **[**Kreeft and Dewaet, 2008**]**.

Building a new logistical center gives thus opportunities to match the layout of the building with the desired logistical concepts, as described in the earlier paragraphs of this report. In that case it is possible to design a layout which is suitable to deal with all the flows of goods now and in many years to come. The layout namely cannot be adapted very easily and only at high costs. It therefore is important to design a layout which supports hospital strategy, but also takes the internal, external and future circumstances and uncertainties into account. Some important variables, however, need to be researched before a hospital can decide to relocate the central warehouse. Examples are **[**Kumar et al, 2008**]**:

- Supplier lead time
- Delivery frequency
- Amount of suppliers
- Geographical spreading of suppliers (distance to the hospital)
- Storeroom size
- Amount of days of stock
- Inventory turnover (cost of goods sold / average inventory; average inventory = beginning inventory + ending inventory / 2)
- Average takt time (maximum time to deliver a product in order to meet demand)

Figure 17 illustrates the main differences between conventional and new supply structures and highlights the main advantages of the new system, which lie in inventory reduction, staff savings and enhanced service[Kaczmarek, 2009].

Supplier delivery method	Bulk	"Eaches" – unit of use
Supplier delivery frequency	Once a week	Daily
Number of suppliers utilized	35+	1-2
Clinical staff involvement in daily materials-related tasks	Significant	Almost none
Hospital receiving procedures	Receive/verify each item	Selected sampling, one-step receiving
Supplier fill rates	90-95%	98%+
Hospital storeroom size	6,000 sq. ft	300 sq. ft
Storeroom inventory	6-8 weeks supply	1-3 days supply
Inventory turnover	6.5 to 8.7	171 to 365
Total materials management (full time equivalents)	31	13

Note: Figure a typical 400-bed hospital
Source: Adapted from Arthur Andersen & Co. (1990, p. 65)

***Figure 17**, Characteristics of replenishment methods (source: Rivard-Rover et al, 2002)*

2.5 Performance Objectives

To be able to complete this theoretical framework and to be able to create the conceptual – or research model, we finally will discuss the performance objectives of this research. Performance objectives are defined as "aspects of operations performance that satisfy market or customer requirements and therefore that the operation is expected to pursue". In former times the focus was mainly on the financial performance of health care organizations. Nowadays, mainly non-financial – or combinations of financial and non-financial performance objectives are under discussion. Many authors also have defined their own set of performance objectives. No overall agreement exists on either the terminology to use when referring to these objectives or what they are. Studying performance in the health care industry thus asks for choices.
Based on the work of Slack and Lewis [2002], it is possible to mention five general, often used performance objectives:

- quality
- speed
- dependability
- flexibility
- cost

As already mentioned during the introduction and theoretical framework, this research is mainly focused on three of these five performance objectives: costs, quality and speed. Although these objectives are already mentioned several times, it is important to give a short clarification and operationalization [Slack and Lewis, 2002].

Speed
At its most basic, speed indicates the time between the start of an operations process and its end. It is the elapsed time. Often this is described as throughput time, which is defined by

Schönsleben [2007] as "the span of time required to perform a process (or a series of operations). In logistics context, it is the time between the recognition of the need for an order and the receipt of goods and services." Although this definition is more related to a production environment, it is possible to translate it to a hospital environment. Here throughput time can be defined as "the span of time from the moment a demand for care (which is a surgery in the case of this research) originates until the moment the demanded care is provided and finished.
This research towards the different logistical processes at - and in the direction of the surgery center is not really aimed at improving the different throughput times. It more is aimed at describing and analyzing the speed of the different processes. Based on knowledge of the speed of different processes, it is possible to provide recommendations about a possible restructuring of the current logistical processes and facility locations of the supply chain of the UMCG.

The speed will in this research be analyzed by looking at:

- The takt time (maximum time allowed to deliver materials and instruments to meet the demand of patients and surgeons) *(a)*
- The required transport time from Logistical Center "The Eemspoort" to the Central Warehouse at the Surgery Center *(b)*
- The required transport time from the Sterile Processing Department to the Central Warehouse at the Surgery Center *(c)*
- The required time for a surgical assistant to collect the required materials and instruments in the Central Warehouse at the Surgery Center (UMCG research) *(d)*
- The required time for a logistical employee to collect the required materials and instruments in the Central Warehouse at the Surgery Center (MARTINI research) *(e)*

These different researched processes are presented in figure 18.

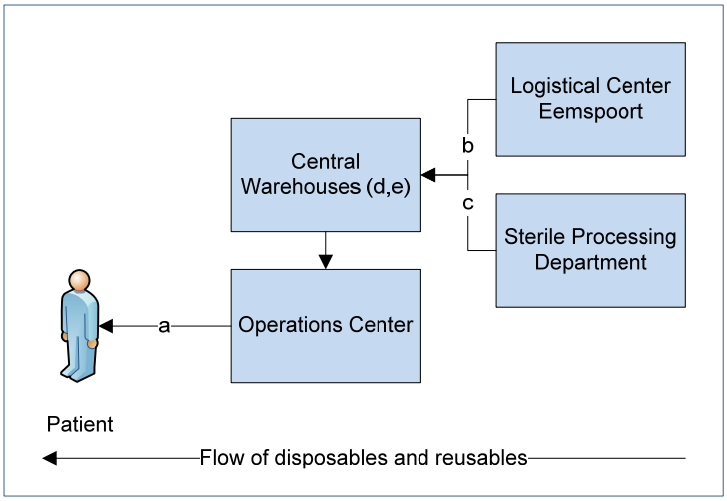


***Figure 18**, Researched "speed" processes*

Costs

In many companies, cost is the most important performance objective. Many companies namely have to compete directly on price. The lower the costs of producing their products and services, the lower can be the price to their customers. Although quality is of course the most important performance objective of hospitals, the new policy of the Dutch government has, as already mentioned in the first chapter, increased the importance of costs. Dutch hospitals now also are focused on keeping their costs as low as possible. Other things being equal, every euro removed from the operations' cost base is a euro added to the profits or a euro subtracted from the cost-

price. This increases the possibility of care-contracts with insurance companies and thus patients choosing for your hospital.
This research will mainly be focused on a removal of operations' cost by means of decreasing the inventory costs, labour costs and transport costs. It is expected that a restructuring of the current logistical processes and facility locations of the supply chain of the UMCG will lead to lower inventory costs, labour costs of surgical assistants and logistical personnel and transport costs of different sub-processes of the total supply chain.

Quality
Researchers have struggled for years to formulate a general applicable definition of quality of health care [Lytle and Mokwa, 1992]. A frequently used definition is a definition of Palmer [1997]. They defined quality of health care as "the production of improved health and satisfaction of a population within the constraints of existing technology, resources and consumer circumstances."
Quality of health thus involves a technical and an interaction aspect. The technical aspects of quality of care exist of two sub-dimensions: the appropriateness of the services provided and the skill with which appropriate care is performed. Appropriateness of the provided service requires high-quality decisions about care for each patient. The skill with which the appropriate care is performed requires skill, judgment and timeliness of execution. The quality of the interaction between employees and patients depends on several factors like the quality of communication, ability to maintain the patient's trust and ability to treat the patient with concern, empathy, honesty and sensitivity [Asoh and Rivers, 2007].

This research mainly focuses on the appropriateness and the skill of the care provided. As is already mentioned, the quality of care is dependent on the skill and timeliness of execution. In line with this research, this is further influenced by the timeliness availability and listing of the correct materials and instruments. This research therefore will criticize quality of care by regarding:

- Amount of emergency orders
- Amount of times leaving the operation room
- Reliability of current inventory – and planning policy

Besides the availability of the correct materials and instruments, it also is important that the employees have enough time and concentration to provide the correct care. This research therefore will also criticize the quality of care by regarding:

- The amount of stress of surgical assistants
- The amount of satisfaction of surgical assistants
- The amount of care-related time of surgical assistants

2.6 Research Model

To get a transparent and concrete picture of the required knowledge to reach the research goal, the problem situation needs to be analyzed with the use of a research model. A research model states: (1) the boundaries of the research, (2) the selection of the variables and (3) the relations between these variables. Based on the earlier elaborate description of the motivation – and theoretical framework of this research, it is possible to create the required model. It is presented in figure 19.

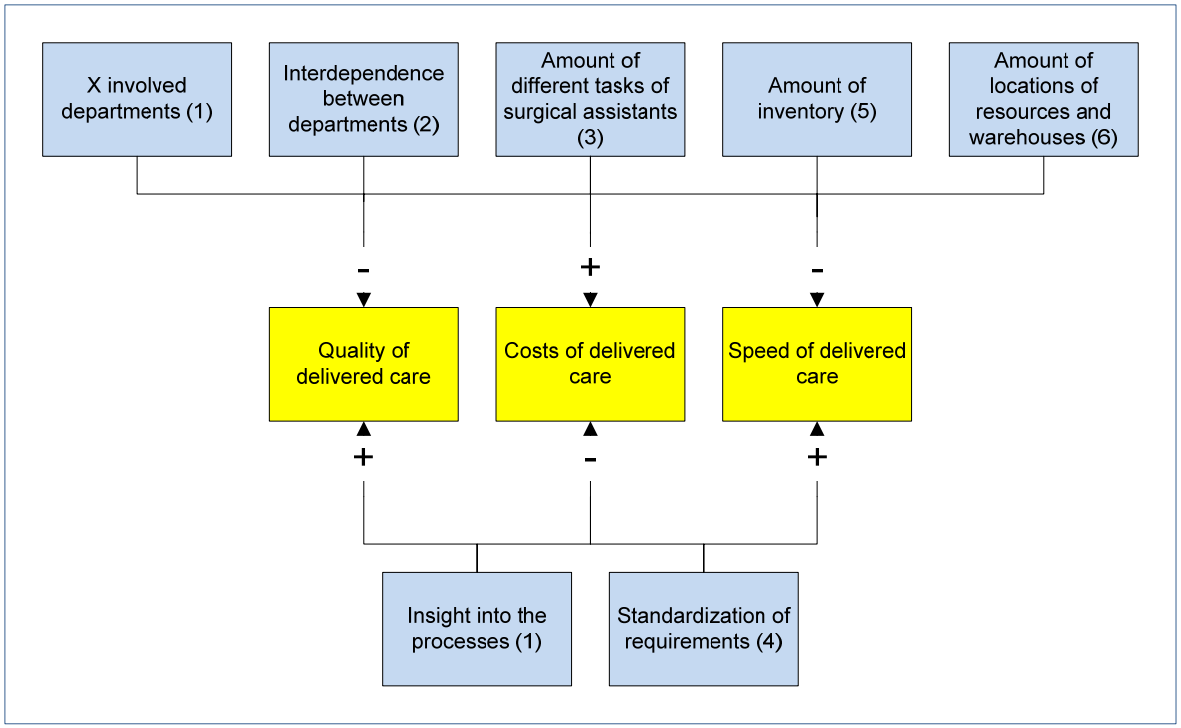


***Figure 19**, The conceptual model of this research (paragraph numbers are between brackets)*

2.7 Research Questions and Operationalization

The theoretical framework and the created research model, have led to a delimitation of this research. Based on the theoretical framework and conceptual model, it is possible to formulate the final research question:

> How should the logistical processes, which are facilitating the execution of the surgical process, be reengineered and where should the functional separation between logistical - and care related tasks be placed to be able to increase the speed and quality and decrease the costs of the total surgical process in the University Medical Center Groningen?

The starting point of this research is the current organization and structure of the logistical processes in the direction of an operation room. For the understanding of total research it is necessary to analyze the different persons and departments that currently are involved at the logistical and surgical processes, the amount – and sort of process steps, the transition point from logistical to care related tasks and the insight in the different process steps. This paragraph presents a general overview of the current situation and facilitates the analyses in the subsequent paragraphs. The sub question that originates from this objective is:

> 1. How are the logistical and care related processes in the direction of an operation room currently organized and what is the quality of the current insight into the different steps of the total process?

The result of the first sub question is an elaborate description of the different logistical and care related tasks and an overview of the involved employees and departments. To be able to analyze the quality of the current organization and to be able to provide reengineering possibilities, we have to study the current relationships between the different involved persons and departments. Different sorts of relations, analyzed in terms of interdependencies, are possible. The amount of interdependency is influencing the quality, speed and costs of the logistical – and care related processes and determines the optimal lay-out, structure and organization of the different processes in the direction of an operation room. This leads to the second sub question:

2. How great are the interdependencies between the different involved persons and departments?

The transition point from logistical tasks to care related tasks is currently placed at the surgical assistant function. They currently are the most prominent actor in the organization of the logistics at the operations center. They are responsible for a great amount of logistical related tasks. Their core task, however, are care related tasks in an operation room. In view of the importance of the surgical assistant in the execution of the surgical process and the current shortage of surgical assistants in The Netherlands it is important to create an overview of the current work processes and task diversity of a surgical assistant. It besides that also is important and required to study the consequences of placing the transition point at the surgical assistant function in terms of quality, speed and costs of the processes and the consequences for the surgical assistant's health and happiness. This leads to the third sub question:

3. How great is the task diversity of a surgical assistant and what are the consequences of placing the transition point at this function?

The main input to the organization of the logistical – and care related processes is the demand for surgeries and the resulting demand for materials and instruments. To be able to provide recommendations for a reengineering of the total process, it thus is necessary to create an overview of the different characteristics of the demand and how they are influencing the possible organization, structure and lay-out of the total logistical – and care related process. This brings us to the fourth sub question:

4. How is the demand for surgeries influencing the organization of the logistical and care related processes?

Based on characteristics of the demand, the organization of the logistical – and care related processes and the insight into the different process steps, it is possible to formulate an inventory management strategy. The management of the inventories is vital to hospital performance and patient care quality. Hospitals need to store a great variety of medical and surgical supplies which are required to be available in sufficient quantity and quality for the staff to use at all times. The formulated inventory management strategy has a significant influence on the costs, speed and quality of the total process. This leads to the fifth sub question:

5. How should the inventory at an operations center be managed?

The formulated inventory management strategy is, in combination with the characteristics of the demand, the organization of the logistical – and care related processes and the insight into the different process steps, determining the amount of locations of resources and warehouses in the total hospital supply chain. The chosen amounts are significantly influencing the costs, speed and quality of the total process and should thus be researched. Since we are not studying the total hospital supply chain, but only the chain from the LCE and SPD to an operation room, we will only focus on this part of the hospital supply chain. This brings us to the sixth and last sub question:

6. At which locations in the (researched part of the) hospital supply chain should resources be stored and warehouses be placed?

Operationalization

This research takes three of the five performance objectives of Slack and Lewis **[**2002**]** as point of origin: speed, cost and quality. The necessary operationalization is presented in table 5. This operationalization actually translates the described theoretical performance objectives (in the theoretical framework) to empirical, visible and measurable concepts. This translation is necessary to be able to present the current performance and to be able to criticize (in the future) whether performance has been improved by the implementation of mentioned recommendations.

Perf. Ind.	**Operationalization**
Speed	• The takt time (maximum time allowed to deliver materials and instruments to meet the demand of patients and surgeons) • The required transport time from logistical center "The Eemspoort" to the central warehouse at the operations center • The required transport time from the sterile processing department to the central warehouse at the operations center • Materials preparation time (for a surgery) • Materials clearing away time • Operation room preparation time
Cost	• Inventory costs • Labour costs • Emergency appeal costs • Surgery costs • Failure costs
Quality	• Amount of supply rounds • Amount of times of ordering replenishment stocks • Amount of involved persons and departments • The general health of surgical assistants • The burnout rate of surgical assistants • The amount of care-related activities of surgical assistants • Amount of procedure trays • The amount of insight into the different steps of the logistical process in the direction of an operation room • Amount of handover moments • Amount of door movements of an OR • Average appreciation of the logistics • Amount of communication between involved persons and departments • Amount of learning of logistical employees • Reliability of inventory management practices • Frequency of controls of perishable dates • Amount of warehouses • Lay-out of the operations center and the warehouses • Amount of emergency appeals

	• Amount of times out OR • Amount of emergency appeals

***Table 5**, Operationalization of the performance indicators*

The above presented overview of the operationalization of the performance indicators is a collection of all the measured variables in this research. With this overview it is possible to criticize the current organization (and possible improvements) of the logistical and care related processes in the direction of an operation room. We have decided to present a total overview of the variables (without the corresponding research questions and paragraph numbers) since they are discussed in several of the six different sub questions.

The next chapter will describe the research methods and explains how the answers to the research questions were found.


OPMI Movena
Carl Zeiss

3.

- Methodology –

Methodology can be regarded as the study of the scientific methods, the procedures and routines that should be used to acquire knowledge and to bring science ahead. The term methodology originates from the Greek words *meta* (after), *hodos* (way) and *logos* (doctrine), and literally means "doctrine of the covering way." Nowadays, the concept has several meanings:

- The analysis of the principles of the methods, rules, theories and principles used by different disciplines
- The development of methods, used within different disciplines
- The applied methods of a research
- A specific procedure or collection of procedures

In this research the third meaning will be used. This chapter will explain how the different answers on the different research questions were obtained, how the data was collected and how the data was analyzed.

3.1 Introduction

The previous chapter described the theoretical framework and the main thoughts about the relationship between a number of variables and their possible influence on the quality, speed and costs of the processes at and around an operation room. As already mentioned in the introduction of this research, the logistical processes at and around an operation room are a reasonable new and not thoroughly researched subject. In combination with the specific management question of the UMCG it therefore was decided to choose for a case study research as main research method. Case study research namely has been one of the most powerful research methods in operations management, especially when developing new theories, *investigating how and why questions* and theory testing and refinement **[**Voss et al, 2002**]**. This research is mainly focused on answering the stated how and why questions (paragraph 2.7). The answers on these questions however also can be used for the development of new scientific theories.

Since this research was executed at the University Medical Center Groningen, most research questions were answered in one organization; leading to a single case study. This on the one hand limits the generalisability of the developed conclusions, models and theories but on the other hand does provides an opportunity for an in-depth observation. To abolish the disadvantages of single case research, the most important research questions were also studied in multiple cases. This increases the external validity and helps to guard against observer bias. The other cases were selected to produce contrary results **[**Voss et al., 2002**]**. The selected other cases are:

- Medical Center Leeuwarden
- Martini Hospital Groningen
- Deventer Hospital
- University Medical Center Utrechtr

During the case study, different research instruments were used. The prime sources of data were interviews (semi-structured and open), personal observation, informal conversations, attendance at meetings and events, collection of objective data and review of archival sources. Figure 20 shows the used instruments per research questions. Table 6 explains the stated numbers. The most important instruments are discussed in the subsequent section.

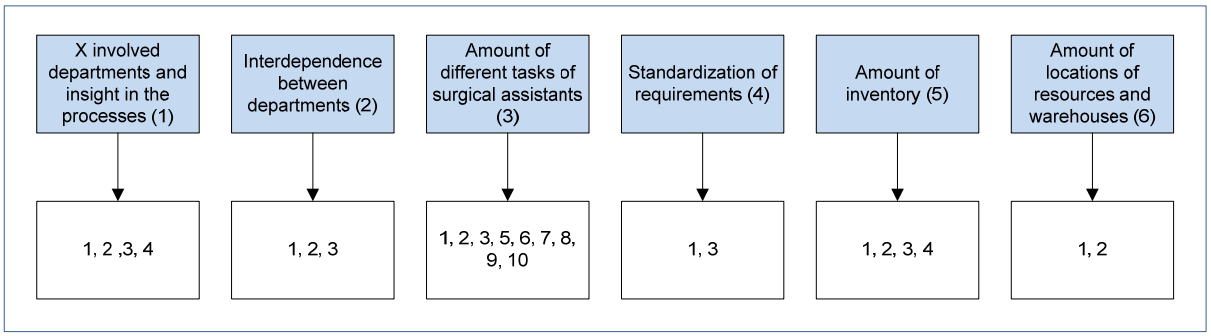


***Figure 20**, The used research instruments per research question*

1.	Interviews (semi structured & structured)
2.	Personal Observation
3.	Archival sources and objective data
4.	Process Mapping
5.	Average materials preparation time study
6.	Work measurement of surgical assistants (MDWS technique)
7.	Out of OK study
8.	Duration out of OK study
9.	Amount of OR door movements study
10.	Survey surgical assistants

***Table 6**, Explanation of the mentioned numbers in figure 20*

3.2 Used instruments

Interviews

Personal interviews were, as in many case researches, one of the greatest sources of data during this total research. As can be seen in table 7 different interviews were executed. A personal interview (or face to face communication) is a two-way conversation initiated by an interviewer to obtain information from a participant. The differences in the roles of interviewer and participant are pronounced. They are typically strangers, and the interviewer generally controls the topics and patterns of the discussion. The consequences of the interview are usually insignificant for the participant. The participant is asked to provide information and has no indication of receiving any immediate or direct benefit from this cooperation.

There are real advantages as well as clear limitations to personal interviewing. The greatest value lies in the depth of information and detail that can be secured. It far exceeds the information secured from telephone and self-administered studies via intercepts, mail surveys, or computer.

The interviewer can also do more things to improve the quality of the information received than with any other method. The greatest disadvantages of personal interviewing are the costs, in terms of both money and time.
Three broad conditions must be met in order to have a successful personal interview:

- The participant must possess the information being targeted by the investigative questions
- The participant must understand his or her role in the interview as the provider of accurate information
- The participant must have adequate motivation to cooperate

In practice, three types of interviews are used (structured, semi-structured and open). The personal interviews in this research were mainly semi-structured and open. Semi-structured interviews differ from structured interviews because they are not totally worked out. A list of themes and questions is formulated but there is room to further explore relevant issues arising during the interviews with the individual respondents. In case of open interviews, no themes and questions were formulated. The interviews in this research were one to one and face to face with different employees that had different sorts of information at their disposal.

Since not all employees have all the required knowledge, multiple employees were interviewed (especially many different surgical assistants). Names of possible interesting and best informed employees (principle informants) were provided by the supervisor of this research, Mr. Goudswaard. The first contact for the semi-structured interviews was made by email. A standard message, that defined the goal of the interview and the value for the research and the UMCG, was used. Email was also used by arranging the interview date and location. All the semi-structured interviews were conducted at the office of the interviewee. The different open interviews were conducted during the observations and data collection. No specific appointments were made.

The interviews were conducted by a single investigator. During the interviews (and observations) no tape-recorders were used. Field notes were taken from the interviews (and during observations and data collection). After an interview or observation, expanded typed notes were made as quickly as possible.

An overview of the different interviews is presented in table 7.

Date	Function	Interview type
08 April 2009	Senior Purchaser UMCG	Semi-structured
09 April 2009	Executive OZO Sector 1 UMCG	Semi-structured
10 April 2009	Manager SPD Martini Hospital Groningen	Semi-structured
16 April 2009	Employee SPD UMCG	Open
17 April 2009	Manager Logistical Center Eemspoort	Semi-structured
17 April 2009	Manager Logistics UMCG	Semi-structured
20 April 2009	Executive OZO Sector 1 UMCG*	Semi-structured
20 April 2009	Surgical Assistant UMCG	Open
21 April 2009	Executive OZO Sector 1 UMCG*	Semi-structured
22 April 2009	Manager Logistics OZO UMCG	Semi-structured
23 April 2009	Executive OZO Sector 1 UMCG	Semi-structured
27 April 2009	Employee Logistics UMCG	Semi-structured
28 April 2009	Manager Logistics UMCG	Semi-structured
29 April 2009	Functional data administrator UMCG	Semi-structured
29 April 2009	Manager OZO UMCG	Semi-structured
04 May 2009	Manager SPD Martini Hospital Groningen**	Semi-structured
06 May 2009	UMCG Purchasing Department	Semi-structured

11 May 2009	Executive OZO Sector 1 UMCG	Semi-structured
11 May 2009	Surgical Assistant UMCG	Open
12 May 2009	Physician Assistant Orthopaedics	Semi-structured
12 May 2009	Manager SPD UMCG	Semi-structured
12 May 2009	Executive OZO Sector 3 UMCG	Semi-structured
13 May 2009	Executive OZO Sector 2 UMCG	Semi-structured
18 May 2009	Executive OZO Sector 1 UMCG	Semi-structured
18 May 2009	Graduate Operations & Supply Chains (research at the Orthopedic department)	Semi-structured
20 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
22 May 2009	Team Leader Logistics UMCG	Semi-structured
25 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
25 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
26 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
27 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
28 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
28 May 2009	Surgical Assistant Thorax Surgery UMCG	Open
29 May 2009	Surgical Assistant Orthopedic Surgery UMCG	Open
08 June 2009	Manager Operations Center CZ Hospital Deventer***	Semi-structured
	Surgical Assistant Orthopedic Surgery UMCG	Semi-structured
17 June 2009	Surgical Assistant Orthopedic Surgery UMCG	Open
17 June 2009	Surgical Assistant Orthopedic Surgery UMCG	Open
17 June 2009	Anesthetist UMCG	Open
09 July	Logistical Advisor Operations Center and Intensive Care Isala Klinieken Zwolle	Semi-structured
07 Sept. 2009	Meeting GHX, GS1, Chipsoft, University Medical Center Utrecht, Deventer Hospital, Catharina Hospital, University Medical Center Groningen	Open
10 Sept. 2009	Logistical Employees Martini Hospital Groningen	Open
11 Sept. 2009	Logistical Employees Martini Hospital Groningen	Open
14 Sept. 2009	Surgical Assistant Orthopedic Surgery UMCG	Open
24 Sept. 2009	Staff member division Perioperative Care and Urgent Care University Medical Center Utrecht	Semi-structured

* Accompanying for two full days
** Executing logistical tasks for a full day
*** Inclusive elaborate guided tour and demonstration of the used information system

***Table 7**, Conducted personal interviews*

Process mapping

Chapter 4 starts with an elaborate description of the current organization of the logistical processes between logistical center the Eemspoort and an operation room and between the sterile processing department and an operation room. The organization of the logistical processes will be visualized with the help of process maps (flow charts). Process maps are very useful tools to give a detailed understanding of a process prior to possible improvement. Process mapping simply involves describing processes in terms of how the activities within the process relate to each other. The act of recording each stage of a process quickly presents poorly organized flows. Process maps can also clarify improvement opportunities and shed further light on the internal working of an operation. Finally, and probably most importantly, they highlight problem areas where no procedure exists to cope with a particular set of circumstances **[**Slack et al, 2004**]**.
There are different techniques that can be used for process mapping. However, all the techniques have two main characteristics:

- They identify the different sorts of activity that take place during a process
- They show the flow of materials, people of information through the process

The introduction of the process will be described with the use of high level process mapping, which is mapping processes on an aggregated level. The different elements of the total process will be described with the use of detailed process mapping, which is mapping processes on a

more detailed level. The content of the process maps is obtained with the help of observations and personal interviewing.

Average materials preparation time study

One of the most important elements by determining the interdependencies between the different concerned departments, is the duration of the different parts of the logistical process. The average duration of most parts was obtained with the help of personal interviews, observations and evaluation of secondary data. Because it, however, was not possible to obtain the average duration of the preparation of materials, an average materials preparation time study was executed. During this study the average necessary time of preparing materials for a surgery was measured by the surgical assistants. With the help of a mobile phone, stopwatch or present clock, the average time was measured and recorded. Because not all surgeries require the same amount of materials (because of differences in complexity of surgeries), also the amount of necessary materials was counted and recorded. The used record list is presented in *Appendix Book VII*.

Work measurement of surgical assistants

Surgical assistants are the last link in the logistical process of materials in the direction of an operation room. Surgical assistants have, based on their education, different tasks and responsibilities. Some of these tasks are necessary, others might be redundant. To be able to criticize whether tasks are necessary of redundant, the work of the surgical assistants was measured. Work measurement is a term which covers several different ways of creating an overview of the different tasks of a certain job. It can be defined as the systematic determination, through the use of various techniques, of the sort and amount of effective physical and mental work.

With this work measurement study, we are mainly interested in the amount of logistical tasks of a surgical assistant. They are on the one hand not educated for this kind of work and on the other hand there also is a great shortage of surgical assistants in The Netherlands. Besides that there are also negative consequences for the quality of the delivered care. On the one hand because they cannot bring the same quality of work as logistical educated employees and on the other hand because they disturb the sterile environment in an operation room and also might be needed when they leave the operation room for logistical tasks.

To be able to determine the task diversity of the surgical assistants, different studies have been executed. The sample of the surgical assistants was not randomly obtained. The concerned specialisms and surgical assistants were, because of the great amount of different specialisms and the positive stand of these specialisms with regard to this research, assigned by the supervisor of the UMCG. The concerned specialisms (and surgical assistants) are the Thorax Surgery and the Orthopaedics Surgery. The greater part of the research was executed at the Thorax Surgery. Because of the limited extent of the Thorax Surgery and the situation that some methods of working of the Thorax Surgery are not generalizable to all the surgical assistants, some studies were also executed at the Orthopaedics Surgery. The data was collected during a four weeks measurement in the spring of 2009 **[**Mobach, 2008**]**.

Work measurement with MDWS technique

Work measurement consists of seven different techniques. First, subjective evaluation separates the work down in essential parts. Participants then assess how long they have spent accomplishing each different task. Second, Self-reporting requires participants to document their use of time in a journal or logbook. Third, productivity data requires the registering of the amount of work tasks completed. Fourth, direct time study is a continuous measurement for a selected time interval. It requires direct observation of specified activities when they are

accomplished. Fifth, standard time study requires the identification of standard times. This is the average time necessary for an experienced employee to perform a work task. Sixth, work sampling technique measures time, the activities of employees, machines or any observable state, condition or operation. It comprises a large amount of observations by pre trained observers. The observations are taken either at random or in fixed intervals. Seventh, the multi-dimensional work sampling (MDWS) technique requires employees to record their own tasks or activities. They may use a small device with a bleeper function. This bleeper sounds at randomly generated times to remind the employee to record the activity he or she is accomplishing at that time.
The use of MDWS has several advantages. It is a nice instrument when work activities are central, not the person's job. It allows professional activities to be more precisely assessed. It is proficient when recording mobile staff. It also allows a research to be done fast, easily, economically without the need to train and pay a specialized observer. It finally is useful over long time periods and also employees often prefer MDWS. Consequently and because of the pleasant experiences of my university supervisor (and the availability of measurement devices), the MDWS was chosen as one of the modes of data collection.

For the general-work measurement with multi-dimensional work sampling, pocket size machines were used. These machines could be put away in the pockets of the special surgical assistant clothing and they did not hamper normal work tasks. This research made use of so-named "Re-pipip" devices. These devices were especially developed for a Dutch study towards general pharmacy work. The machines made a sound signal in a randomly distributed time interval. When the bleep is generated, the employees chooses one item from a standardized tasks list. With MDWS the amount of bleeps the device emits can be modified to generate the amount of measurements required for the research. A total of 14.400 observations is required to describe activities with ± 5% accuracy. A compromise in accuracy to ± 10% allows a decrease to 3.600 observations. Because of limitations in time and approval, the multi-dimensional work sampling technique in this research comprises 1498 observations.
The used bleep devices in this research had a sampling rate of 3.8 per hour. It was not possible to influence the amount of sampling rates since these were standardized by the Swedish producer. The amount of sampling rates always is a trade off between the need of density of the data and the practicability for the employees. Although it was not possible to influence the amount of sampling rates, the assumption is that a higher amount of sampling rates would not had been accepted by the employees of the concerned departments **[**Mobach, 2008**]**.

As already stated, the employees were supposed to choose a task of a standardized task list when a bleep was generated. The first task list was created on the base of literature - and internet review towards the tasks of surgical assistants and on the base of the specific logistical tasks this research is interested in. This first task list was corrected several times after, among others, reviews by surgical assistants, the management of the Thorax Surgery and the supervisor from the university and by concrete wishes (additions) of the surgical assistants. The final task list is presented in table 8. A copy of the used task list card is presented in *Appendix Book VIII*.

Inside an Operation Room	
Executing and directing Time Out Procedure	Final check with the patient and surgeon concerning the surgery, procedures and necessary materials
Preparing materials and OR	Placing necessary materials on the sterile tables, picking last necessary materials out of the OR stock
Administration	Administration of used prostheses, heart valves, present persons in the OR
Handing requirements to instrumenting surgical assistant	Handing requirements that are not present on the sterile tables to the instrumenting surgical assistant
Waiting (for work)	No tasks that need to be executed. Waiting for a new task
Cleaning up OR after a surgery	Cleaning up materials and garbage
Other tasks inside an Operation Room	
Outside an Operation Room	
Logistical tasks	Ordering, preparing, clearing, searching and/or administration of necessary materials for a surgery
Other tasks outside an Operation Room	

***Table 8**, Final task list of surgical assistants*

Out of OK study

As already stated, MDWS was among others used to get an overview of the amount of logistical tasks surgical assistants (function: walk around; *Dutch: omloop*) are executing. Logistical tasks are not part of the primary tasks of a surgical assistant and it is expected that they negatively influence the quality of the delivered care.

One disadvantage of the executed MDWS study, however, was the use of devices with standardized sampling rates. As already stated, the standardized amount of bleeps was the consequence of a trade off between employee co-operation and punctuality. On beforehand there however was the expectation that the amount of bleeps (± 3.8 per hour) were too minimal to get an accurate overview of, especially, the logistical tasks of the surgical assistants. It therefore was decided to establish an extra, control and complementary research: *the out of OK study*.

In this out of OK study surgical assistants were asked to record the amount of times they left the operation room. During the weeks of 11 until 22 May they were asked to record this on a specially developed form, which is presented in *Appendix Book IX*. Besides the amount of times they left the operation room, they were also asked to record the kind of surgery and the reasons of leaving the OR. This last category makes it possible to group the reasons of leaving the OR, whereupon it is possible to become aware of the percentage of logistical related "OR leaves".

To be able to draw significant and reliable conclusions about the amount of OR leaves, a reasonable amount of measurements is necessary. It therefore was concluded to add the Out of OK study in reduced form to the work measurement study with the MDWS technique. Besides recording their tasks, surgical assistants were also asked to keep recording the amount of times they left the operation room. This also is visible on the distinctive part of the task list card which was presented in *Appendix Book VIII*.

Duration out of OK study

When only measuring the amount of times a surgical assistant (function: walk around; *Dutch omloop*) leaves the OR, it would not be possible to draw accurate conclusions about the influence on the speed, quality and costs of the delivered care. It therefore was decided to also measure the duration of the time surgical assistants left the operation room.

This study was executed during the work measurement study and the out of OK study. Because the researcher was already present in the operation rooms to guide the different studies, it was possible to measure the duration of time surgical assistants left the operation room. With the help of a mobile phone with time measurement function, 30 measurements were executed during the spring of 2009. These measurements were spread over 4 weeks of time. It was thought that 30 measurements were sufficient to be able to present reliable conclusions.

Amount of "OR door movements" study

During the work measurement study and the out of OK study only the OR exits of the surgical assistants with walk around function were measured. As already stated, every door movement of an operation room has a negative influence on the sterility inside an OR. The surgical assistants with walk around function are however not the only employees who are leaving the OR. Also the other surgical assistants, surgeons, anaesthetists, anaesthesia employees, recovery employees and (in case of heart surgery) perfusion employees are leaving the OR. It thus is possible to incense the sterile climate of a operation room even more. It therefore was decided to also add an "amount of "OR door movements" study" to this research. Because of the impact on the available research time and the fact that the results are not directly contributing to the answering of the research question, it was decided to execute this study for a limited amount of hours during both Thorax and Orthopaedic surgery. The amount of door movements were simply scored on a piece of paper. This study also was executed during the spring of 2009.

Survey Surgical Assistants

As already stated, one of the hypothesizes of this research was that the logistical tasks, which were considered as tasks on top of the normal care related tasks, could lead to extra stress by the surgical assistants. To be able to test whether this hypothesis can be accepted, a self-administered survey was used. The self-administered questionnaire is one of the most often used research methods in modern living. Service evaluations of hotels, restaurants, car dealerships, and transportation providers are familiar examples.

The greatest advantages of self-administered surveys are the costs. Self-administered surveys of all types typically cost much less than personal interviews. Other advantages are the possibility of contacting participants who otherwise might be inaccessible, the fact that participants can take more time to answer a question and the greater anonymity than other communication methods.

A major limitation of self-administered surveys concerns the type and amount of information that can be secured. Researchers normally do not expect to obtain large amounts of information and cannot deeply probe into topics. Participants also will generally refuse to cooperate with a long and/or complex survey. One general rule of thumb is that the participant should be able to answer the questionnaire in no more than 10 minutes. A final major weakness of the self-administered study is the no response error. The response rate often is very low. Mail surveys with a return of about 30 percent are often already considered as "satisfactory" **[**Cooper and Schindler, 2003**]**.

The used questionnaire is a standard questionnaire which is used in the course "Work stress" (*Course code: PSMAB-5*) which is part of the MSc Psychology (AOP). The questionnaire is provided by the coordinator of the course for a practical assignment to make a work stress profile of four respondents of a specific occupational group. The questionnaire consists of different elements, all studying a different stress-related element:

Because not all the questions of this standard questionnaire were seen as relevant for this research and to decrease the length of the questionnaire, the questionnaire was slightly modified. The questions of part 1 and 2 were maintained, part 3 only measures the Job descriptive index of the work items, part 4 was removed, part 5 measures eight stressors instead of twenty-six and part 6 was filled with general questions about the opinion of the employees concerning the logistics on the operations center. With this questionnaire it finally was possible to:

- Rank the general health of the surgical assistants
- Give the burnout rate of the surgical assistants
- Give the Job Descriptive Index (work items) of the work of the surgical assistants
- Determine whether there are possible stressors (causes of stress) in the work of surgical assistants

- Analyze the opinion of the surgical assistants about the current logistical activities at the operations center

1. *Part 1: 12 General Health Questions*

The general health questions were scored on a 4 points scale. Koeter and Ormel [1991] indicate that a score of 3 (or higher) indicates an amount of psychological unwell being. This psychological unwell being needs extra attention and/or interventions **[**Koeter and Ormel, 1991**]**.

2. *Part 2: Utrecht Burnout Scale*

Burnout was assessed with the Utrecht Burnout Scale (UBOS). The UBOS is the Dutch version of the Maslach Burnout Inventory. This instrument quantifies burnout which is defined as work-related psychological exhaustion. There are three versions of the Utrecht Burnout Scale:

- UBOS-C for contact professions (20 items)
- UBOS-L for teachers (22 items)
- UBOS-A for general use (15 items)

In this research, the UBOS-A version was used. The Utrecht Burnout Scale contains three subscales:

- Emotional exhaustion ("*I feel exhausted by my work"*)
- Depersonalization ("*I notice I have created distance to my work"*)
- Personal accomplishment ("*I feel I am doing my work well*")

According to different researchers, the multidimensional structure of the burnout concept does not allow for combining these three different elements into a one-dimensional variable. Different objections are stated:

- Associations between dimensions and with other variables are complex. Combining dimensions would result in a loss of information
- The dimensions are constructed in such a way that they are maximally independent from another
- The role of the dimensions can vary in the different phases of the burnout process

On the other hand it also has been argued that a burnout is mainly dominated by emotional exhaustion and that the influence of the other two dimensions is restricted. Although the multidimensionality of a burnout is widely acknowledged, there are thus theoretical and practical reasons to consider a burnout as a single construct. The greatest advantage is the possibility of simplifying the results. Reporting findings for the variable burnout, instead of reporting findings for the underlying dimensions, may give interested persons a better understanding of the outcomes.
To be able to chose between the three-dimensional continuous or dichotomous conceptualization of a burnout, a decision tree can be used (figure 21).

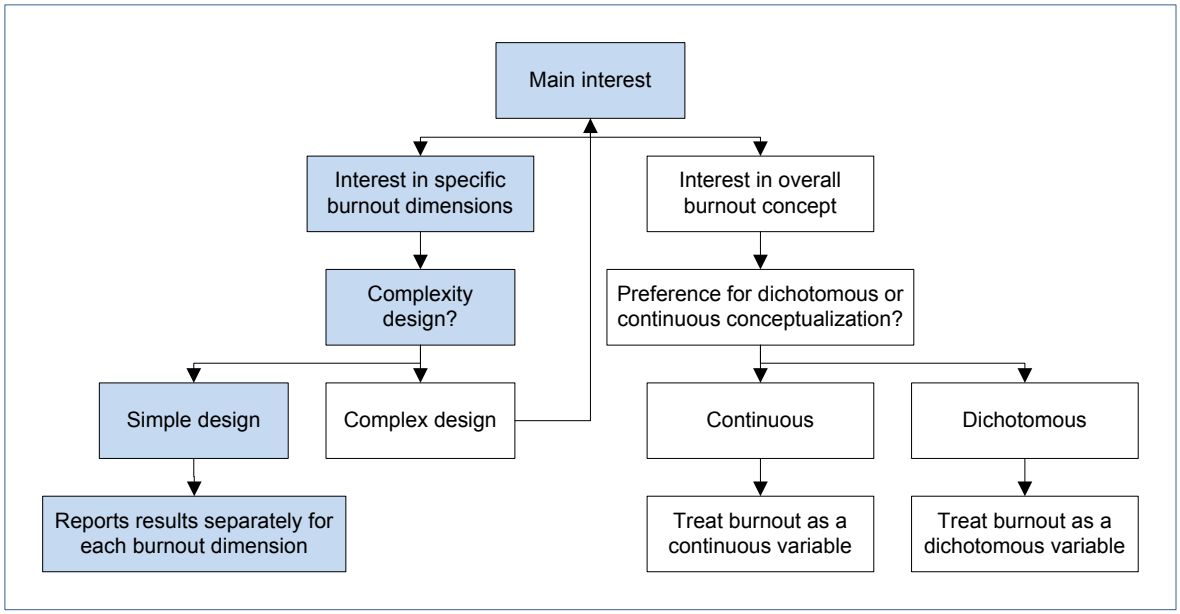


***Figure 21**, The used decision tree*

The decision tree shows that researchers, who are primarily interested in the different burnout dimensions can report results for each dimension separately. Researchers interested in the overall concept of burnouts can decide to combine the different dimensions into a single score. Once opted for a single score (or one-dimensional), it is important to decide between a dichotomous or continuous conceptualization of a burnout. In this research, we have chosen to report the results for each dimension separately **[**Brenninkmeijer, 2002**]**.

The items of the UBOS-A version were scored on a 5 points scale from really low until really high. The five classes are defined as:

Really low		Score	← 5 percentile
Low	5 percentile ←	Score	← 25 percentile
Average	25 percentile ←	Score	← 75 percentile
High	75 percentile ←	Score	← 95 percentile
Really High	95 percentile ←	Score	

***Table 9**, Five classes of the UBOS-A version*

The following norm table is used:

	5%	25%	75%	95%
Exhaustion	.19	.99	2.20	4.20
Depersonalization	.00	.49	2.00	3.50
Personal Accomplishment	2.60	3.66	5.00	5.80

***Table 10**, The used norm table*

A high score on exhaustion in combination with a high score on depersonalization and/or a low score on personal accomplishment indicates a burnout **[**Schaufeli and Van Dierendonck, 2000**]**.

3. *Part 3: Job descriptive index*

The Job Descriptive Index (JDI) is the most often used instrument to measure work satisfaction **[**Hanisch, 1997**]**. The JDI consists of items about the work, management, salary, promotion opportunities and colleagues of employees. The three answer alternatives are yes, "?" and no.
Research by Smith et al. showed that the answer alternative "?" contains a more negative than positive strain. We therefore changed the score procedure from *no = 1, ? = 2 and yes = 3* to *no = 1, ? = 2 and yes = 4*.
Because there are obvious differences between men and women, there are different norms for the Dutch version of the Job descriptive index (table 11) **[**Van Yperen and De Jong, 1997**]**.

	Men			Women		
Work	2.66	.74	.89	3.02	.72	.89
Management	2.71	.75	.90	3.08	.72	.90
Salary	2.66	.81	.79	2.57	.73	.76
Promotion	2.53	.80	.82	2.08	.66	.73
Colleagues	2.71	.81	.93	3.10	.77	.93

***Table 11**, Norms for the Dutch version of the JDI*

In this survey only the JDI item *work* was researched **[**Smith et al, 1969**]**.

4. *Part 5: Stressors*

The standard questionnaire provides twenty-six possible stressors. A stressor is defined as an agent, condition, or other stimulus that causes stress to an organism. Table 12 presents the provided stressors.

Work strain	Relationship with colleagues
Emotional strain	Relationship with management
Spiritual strain	Cooperation in the team
Work speed and quantity	Cooperation with other departments
Independence and autonomy	Communication
Variation in work	Participation
Changes in the tasks	Learning possibilities
Vagueness of tasks	Career possibilities
Work content	Recovery possibilities
Organization of the work	Adjusting work and private life
Physical environment	Future possibilities
Feedback	Salary
Contact with colleagues	Work and resttimes

***Table 12**, The provided and used (blue) stressors*

Based on preliminary interviews with several surgical assistants and the managers of the surgical assistants, eight stressors were selected from the above list **[**Van Yperen, 2006**]**. These stressors are blue colored.

5. *Part 6: General questions*

The final part of the questionnaire consists of some general questions (gender, age, working hours, etc.) and some questions about the opinion of the employees concerning the current organization of the logistics on the operations center. In combination with the outcomes of the interviews with the managerial employees, it is possible to create a total picture of the appreciation of the logistics on the operations center.

The questionnaires were distributed during the spring of 2009. The questionnaires were distributed to all the employees of sector 1 and 3 of the operations center of the University

Medical Center Groningen. The size of this research group was 69 employees (N = 69). The respondents received three weeks of time for filling in the questionnaires. In consultation with the managers of the two departments where the survey executed (Thorax and Orthopaedics), the expected response rate was set at 40%. Used ways to reach this response rate were:

- Short questionnaire length (< 10 minutes)
- Use of an introduction letter
- Guaranteeing anonymity
- Defining deadline date
- Preliminary notification via e-mail and supervisor
- Support of supervisors
- Reminder by mail

The final response rate of the questionnaire was 42%, which can thus be regarded as satisfactory. The used questionnaire is presented in *Appendix Book X*.

3.3 Credibility of the results

When performing case research it is very important to pay attention to the reliability and credibility of the results. This paragraph therefore first of all will discuss the reliability of this research and will be followed by a discussion about the credibility of this research.

Reliability

Yin **[**2003**]** has defined the concept of reliability as *the extent to which a study's operations can be repeated, with the same results.* Reliability can be achieved in many ways in a case study. One of the most important methods is the development of a case study protocol. A case study protocol contains procedures and general rules that should be followed when using the research instruments. It is to be created prior to the data collection phase. It is essential in a multiple-case study, and desirable in a single-case study.

To increase the reliability of this research we have tried to create a clear research protocol. We have presented a clear overview of the general topics of inquiry and the purpose of this case study. Next to it, we tried to present an elaborate description of the data collection methods and an overview of how the data was collected in the field. During the data collection, the observations and actions were recorded as concrete as possible in a case study database. This database was accessible at every moment of the research. We finally tried to increase the reliability of this research by asking the same questions to several interviewees. A clear signal of the reliability of the results was the frequent receipt of similar answers.

The reliability of this research was decreased by the fact that only one researcher was used **[**Riege, 2003**]**. This however is one of the obligations of the graduation and could thus not be changed. Overall, it should be possible to repeat this research with obtaining more or less the same results leading to a reasonable high reliability.

Validity

It is possible to mention different forms of validity of a research. This research pays attention to three sorts of validity: construct validity, internal validity and external validity.

Construct validity is defined as *the extent to which we establish correct operational measures for the concepts being studied* **[**Voss et al, 2002**]**. The construct validity of this research was confirmed by similar results by the usage of different sorts of research instruments. It further was confirmed by the match between the predictions – and the outcomes of relations between different variables. The

construct validity further was raised by the use of triangulation. Triangulation indicates that different methods/sources are used for the measurement of the same variables. Triangulation is used to double (or triple) check the results. It also is called cross examination. In this research it for example was applied to the examination of the inventory management system of the UMCG. The construct validity of this research finally was raised by letting the respondents check the results of the data collection and by letting them check the drafts of the final research report.
Internal validity is defined as *the extent to which we can establish a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships* **[**Voss et al, 2002**]**. The internal validity of this research was strengthened by the use of triangulation and by asking the same questions to several respondents.
The external validity, finally, is defined as *knowing whether a study's finding can be generalized beyond the immediate case study* **[**Voss et al, 2002**]**. Since this research mainly is executed as a single case study, not all the results can be generalized beyond this study. To increase the external validity of this research, the most important research variables and relationships were also studied in the Deventer Hospital, the Martini Hospital and the Medical Center Leeuwarden.
The above discussion of the different reliability concepts brings us to the conclusion that we think we can present results with a reasonable high validity.

3.4 System and environment of the research

Besides describing the research questions and the methodology used to answer the research questions, it also is important to give a description of the system and the environment of this research. Describing the functioning of an organization, it is important that not only the separate elements are observed, but also the organization and structuring of these separated elements. The whole namely is more than the sum of its parts. A system can be characterized as a collection of elements and their mutual relations. A system is recognizable by the stable relation between the elements; this is the structure of the system. Within an organization, departments can be considered as the stable relations between those elements and the structure of the system.
A system always finds oneself in an environment. An environment consists of everything outside the system, but which does has a connection with this system. The division between the system and his environment is named the boundary of the system **[**De Leeuw, 2002**]**.
In practice it is possible to distinguish open and closed systems. In case of a closed system, the behavior of a system can always be explained without considering the environment. In case of an open system, the behavior of a system can only be understood when the environment is considered. An organization always is an open system.
In case of an open system, we speak of inputs, processes and outputs. The inputs can be information, materials and services. The information and materials are processed and the produced products or services are sold to the market. After the transaction, the system has the possibility to receive feedback. The output of the system generates information about the operation of the system. This feedback is very important. Only in this way it is possible to see whether the system is functioning properly or whether things need to be changed or stopped **[**Riezebos, 2004**]**. The system and environment of this research are visually presented in figure 22.

The system of this research (yellow lines) consists of the logistical process from logistical center the Eemspoort to the warehouses at the operations center and the logistical process from the sterile processing department to the warehouses at the operations center. It furthermore consists of the locations and lay-out of the warehouses, the logistical processes between the warehouses and the operation rooms and the work processes inside an operation room. Finally also the

logistical process of dirty sets from the operations center to the sterile processing department is (partially) studied.

The environment of this research (blue lines) consists of the work processes at the different suppliers and the logistical process between the suppliers and logistical center the Eemspoort. It furthermore also consists of the work processes at logistical center the Eemspoort and the work processes at the sterile processing department.

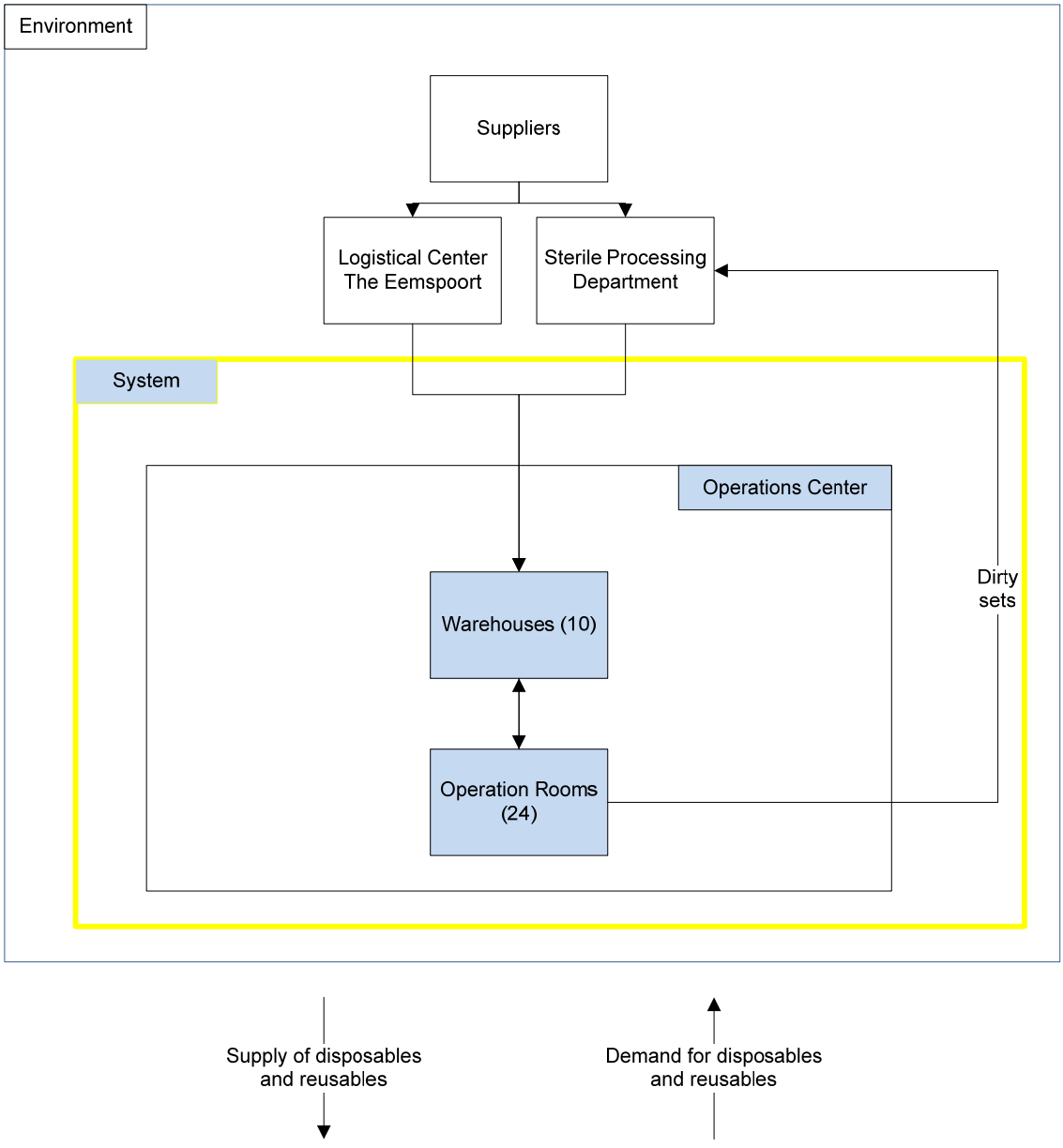


***Figure 22**, System and environment of this research*


Latex-Free
Powder-Free
Single Use Only
Small

4.

- Results –

In this chapter, the different results of this research will be presented. The results will be discussed with the use of the different stated sub questions (see also chapter 2.7). Chapter 4.1 first of all gives an elaborate description of the organization of the logistical processes in the direction of an operation room whereby mainly the involved persons and departments and the insight into the different steps of the process are discussed. Chapter 4.2 subsequently describes the interdependencies between the different concerned persons and departments. Chapter 4.3 then presents the results of the study towards the task diversity of the surgical assistants. It also discusses the different consequences of the outcomes of this sub question. Chapter 4.4 furthermore describes the characteristics of the demand of surgeries and subsequent materials and instruments. Chapter 4.5 subsequently shows how the inventory on the operations center is managed and chapter 4.6 finally describes the current amount of locations of resources and warehouses in the researched hospital supply chain.

4.1 How are the logistical and care related processes in the direction of an operation room currently organized and what is the quality of the current insight into the different steps of the total process?

This first paragraph functions as basis and foundation of this total research. For the understanding of the total research it is necessary to analyze the different persons and departments that currently are involved at the logistical and surgical processes, the amount – and sort of process steps, the transition point from logistical to care related tasks and the insight in the different process steps. It however is important to keep in mind that each process step actually is a point where materials, instruments and information are processed, transferred and/or stored. Although different persons and departments are involved at these processes, the ultimate focus of this research is on the flow of materials and instruments and the consequences for the costs, speed and quality of the total surgical process.

This paragraph continues with an important explanation of the different sorts of used medical resources. We then present the corresponding logistical processes. Since three different sorts of medical resources can be distinguished, also three different sorts of logistical processes are presented: the disposable cycle, the reusable cycle and the sets on loan cycle. Each distinct cycle will be introduced and discussed by which we mainly will look at the different involved persons and departments. This paragraph finally will pay attention to the ownership of the different medical resources and the insight into the different steps of the process.

4.1.1 Medical Resources

The category of logistical material flows in hospitals that comprises the greatest consumption value, the broadest assortment and the highest number of suppliers are the medical resources (table 13). When regarding the high consumption value, many hospitals hold the expectation that medical resources contain a great amount of saving potential.

Article Type	Consumption Value (€)	Width Assortment	Number of Suppliers
Medical resources	*14.0 mln.*	*Very wide*	*Many*
Household articles	8.0 mln.	Narrow	Limited
Office and print supplies	5.5 mln.	Wide	Limited
Bedclothes, sheets, etc.	2.5 mln.	Narrow	Limited
Nutrition	5.5 mln.	Average	Limited
Medicines	11.0 mln.	Very wide	Limited

***Table 13**, Main categories of logistical material flows in hospitals*

To be able to examine the saving potential of medical resources, it is necessary to distinguish two different groups of medical resources in the UMCG. On the one hand because they differ in use and on the other hand because they both follow a different logistical path through the hospital. These two main groups of medical resources are *disposables* and *reusables*.

Disposables are, as the name already indicates, medical resources that are used only one single time and are thrown away after use. To get a clear view of the different used disposables in the UMCG, table 14 presents the different disposable categories based on NZI codes. Disposables flow to the operations center from logistical center the Eemspoort.

NZI Code	Definition
4625	Resources, prostheses and implants
4626	Bandages and casts
4627	Sutures
4629	Other surgery supporting medical supplies
4643	Incontinence materials
4651	Administering and Seizing systems
4652	Catheters and Tubes
4653	Medical Gloves

***Table ?**, Different disposable categories based on NZI codes*

Reusables, also named instrument sets, are medical resources that are cleaned, disinfected and sterilized by the sterile processing department. Based on the necessary materials during a specific surgery, these sets are cleaned, packaged, disinfected and sterilized in special so called nets. Preliminary to a surgery, these nets are opened by the surgical assistants and the instruments are spread over a special sterile table. After a surgery these instruments are collected and placed back in the net after which the net will be transported to the sterile processing department for a new decontamination round.

Two different logistical processes in the direction of the operations center can thus be distinguished (figure 23):

1. From logistical center the Eemspoort via the goods-receipt point to the operations center (*the disposable cycle*)

2. From the sterile processing department to the operations center (*the reusable cycle*)

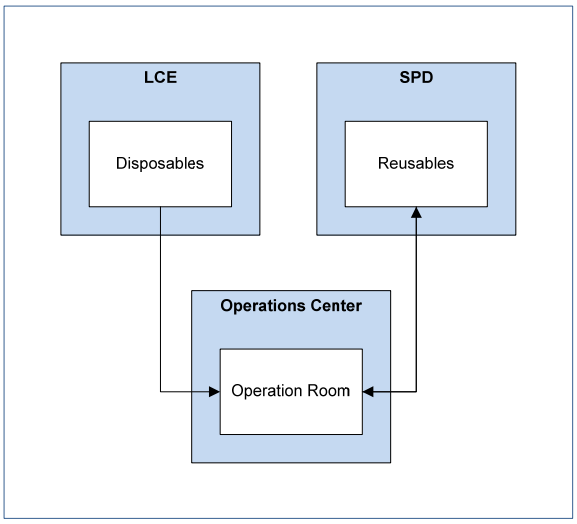


Figure 23, *The disposable cycle and the reusable cycle*

4.1.2.1 From logistical center the Eemspoort (LCE) to the goods-receipt point at the UMCG (*the disposable cycle*)

As already stated in the introduction, the logistical center the Eemspoort (LCE) is a special extension of the UMCG. The LCE has a modern warehouse at its disposal where different fast moving products are stocked. On average there are 5000 different products stored. The average turnover rate is 10 and on average there are four weeks of stock to the value of €2.700.000.
The LCE also functions as acceptance point for all the other products that are supposed to be delivered at the UMCG. There actually are thus two different sorts of products that are transported to the UMCG: *stock items* and *non stock items*. Stock items are the items that are stocked at the LCE, non stock items are items that are not stocked at the LCE and only are transshipped (figure 24).

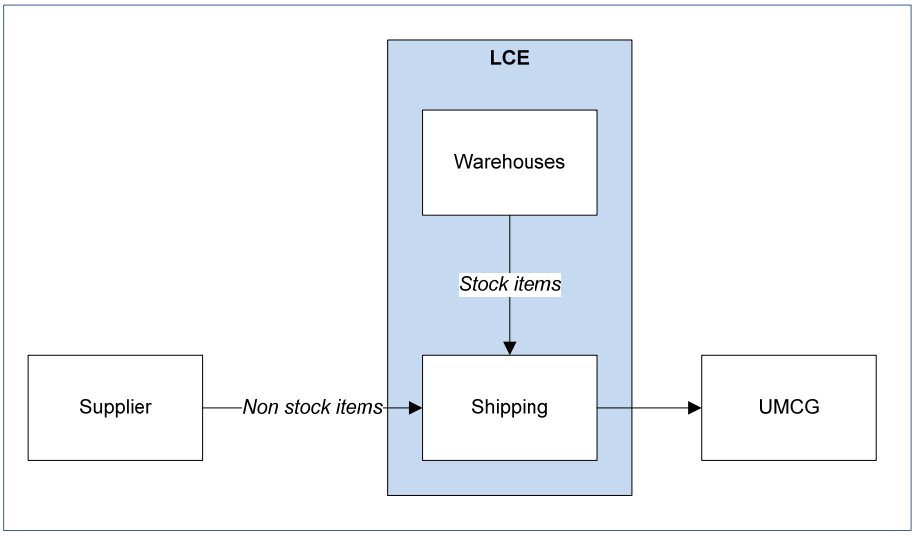


Figure 24, *Stock items and Non stock items*

The stock items are products that are used very regular and/or have a low purchase price. These items are directly ordered by the concerned specialisms, the purchasing department or the

logistical department. The LCE receives these orders and collects the ordered items with the help of the roll through shelves and the management warehouse system. The items are placed in special produced containers and subsequently in special produced carts. These carts are provided with the internal address of the recipient (especially the special home postcode of the UMCG is important) and then placed at the shipping dock. At this place the carts will wait until the next supply round.

The non stock items are products that are not regularly used and/or products with a high purchase price. These items are also directly ordered by the concerned departments, the purchasing department or the logistical department. These products are delivered by the supplier at the LCE. At the LCE the delivery is checked and prepared for shipment. The items are also placed in containers or carts and then provided with the internal address of the recipient. They then are placed at the shipping dock where they, together with the stock items, wait until the next supply round.

During the day there are in total eight supply rounds in the direction of the UMCG. The first supply round starts at 08:00 am after which a truck drives to the UMCG every hour. Although there however are eight supply rounds every day, there only are two supply rounds from the LCE in the direction of the operations center: one at 09:00 am and one at 15:00 pm. These supplies are not in own control, but are executed by *DHL*. The supplies are not in own control because the transport by DHL is less expensive and DHL is better capable of providing alternative transport in case of breakdowns. Because of the importance of the supplied items, it is very important that they reach the UMCG on the arranged moments. The trucks that are used by DHL are capable of transporting a maximum of 48 carts.

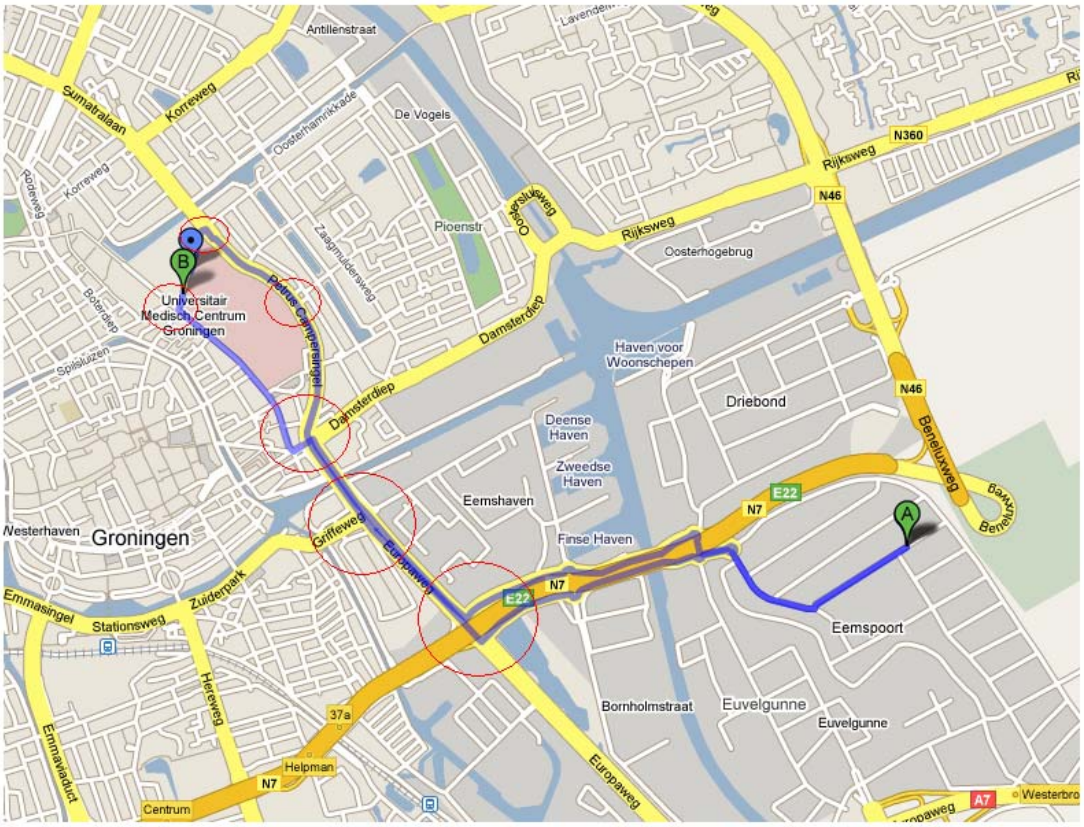


Figure 25, *The location of the LCE with regard to the UMCG*

The LCE is located at industrial zone the Eemspoort which is located in the South-East of Groningen. The distance from the LCE to the UMCG is around 4.2 kilometers. It takes, based on the traffic situation, on average 15 minutes to drive from the LCE to the UMCG. During the morning and during the end of the afternoon, the driving time is higher because of building up of traffic before different traffic-lights (red cirkels at figure 25).

Distance	Departure time LCE	Arrival time UMCG
4,2 KM	9:00	9:15
	15:00	15:15
Emergency	< 30 min.	

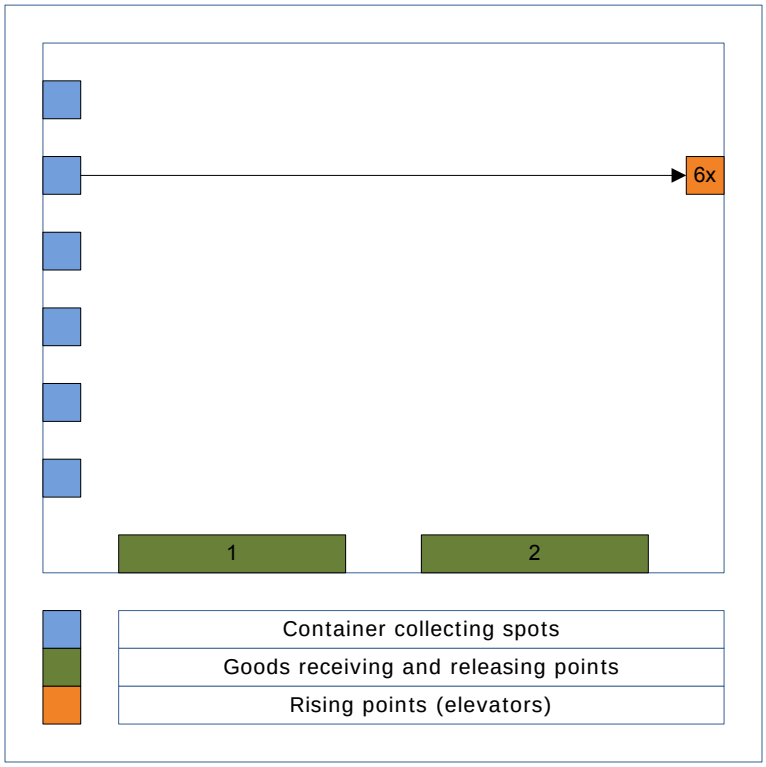
***Table 15**, Overview of the distances and times from the LCE to the UMCG*

As in every hospital, there also are emergency situations by which medical resources need to be transported to the UMCG as quick as possible. This can be because of emergency situations (accidents), uncertainty reduction or because of logistical problems at the LCE, the internal logistical transport of the UMCG or at the operations center. For these situations, the LCE can call in the help of *CE Couriers*. They will deliver the necessary medical resources *on the desired medical department* within thirty minutes.

4.1.2.2 From the goods-receipt point to the operations center (*the disposable cycle continued*)

The different supplies are delivered at the UMCG on basement level. The UMCG namely has an elaborate logistical corridor system at the basement. Containers are delivered at the goods-receipt point and then turned over. From the turnover point the containers are transported to so-called "rising points". At these rising points the containers can be transported by elevator to the concerning departments.

There are two turnover points at the goods-receipt point with a total capacity of 45 containers at a time. After the turnover, the containers are placed at special container collecting spots. There are six spots whereby every spot corresponds with a rising point. The containers are placed in a row and then transported to the rising points (figure 26).



At the container collecting spots, there are also two special spots for the operations center (first and third floor). The containers that enter the goods-receipt point and that are meant for the operations center are picked out and placed at the right spots. The containers however are not always correctly loaded. Frequently, goods need to be repacked and distributed over several different carts or containers. This takes a lot extra time for the logistical employees.

***Figure 26**, Lay-out of the goods-receipt at the UMCG*

During a tour through the hospital we visited a lot of different warehouses at different departments. The LCE was closed this Friday because of Ascension. It stroked me that many shelves and racks already were empty while it only was Friday. Because the LCE was closed, it namely was not possible to order replenishment stocks. This lead to many emergency orders and thus to many extra costs. Because the LCE also is closed during the weekends (Saturday and Sunday), it was supposed that many extra emergency orders were necessary.

The corridor from the goods-receipt point to the rising point at the operations center has a length of around 1.7 kilometres. The Still tractors are driving with a speed of 13 km/hr which means that in normal circumstances the distance can be covered in approximately 7.8 minutes. In contrast with the transport between the sterile processing department and the operations center, the transports are not executed on standardized moments. The transport between the goods-receipt point and the operations center is executed with the use of window times. This means that the transport always is executed in a certain time period but that the exact delivery moment will vary. The time window is known by – and visible for all the involved employees.

There are two moments at which it is possible that supplies enter the operations center. The first supply moment is around *10:00 am* and the second around *16:00 pm*. The containers are transported to the first or third floor at the rising point and then placed at the goods-receipt point at the operations center. From here it is the responsibility of the logistical employees of the operations center to transport the different goods to the warehouses. The internal logistical employees are not allowed to transfer the deliveries to the warehouses at the operations center because of special sterility requirements. They are only allowed to enter the operations center when using special operations center clothes and when considering the hygiene protocols.

From the LCE to the goods-receipt point UMCG		
Distance	Departure time LCE	Arrival time UMCG
4,2 KM	9:00	9:15
	15:00	15:15
From the goods-receipt point UMCG to the Operations Center		
Distance	Departure time OC	Arrival time OC
1,7 KM	9:50	10:00
	15:50	16:00
Total driving time	23 min.	
Total handling time	37 min.	
Emergency	< 30 min.	

***Table 16**, Overview of the distances and times from the LCE to the UMCG and from the goods-receipt at the UMCG to the Operations Center*

Table 16 presents the total delivery time from the LCE to the operations center. The table shows that it takes around one hour to deliver the ordered products from the LCE to the operations center. This disposable cycle is visually presented in figure 27. This figure shows that in total six different persons or departments are involved at the logistical process between the LCE and the operations center. Besides that, the figure also shows that the different transports are taking place on the ground, first and third floor and in the basement.

4.1.2.3 From the goods-receipt at the operations center to an operation room (*the disposable cycle continued*)

The disposables that are placed at the goods-receipt point at the operations center are transported to the warehouses by the logistical department of the operations center. The disposables will stay in the warehouse until they are required for a surgery. They are collected by surgical assistants, who currently are responsible for the preparation of individual surgeries. During a surgery, the necessary disposables are laid out on a special sterile table, or stored in a special disposable basket. When disposable materials from the disposable basket are required, it will be handed by one of the surgical assistants (walk around function).
After a surgery the used disposables are simply thrown away in garbage bags. The not used disposables are returned to the warehouses in the special disposable baskets. They are placed back at the shelves by a sector assistant or a surgical assistant. This often leads to a "pollution" of the warehouse, since the disposables are not replaced on the correct shelves or racks. Besides that it often also takes a lot of time before the materials are replaced. They just stand on the corridors for certain minutes or hours.

4.1.3 From the sterile processing department to the operations center (*reusable cycle*)

As already mentioned in the introducing chapter, the sterile processing department decontaminates (cleans, disinfects and sterilizes) reusable medical resources. The consumers or customers of these medical resources are all the departments where medical, paramedical or nursing activities are taking place. One of these customers is the operations center (22 theatres). During each surgery several instrument sets (combinations of instruments) or loose instruments are used. After use, these instruments are collected, placed back in the correct sets, placed in a special cart en finally transported to the SPD. At the SPD, the instruments are decontaminated and then returned to the operations center where they will be stored in a special warehouse until the next use.

The logistical process in the direction of the operations center actually starts at the exits of the autoclaves. An autoclave is a device to sterilize equipment and supplies by subjecting them to high pressure steam at 121° C or more. This sterilization process is the last step in the decontamination process at the sterile processing department. After the sterilization the instruments (loose and sets) are placed in special carts and transported to the elevators (the rising point).

Downstairs, at the basement, the carts are picked up by an employee of the internal logistical department of the UMCG. He or she places the carts in a row and transports the carts from the rising point at the sterile processing department to the rising point at the operations center. From here it is the responsibility of the logistical employees of the operations center to transport the different goods to the warehouses.

Every week there is one person responsible for the transport between the SPD and the operations center. These tasks are then also considered as day tasks; the responsible employee is not executing other tasks during the day. The transport frequency between the SPD and the

operations center, in the way it currently is arranged, can thus be considered as very high. Without an addition of extra employees it is not possible to increase the transport frequency.

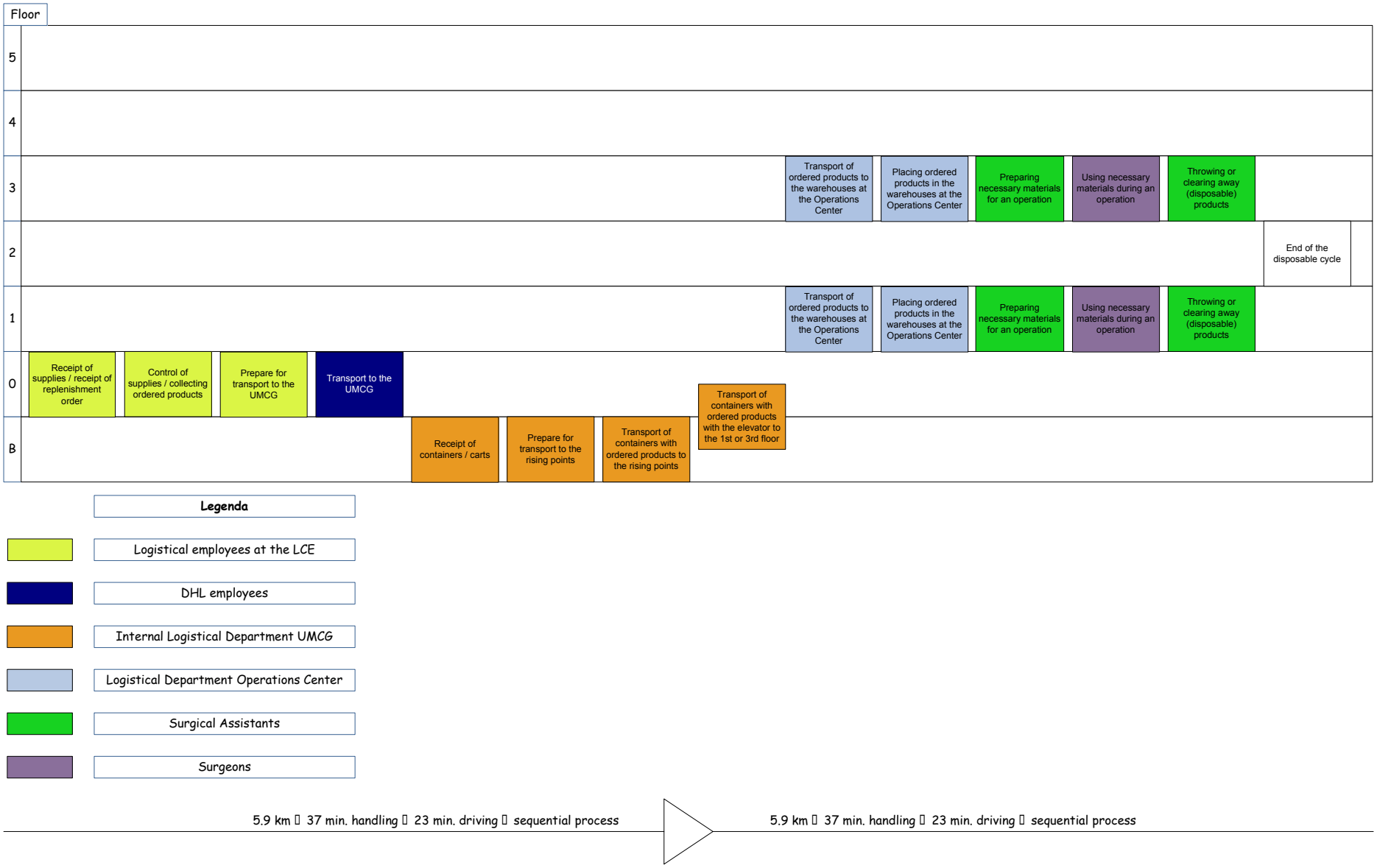


***Figure 27**, Process map of goods flow from the LCE to an operation room*

The transport between the sterile processing department and the operations center is based on a special developed time schedule (*Appendix Book XI*). In contrast to the window times used for the transport between the goods-receipt point and the operations center, this are fixed times. When there are no carts present at the rising points, there will be no transport in the direction of the operations center. This means that in some occasions the necessary instruments are not transported to the operations center.

The corridor from the sterile processing department to the rising point at the operations center has a length of around 0.9 kilometres. The Still tractors are driving with a speed of 13 km/hr which means that in normal circumstances the distance can be covered in approximately 4.1 minutes.

After usage in an operation room, the loose instruments and instrument sets are put back in the special carts. The carts are transported to the rising point at the operations center, from where they are transported to the sterile processing department. Here the decontamination process starts all over again.

The logistical process between the sterile processing department and the operations center and the involved persons and departments is presented in figure 28. This figure shows that in total five different persons or departments are involved in the logistical process between the sterile processing department and the operations center. Besides that, the figure also shows that the different transports are taking place on the first, third and fifth floor and in the basement.

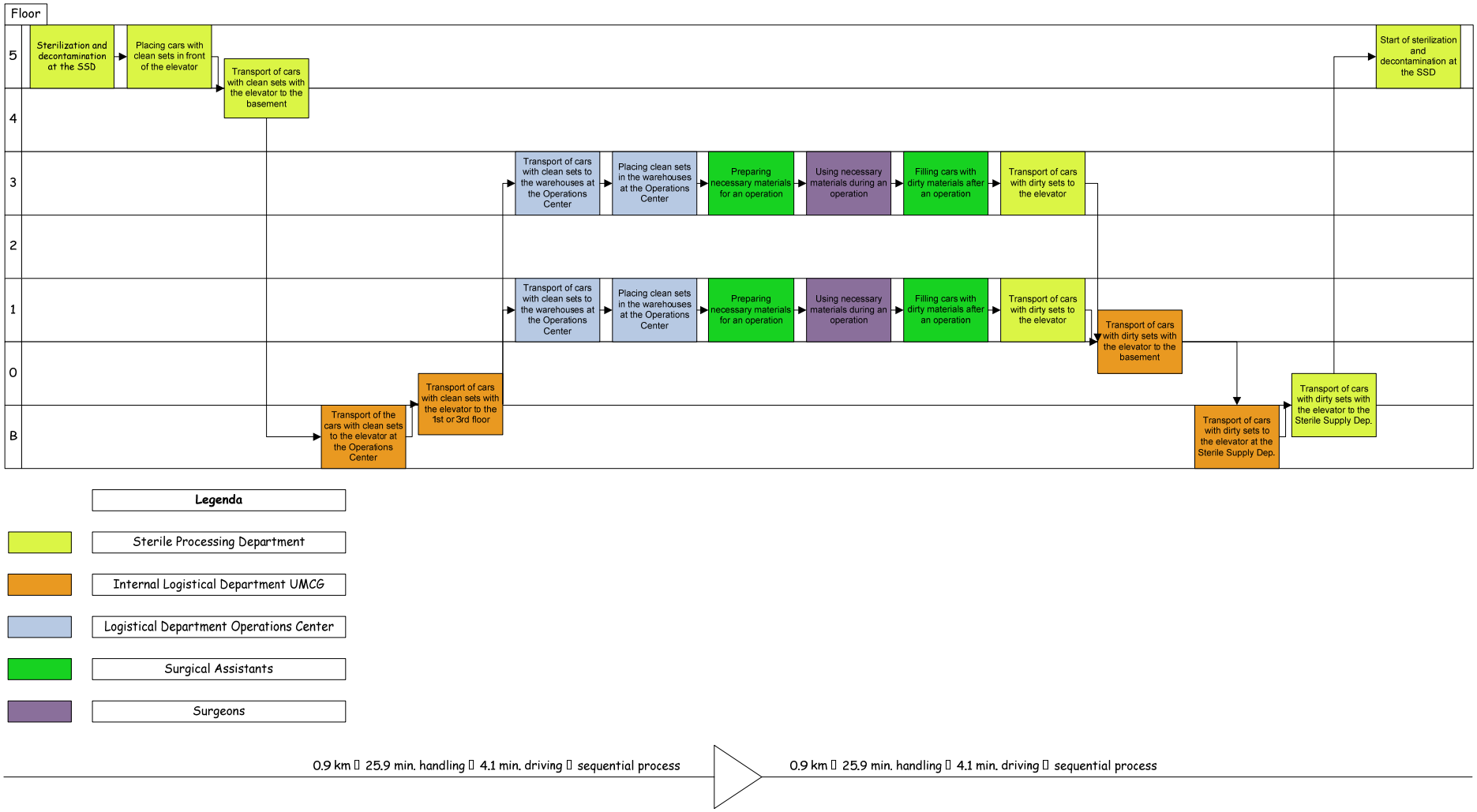


***Figure 28**, Process map of goods flow from the SPD to an operation room*

4.1.4 Instrument sets on loan (*the set on loan cycle*)

A special logistical process in the direction of the operations center is the process of instrument sets on loan. Instrument sets on loan are sets that are hired from the supplier because they are not in stock at the UMCG. These instrument sets are not in stock because they often are too expensive and/or they are not often used. The instrument sets on loan are following the disposable circle and the reusable circle (figure 29).

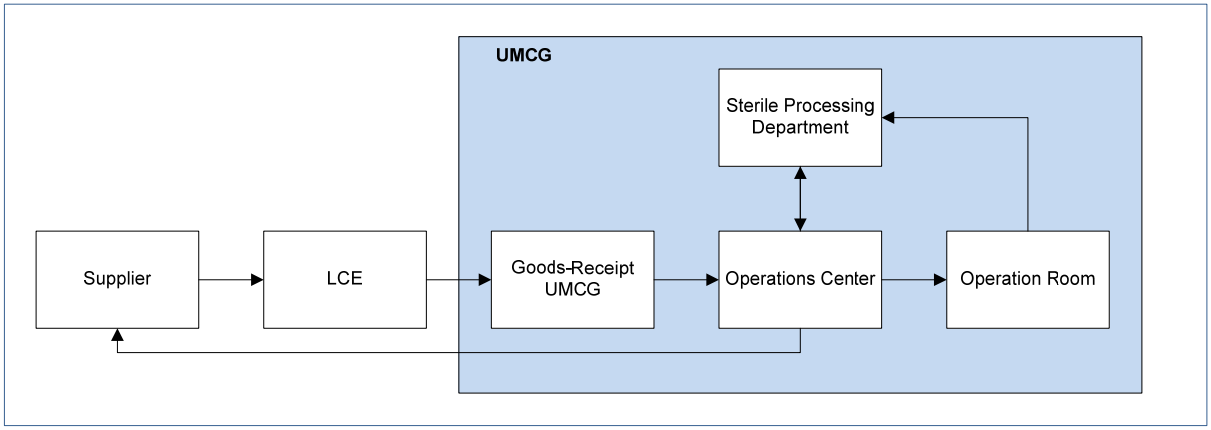


Figure 29, *The set on loan cycle*

The logistical process of an instrument set on loan starts with filling in a paper application form by the appealing department. This paper form is handed over to an employee of the logistical department operations center. The manager of the logistical department operations center then phones to the purchasing department for an order number for the application form. The application of an instrument set on loan namely is a so called "status 18 application". A status 18 article is an article that is on loan or on view by a supplier. During or preliminary to a surgery the surgeon decides what item is necessary for a specific surgery. The items that are not used are returned to the supplier. The final invoice then only is based on the used item including the shipping costs. Because it preliminary to the surgery is not known which item is used, an empty order is created. The application form of the appealing department is assigned with the order number which corresponds to the created empty order. The manager of the logistical department operations center then orders the set on loan at the supplier.
The set on loan enters the logistical process when it is delivered by the supplier at the LCE. Here the set is transmitted to the appealing department based on the order information on the packages. Because it is a status 18 appeal, it is not possible to discover the content of a package or the information of the appealing department (in case this is missing or not right). The package is just blindly transmitted.
When the set on loan enters the operation center it is received by the logistical department operations center who will deliver the package to the appealing department. The department then transmits the package, when necessary to the sterile processing department. Here the set is decontaminated and returned to the operations center, where it is stored in one of the warehouses.
When the set on loan is used during a surgery, the sticker with the bar code of the set is removed from the packaging and placed on the application form. During or after a surgery, the paper application form is deposited in a special box at the reception of the operations center. A few times a day one of the employees of the logistical department of the UMCG empties this box and takes the forms away to his office. Here he will copy the form and sends it to the purchasing department. The used set and the remains of the set on loan are then (when necessary after a decontamination process at the sterile processing department)returned to the supplier who will

send an invoice based on the used items. This invoice can be compared to the application form to check whether the right items are billed.

4.1.5 Ownership of the different sorts of medical resources

Although all the different medical resources are used to execute the care processes at the UMCG, there are different owners of these medical resources. Three different owners and owned materials can be distinguished:

- Sterile processing department: the sterile processing department is the owner of all the standard instruments and instrument sets (reusables). These standard instruments and instrument sets are used by all the different departments and specialisms
- Operations center: the operations center is the owner of all the standard disposables. These disposables are used by all the different departments and specialisms
- Individual specialisms: the individual specialisms are the owner of all the disposables and reusables that are specially purchased for executing surgeries of these specialisms. These materials are only used by the individual specialism.

Because there are different owners of the used products, there also are overlaps at the strategic and tactic purchasing of the materials. A part of the strategic and tactic purchasing is executed by the purchasing department, but an unknown part is also executed by the manager of the logistical department operations center. These processes interfere with each other and the purchasing department has the feeling that the manager of the logistical department operations center is working inside their scope. The consequence of this situation is poor communication between the concerned departments, unexpected changes in the assortment (for the care related employees) and identical products of different suppliers.

The purchase price of new products is paid by the purchasing department. This means that the sterile processing department pays the purchasing costs of standard reusables, the operations center pays the purchasing costs of standard disposables and an individual specialism pays the purchasing costs of specific reusables and disposables. The stock carrying costs however are paid by the UMCG. These are not charged to the purchasing department. This means that there is no incentive to keep the amount of stock as low as possible.

4.1.6 Insight into the different logistical processes

When regarding the different logistical processes in the direction of an operation room, it is very important that there always is a high insight into the different logistical process steps. This means that the customer should always be able to trace the location and amount of stock of ordered or necessary materials.

Figure 30 shows the current insight into the three different logistical cycles in the direction of an operation room. The figure shows that at this moment it only is possible to trace the location of reusable instrument and instrument sets at the sterile processing department. At all the other different parts of the cycles, it is not possible to trace the location and amount of stock of materials.
All the different instruments and instrument sets that flow through the sterile processing department are labelled with a bar code. Before the start of each of the four different decontamination steps, the bar code is scanned. This first of all generates a great amount of management information but also provides a possibility to trace the location of a particular instrument and/or instrument set. This location is visible in the used information systems. Process steps after the sterile processing department cannot be traced. The then visible

"location" is *SPD out*. This however can mean that the particular instrument or instrument set is transported to the operations center, waiting at the raising point at the operations center, stocked in a warehouse, stocked in a prepared surgical cart, used during a surgery, stocked in a SPD cart after a surgery or transported back to the SPD.

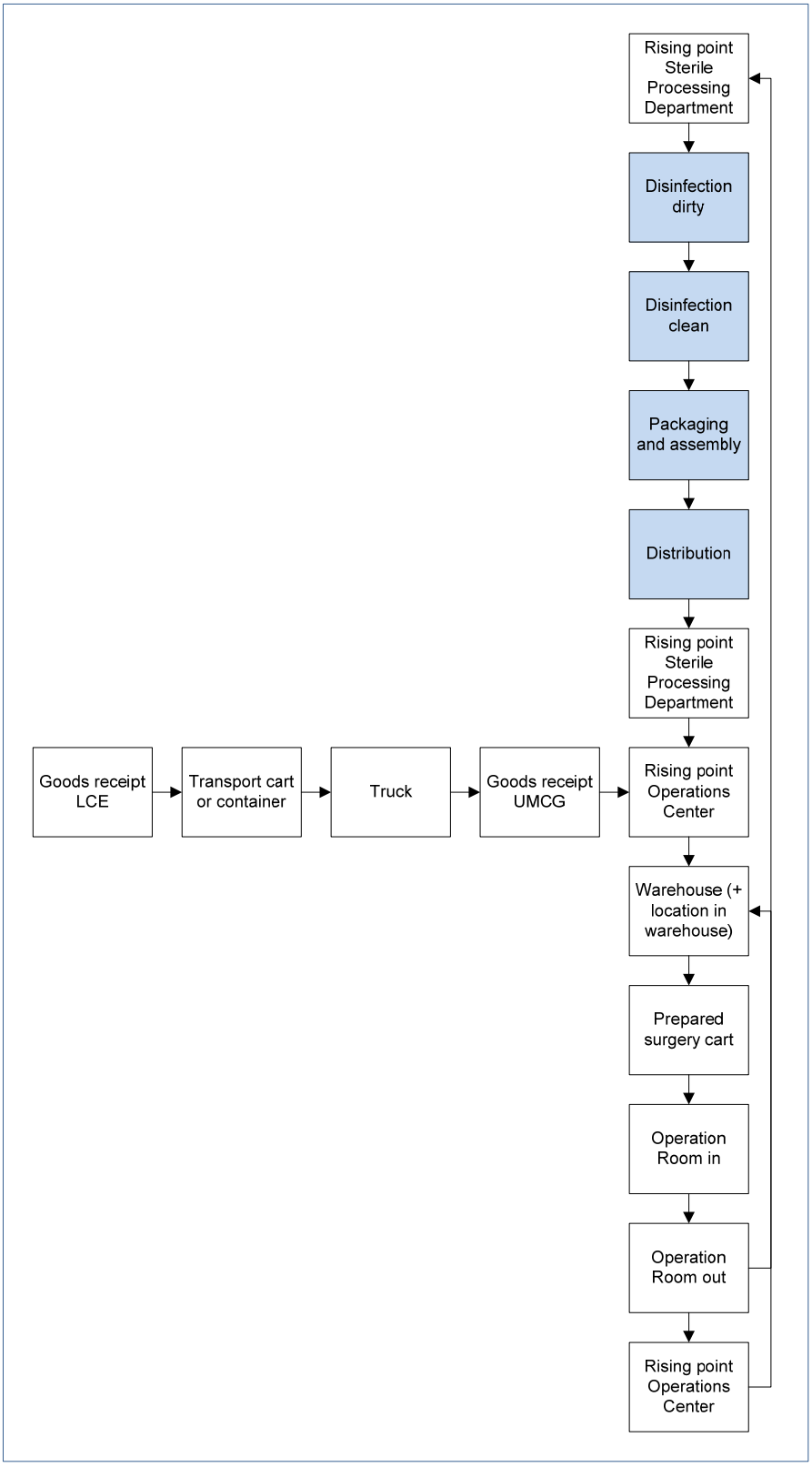


***Figure 30**, Insight into the different logistical processes*

The used information systems at the reusable cycle are CS-Steriel and OK-plus. CS-Steriel is a special system for sterile processing departments and OK-plus is a special system for operation centers/rooms. Both systems are connected to each other which means that employees of the SPD can search for relevant information in OK-plus and vice versa. Both systems also are produced by the same software producer (Chipsoft).

Besides the bar code scanning, the sterile processing department also uses paper labels which are attached to each instrument and instrument set (figure 31).

***Figure 31**, The used paper labels*

The blue labels are attached to every instrument and instrument set. They serve as current mode of identification, so it always is possible to trace which employees (from the sterile processing department and during a surgery) have used the particular instrument or instrument set. It is also used because instruments and instrument sets are not scanned during surgeries. Data that must be recorded is:

- By SPD employees:
  - Date and time
  - Set number
  - Name of employee
  - Possible comments
- By surgical assistants:
  - Date, time and OR number
  - Set number
  - Name of employee
  - Possible comments

Besides the blue labels, also red labels are used. These labels are attached to an instrument or instrument set when it shows defects. When for example elements are missing, elements are defect or need maintenance this can be written down on the red label. Employees of the sterile processing department then notice this when they receive the used instruments and instrument sets. A great disadvantage of these paper labels is they are easily spotting.

4.1.7 Involved persons and departments in the logistical processes in the direction of the OC

Table 17 shows that different persons and departments are involved in the logistical processes in the direction of the operations center. The most outstanding departments are the internal logistical department UMCG and the logistical department operations center. Although both departments are executing the same tasks, two different departments were created. The logistical processes *in and around the UMCG* are executed by the internal logistical department UMCG. This department is responsible for all the logistical tasks in the UMCG with the exception of the logistical tasks at the operations center. The logistical processes *at the operations center* are executed by the special logistical department operations center.

1	Logistical employees at Logistical Center the Eemspoort
2	DHL employees
3	*Internal Logistical Department UMCG*
4	*Logistical Department Operations Center*
5	Surgical Assistants
6	Surgeons
7	Sterile Processing Department employees

***Table 17**, Involved persons and/or departments in the logistical process in the direction of the OC*

The two departments are not only responsible for different elements of the logistical process in the direction of the operation room, they both also have a different position in the organization chart of the UMCG. This means that different persons are responsible for the total logistical process. As can be seen in figure 1, the manager of the operations center is responsible for the logistical department operations center and thus for the organization of the logistical processes at the operations center. Figure 32 shows that the manager of the logistical cluster is responsible for the internal logistical department UMCG and thus for the organization of the remaining logistical processes in the UMCG. The figure also shows that the internal logistical department UMCG can be further subdivided in three different departments (distribution, warehouses and logistical management).

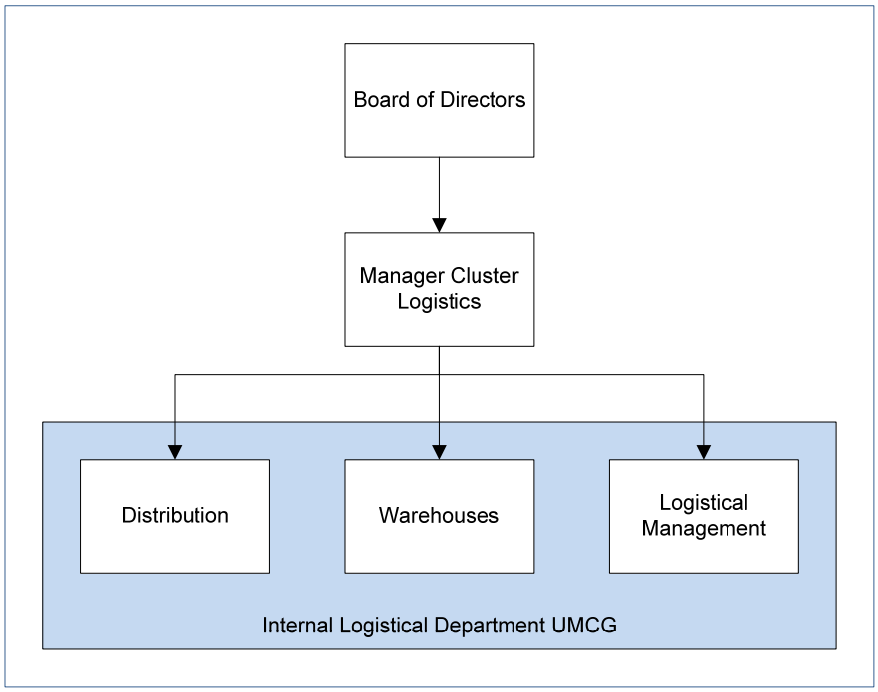


***Figure 32**, Organization chart of the logistics at the UMCG*

4.1.8 Sub conclusions

Based on the presented results in this paragraph about the current organization of the logistical processes in the direction of an operation room we can conclude that three different sorts of medical resources and thus also three different logistical processes can be distinguished. Each logistical process consists of several process steps whereby great distances and also different floors are crossed. At each process also different persons and departments are involved. The limited amount of supply rounds, suboptimal loading of containers, not attaching opening hours, lack of signals and lack of transfer of information all are indications that the different persons and departments are operating in functional silos with mainly an internal focus. This lack of an external focus results in a suboptimal organization of the logistical processes and a suboptimal division of tasks. This is especially visible in the current division of ownership, the existence of two different but actually identical logistical departments and the quality of the insight in the different logistical processes.
It currently first of all is not clear who is the owner of a certain product. Three different departments share the responsibility for the total assortment of materials and instruments. Since the different owners are not responsible for the inventory costs of their owned products, there also is no incentive for the different owners to reduce the amount of stock. This has lead to high inventories and a great amount of warehouses.
The exact height of the inventory however is not known and not visible. It currently only is possible to trace the amount – and the location of materials at the four process steps of the sterile processing department. At all the other described process steps it is not possible to trace the amount – and the location of necessary or ordered materials and instruments.
A final example of the suboptimal organization of the logistical process is the existence of two different logistical departments with identical tasks but with different positions in the UMCG organization chart. This has resulted in a lack of communication between the two departments and different investments and developments.

We finally can conclude that it looks like the different materials and instruments, which were the ultimate focus of this research, are not flowing optimally through the different logistical processes. It is obvious that this has great consequences for the costs, speed and quality of these processes. These consequences will be made visible in the subsequent paragraphs.

4.2 How great are the interdependencies between the different involved persons and departments?

As already was discussed in chapter 2.4.1.1.1, the interdependency between persons, departments and organizations can be classified in three different categories: pooled, sequential and reciprocal. When categorizing the interdependency between persons, departments and organizations, the generally used variable is the sequence of activities that forms the researched process. Based on a detailed overview of the sequence of activities, it is possible to classify the interdependency between persons, departments and organizations.

The sequence of activities that form the logistical processes in the direction of an operation room were already described in the preliminary paragraph. Here it was possible to see that seven different persons and/or departments form part of the logistical process. The figures furthermore showed that, *on paper*, this process can be categorized as a sequential process. When interdependence is of sequential form, parts produced in one department become inputs to another department. Although there are no products produced in this process, disposables and reusables that are processed by a certain employee or department (in combination with required information) become input to the subsequent department.

The words *on paper* already indicate that it is possible that particular occasions lead to a different functioning of the process, creating other interdependencies. Table 18 shows the seven main categories of these particular occasions. The consequence of these occasions is an emergency appeal for a specific product. In case of an emergency appeal the sequential organization of the logistical process is released. The outputs of the different persons and departments now influence the concerning persons and departments in reciprocal form. The amount of emergency appeals can thus be regarded as a clear indication of the current quality of the organization of the logistical process in the direction of an operation room.

1	Late request / confirmation of products by departments
2	Shortage in the warehouses
3	Irregular usage of products (also shortages)
4	Appeal of products to long at purchasing department
5	Crossed delivery period by supplier
6	Part due to (emergency) repairs of products
7	Patient committed products

***Table 18**, Different causes of emergency appeals*

Since three different sorts of products can be distinguished, also three different sorts of emergency appeals can be distinguished:

- Emergency appeals for non stock items (disposable circle)
- Emergency appeals for stock items (disposable circle)
- Emergency appeals for reusable items (reusable circle)

4.2.1 Emegency appeals for non stock items (*disposable cycle*)

The non stock items are products that are not regularly used and/or products with a high purchase price that are not in stock at logistical center the Eemspoort. Because of the different mentioned causes in table 18 it is possible that an emergency appeal for a non stock item is placed. The attended procedure in case of an emergency appeal for a non stock item is:

1. Logistical department operations center phones the purchasing department that a non stock item is necessary for a (coming) surgery

2. The purchasing department orders the concerning non stock item at the supplier
3. The purchasing department informs the LCE that a non stock item will come in
4. The non stock item is taken out of the truck of the supplier or courier, distinct treated and send to the UMCG with the next delivery round
5. Within 4 hours (after arrival at the UMCG) the item is delivered at the concerning department
    a. In case of high emergency, the item can be delivered with CE Couriers within 30 minutes at the concerning department

As already presented, there are different reasons for an emergency appeal of a non stock item. Some of these reasons are preventable, others are not preventable. Because not all the emergency appeals are preventable, the UMCG has set standards for these situations. The used standard is *250 emergency appeals* for non stock items per quarter of a year. The amount of emergency appeals and the reasons for an emergency appeal are registered by the purchasing department.

Table 19 and figure 33 present the amount of emergency appeals over the last eight years. The table shows that until 2004 the UMCG was capable to stay within the boundaries of 250 emergency appeals per quarter of a year or 1000 emergency appeals per year. The year 2005 however suddenly shows an increase of 521 emergency appeals to an amount of 1421 emergency appeals. This amount slowly decreased during the following two years, but shows again a reasonable increase in 2008 to an amount of 1429 emergency appeals. This means an *exceeding of the yearly standard with 429 emergency appeals.*

Year	Amount of emergency appeals
2001	700
2002	600
2003	700
2004	900
2005	1421
2006	1400
2007	1372
2008	1429

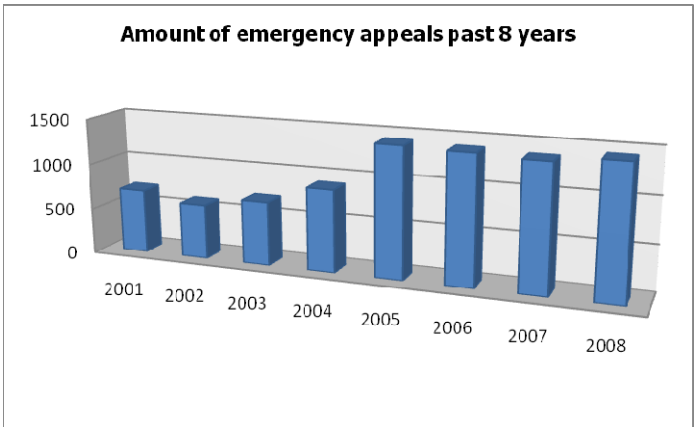


Table 19 *and* ***figure 33****, Amount of emergency appeals over the last eight years*

Table 20 and figure 34 split the amount of emergency appeals per year in the amount of emergency appeals per quarter of a year. The table shows a remarkable outlier in the fourth quarter of 2005. It besides that also shows a climbing trend in the amount of emergency appeals.

Year	Amount
1Q05	281
2Q05	322
3Q05	317
4Q05	501
1Q06	360
2Q06	343
3Q06	302
4Q06	396
1Q07	367
2Q07	375
3Q07	305
4Q07	325
1Q08	362
2Q08	381
3Q08	324
4Q08	362

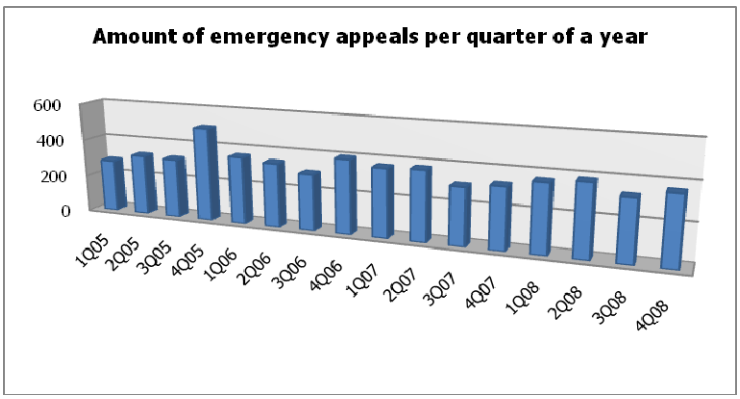


Table 20 *and* ***figure 34****, Amount of emergency appeals per quarter of a year over the last eight years*

The causes of the emergency appeals in the four quarters of 2008 are combined in table 21 resulting in the division of the causes of the emergency appeals in 2008. This table confirms the picture of the tables in *Appendix Book XII*. The most important causes of an emergency appeal are the late request by the appealing department (39%) and the irregular usage of products (25%). The tables finally also show a large category of emergency appeals that cannot be specified. This means that the cause of an emergency appeal is unknown or that the cause does not fits in one of the other seven categories. Some of these not specifiable causes however do have a comment in the raw data overview. A summary of these comments is presented in *Appendix Book XIII*. The most mentioned comments are:

- Wrong product ordered
- Order did not reached the supplier in time
- Wrong delivery by supplier
- Recall of product
- Emergency appeal is missing
- Alternative supply
- Problems with current stock
- Product got lost at the logistical department operations center
- Crossed delivery date by supplier
- Temporary not deliverable product

Based on these comments the conclusion can be made that the problems often are due to wrong ordering of products, problems at the supplier and problems at the logistical department operations center.

1	Late request/confirmation by appealing department	555	39%
2	Shortage in the warehouses	33	2%
3	Crossed delivery period by suppliers	61	4%
4	Irregular usage of products	360	25%
5	Appeal to long at purchasing department	23	2%
6	Patient commited product	132	9%
7	Part due to emergency repair	36	3%
8	Remaining, not possible to specify	228	16%
		1428	

***Table 21**, Causes of the emergency appeals over 2008*

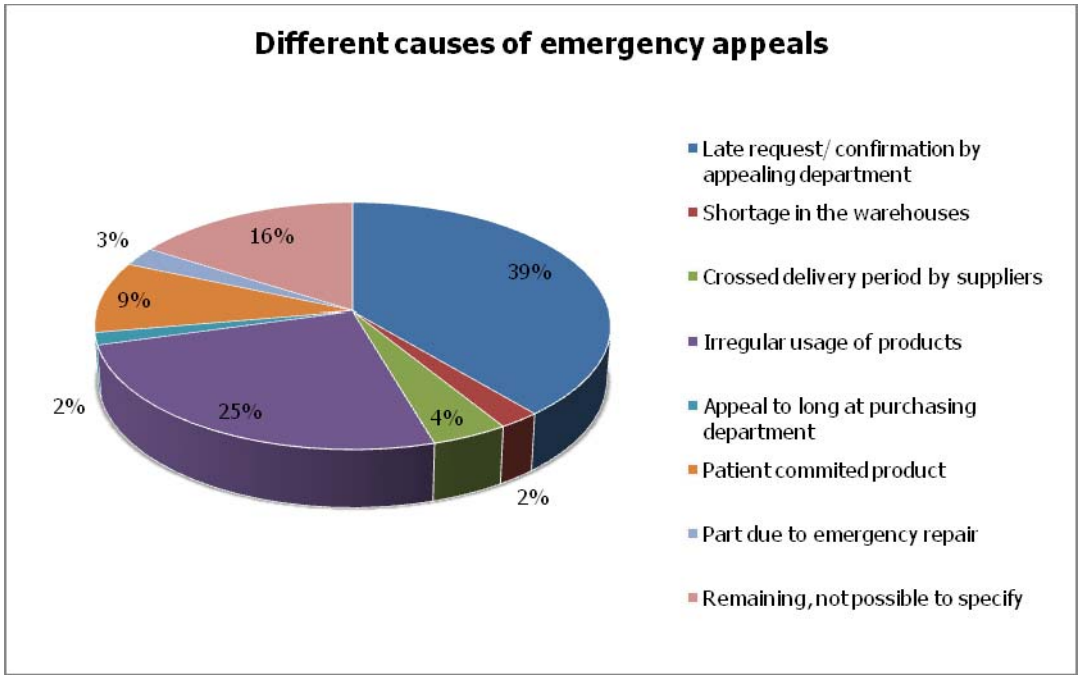


***Figure 35**, Causes of the emergency appeals over 2008*

The different tables and figures clearly show an elaborate exceeding of the yearly standard during the last four years. Although this already is a poor picture, it becomes even worse when the amount of emergency appeals is expressed in monetary values. Table 22 shows the carrier costs which are the result of an emergency appeal for a non stock item during the year 2008. The table shows the costs of only 117 emergency appeals. It unfortunately was not possible to find the carrier costs of all the emergency appeals over 2008. This because of:

- Some emergency appeals are delivered within the stated time-limit without extra carrier costs
- Some suppliers will not calculate extra carrier costs in case of an emergency appeal
- Often, the carrier costs of an emergency appeal are not noticed and recorded as normal transport costs
- Articles are stated on an emergency list but are not an emergency supply of a supplier but are on the list to support the internal emergency procedures

Table 22 shows that the total courier costs of the 117 found expenses are €28.589,91. This means that the average courier costs of an emergency appeal are *€244,36* with a standard deviation of *€169,63* (whereby the outlier of €5355,00 is omitted during the calculation).

Although the presented carrier costs are not complete and hundred percent reliable, it is possible to use the information to create a picture of the size of the total carrier costs over 2008. This picture is also presented in table 22. The table shows that the possible total carrier costs over 2008 are around €348.943,52. Because it was and is not possible to find all the expenses, this picture (as already indicated) is not totally reliable. It however is possible to indicate that the real amount of carrier costs is above the indicated amount of €28.589,91.

N	117	1428
Σ	€ 28.589,91	€ 348.943,52
μ	€ 244,36	€ 244,36
σ	€ 169,63	€ 169,63

***Table 22**, Costs of emergency appeals over 2008*

An overview of the found 117 emergency appeals is presented in *Appendix Book XIV*.

4.2.2 Emergency appeals for stock items (*disposable cycle*)

The stock items are products that are regularly used and/or products with a low purchase price that are in stock at logistical center the Eemspoort. The main reasons for emergency appeals for stock items are:

- Ordering too less
- Ordering too late
- Ordering wrong products
- Poor stock turnover control

All the reasons are the consequence of poor logistical management.

The attended procedure in case of an emergency appeal for a non stock item is:

1. Logistical department operations center phones the service line (12345) that a stock item is needed with great speed
2. The service line informs logistical center the Eemspoort
3. The LCE takes care that the needed article is at the concerning department within 4 hours
    a. In case of high emergency, the item can be delivered with CE Couriers within 30 minutes at the concerning department

Table 23 presents the amount of emergency appeals over the first six months of 2009. The table shows a total of 29 emergency appeals for 35 different products. In total 7040 products with an average cost-price of €0.88 and a total cost-price of €6179.14 were transferred from the LCE to the operations center.

N appeals	29
N products	35
N elements	7040
Costs	€ 6.179,14

***Table 23**, Emergency appeals of stock items*

Appendix Book XV presents an overview of the found 29 emergency appeals for stock items.

Normally, the ordered products are delivered with the normal supply rounds, which means that no extra costs are incurred. In situations with high emergency, the products are delivered by CE Couriers which costs an unknown amount of money. It unfortunately was not possible to discover the amount of emergency appeals delivered by CE Couriers.

4.2.3 Emergency appeals reusable items (*reusable cycle*)

Besides emergency appeals for stock – and non stock items (disposable items), there also are emergency appeals for reusable items. Reusable items are instruments or instrument sets that move through the reusable cycle between the operations center and the sterile processing department. There are different reasons for emergency appeals for reusable items:

- Emergency accidents
- Uncertainty reduction
- No more instruments or instrument sets in stock
- Wrong planning (planning of more surgeries than available instruments or instrument sets)

The first reason is a *force majeure*, but the second, third and fourth reason are the consequence of poor logistical management.

There are two different emergency procedures that can be followed.

- An order (*Dutch: bestelling*)
- An emergency (*Dutch: spoedorder*)

An order is a telephonic appeal for a certain instrument or instrument set because employees notice a low amount in the warehouses or they want to be sure that the instrument or instrument set is available for the next surgery (sometimes next day). The ordered instruments or instrument sets receive priority during the decontamination process but will be transported to the operations center by normal transport on the agreed moments.
An emergency is a telephonic appeal for a certain instrument or instrument set because it is immediately needed. These instruments or instrument sets receive high priority during the decontamination process. This means that they have priority above all the other instruments. After the decontamination process, the instrument or instrument set is transported to the operations center as quickly as possible by one of the employees of the sterile processing department.
Appendix Book XVI shows the emergency appeals over the end of 2007, 2008 and the beginning of 2009. The table shows 344 emergency appeals over the last 13 weeks of 2007, 1140 appeals over 2008 and 217 emergency appeals over the first 9 weeks of 2009.

Table 24 further shows the average emergency appeals per week. The table shows an average of 26.46 appeals per week over 2007, 21.92 per week over 2008 and 24.11 per week over 2009. It is important to realize that the data of 2007 and 2009 are not as reliable as the data of 2008 because of the limited amount of available data.

	Σ	μ
2007	344	26,46
2008	1140	21,92
2009	217	24,11
Total	1701	

***Table 24**, Average emergency appeals of reusable items per week*

Because the sterile processing department is also registering the appealing department, it is possible to split the total amounts per year and week in total amounts per department per year. Table 25 shows that the orthopedic department (23.3%), the neurology department (15.3%) and the thorax department (9.4%) are the most appealing departments.

Department	Σ	%
Hanze Vision	5	0,3%
ODBC	100	5,9%
Other	90	5,3%
OZO Unknown	32	1,9%
Sector 1 – THO	160	**9,4%**
Sector 2 – KNO	82	4,8%
Sector 2 – MHK	146	8,6%
Sector 2 – NEU	261	**15,3%**
Sector 2 – OHK	40	2,4%
Sector 2 – ONC	30	1,8%
Sector 2 – PLA	97	5,7%
Sector 3 – ALG	116	6,8%
Sector 3 – GYN	12	0,7%
Sector 3 – ORT	397	**23,3%**
Sector 3 – TRA	104	6,1%
Sector 3 – URO	11	0,6%
Sector 3 – VAA	18	1,1%
Total	1701	100%

***Table 25**, Amount of emergency appeals per department*

Table 26, shows the total appeals per sector. The table shows that the amount of appeals of sector 2 and 3 is almost the same. The amount of appeals of sector 1 is much lower.

	Σ	%
Other	227	13%
Sector 1	160	9%
Sector 2	656	39%
Sector 3	658	39%
Total	1701	

***Table 26**, Amount of emergency appeals per sector*

Table 27, finally, shows the division between the amount of orders (*bestelling*) and emergencies (*spoedorders*). The table shows a total of 140 or 12% emergencies in 2008 and a total of 26 emergencies or 12% in 2009.

Year	N emergencies	N orders	Σ	% emergencies
2008	140	1000	1140	12%
2009	26	191	217	12%

***Table 27**, Amount of orders and emergencies*

Based on interviews with employees of the logistical department operations center, who receive the appealed instruments and instrument sets, it can be concluded that it often are the same instruments and instrument sets who need an emergency appeal. There are only a few of these items, but the surgeries that need these items are planned very often. This means that certain items often need an emergency appeal to be available again for the subsequent surgery.

4.2.4 Sub Conclusions

Based on the discussion in this paragraph about the extent of the interdependencies between the different involved departments, we can conclude that the current interdependency is not of sequential (as it was *on paper*) but of reciprocal form. The great amount of emergency appeals for stock items, non stock items and reusable items indicate that the current organization of the logistical process, as was already stated in the first paragraph, is of suboptimal form. The great amount of involved persons and departments, the great distances, great amount of transfers (of information and materials) and the low quality of the insight are, among others, responsible for this great amount of emergency appeals. This leads to a great amount of telephone calls, orders, conversations and meetings with persons and departments upstream and downstream in the logistical process. The eventual consequences are extra costs (inventory, couriers), extra required time (postponement of surgeries) and a decrease of the quality of the delivered care (forced usage of other materials).
The main conclusion of the presented results in this paragraph can be that the current structure and organization of the different processes in the direction of an operation room are not adjusted to the characteristics of the logistical process. A sequential process with frequent interactions demands, among others, for horizontal communication and locating units close together. This all is missing in the current organization. It furthermore is striking that the UMCG more or less has accepted the current situation. This is visible in the used standard of 250 emergency appeals per month (or 1000 emergency appeals per year). Taking into account the high (courier) costs of an emergency appeal, the UMCG thus accepts that it "looses" tens of thousands of Euros per year because of a suboptimal organization of the logistical function.

Now we have concluded that the structure and organization of the different processes in the direction of an operation room are not adjusted to the characteristics of this logistical process, we will zoom in on the current transition point from logistical tasks to care related tasks (the surgical assistant function) and present what the effects of the poor organization are for the surgical assistants and the costs, speed and quality of the delivered care.

4.3 How great is the task diversity of a surgical assistant and what are the consequences of placing the transition point at this function?

As already mentioned in the theoretical framework of this research, "transferring the maximum amount of tasks and responsibilities to those workers actually adding value is an important part of the reengineering philosophy. Process reengineering is not only a hard philosophy that changes structures, processes and tasks, but also a soft HRM philosophy that directly alters the feelings of employees. The movement to a new logistical structure cannot be made without an understanding of how workers and processes currently operate. This especially applies to the surgical assistant function. In a time where demand for surgical assistant resources far exceeds the available time, it is critical that this function is set free of as many non-patient care tasks as possible. By freeing them from for example logistical tasks, they can spend more time at their core tasks: delivering care. This maximizes both clinician time and is a major component in improving nursing satisfaction and the quality of the delivered care.

As can be seen in figure 27 and figure 28, the activities of the surgical assistants are the point in the logistical process in the direction of an operation room where logistical tasks cross over to care related tasks (*the transition point*). In the current organization of the logistical process, different logistical tasks are part of the daily work of surgical assistants. The consequences for the surgical assistants are a great amount of logistical – and care related tasks with a high responsibility that must be executed in a limited amount of time. Out hypothesis is that this has a great influence on the health and happiness of the surgical assistants and on the quality, speed and costs of the total surgical process.

This chapter will present the general work - and the influence of the great amount of different tasks on the health and happiness of the surgical assistant. The general work of a surgical assistant will be described with the help of the MDWS technique. Since the surgical assistant is responsible for a reasonable amount of logistical tasks, we also have studied the extent of these non care related tasks. We have researched the amount of times a surgical assistant leaves the operation room, the amount of door movements of an operation room and the average materials preparation time. This chapter ends with a presentation of the results of our research towards the opinion of the surgical assistants concerning the current organization of the logistics at the operations center. Based on the results of this paragraph we can conclude what the consequences are of the current organization of the surgical assistant function and what the consequences are of placing the transition point at this function.

4.3.1 General Work of Surgical Assistants measured using MDWS

When we review the four different tasks of surgical assistants at the UMCG (as described in *Appendix Book XVII*), it is obvious that there are great differences in the content of the different tasks. The assisting and instrumenting tasks totally exists of care related activities. The assisting and instrumenting surgical assistants stand next to the table during the entire surgery (except swaps) and have one primary task: assisting and instrumenting the surgeon. There are no other activities that they are allowed to execute. This mainly has to do with the fact that during a surgery they are not allowed to step outside the sterile area around the surgical table.
When we review the walk around task at the UMCG, we can conclude that the current organization of this function comprises different activities. Besides the care related activities of extending extra materials to the surgeon and operating different machines and computers, the task also comprises logistical related activities as laying out materials, collecting instruments from the warehouses (when they are missing during a surgery), filling the stock of the disposable cart in

the operation room, preparing the necessary materials, monitoring stock in hand at the warehouses and different logistical administrative tasks.

To be able to examine whether the logistical related activities of the walk around tasks influence the care related activities, different measurements were executed. We first of all analyzed the current tasks and activities of a surgical assistant (walk around task) with the multi-dimensional work sampling technique. With the help of this technique it was possible to determine the main activities of a surgical assistant. Table 28 shows that in total 1498 activities were recorded with the help of the MDWS technique. The total duration of the measurement was 255.25 hours.

Items	Measures	Σ	μ	%	σ	T (hrs)
Executing and directing Time Out Procedure		52	1,6	3%	0,5	7,66
Preparing materials and OR		141	4,3	9%	2,1	22,97
Administration		114	3,5	8%	1,7	20,42
Handing requirements to "*instrumenterende*"		70	2,1	5%	1,8	12,76
Waiting (for work)		420	12,7	28%	3,9	71,47
Clearing up OR after a surgery		81	2,5	5%	1,4	12,76
Other tasks inside an Operation Room		353	10,7	24%	4,9	61,26
Subtotal tasks inside an Operation Room		1231	37,3	**82%**	6,2	209,31
Logistical tasks		40	1,2	3%	1,2	7,66
Other tasks outside an Operation Room		37	1,1	2%	1,2	5,11
Break		190	5,8	13%	1,5	33,18
Subtotal tasks outside an Operation Room		267	8,1	**18%**	2,9	45,95
Total activities		1498	90,9	100%	6,3	255,25
Total duration of measurement (hrs)		255,25	7,73		1,63	

***Table 28**, General work of surgical assistants (walk around) measured using the MDWS technique*

Table 28 further shows the total amount of activities per item (Σ), the average amount of activities per measurement (μ), the percentage per item as part of all observed activities (%) the standard deviation of the amount of measures activities (σ) and the total duration of each measurement based on the relative percentage and the total duration of the measurements (T). The table shows that in 82% of the observations, the activities were executed inside an operation room. A total of 18% of the activities were executed outside an operation room.

Based on a combination of the data in table 28 it was possible to create table 29 which shows the percentage of care related tasks versus non care related tasks of surgical assistants. The table shows that 62% of the tasks of surgical assistants are care related and that a total of 30% of the activities are non care related. Since it is unknown which part of the administration tasks is care related and which part is non care related, this item is separately presented.

Items	Measures	Σ	%
Care related activities		932	**62%**
Non care related activities		452	**30%**
Administration		114	8%
Total activities		1498	100%

***Table 29**, Percentage of care related tasks versus non care related tasks of surgical assistants (Omloop)*

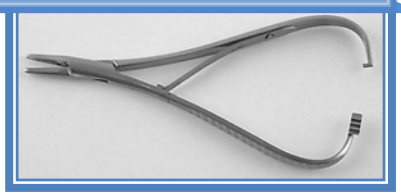
Based on a combination of the data in table 28 it also was possible to create table 30 which shows the percentage of "active" versus "passive" of surgical assistants (walk around, Thorax) measured using the MDWS technique. The table shows that in 59% of the total duration of the measurement the surgical assistants were actively executing tasks. In 41% of the total duration of the measurement they were passive, observing the surgery, checking their email or having social talks.

Items	Measures	Σ	%
Working		888	**59%**
Not working / passive		610	**41%**
Total activities		1498	100%

***Table 30**, Percentage "active" vs. "passive" of surgical assistants (Omloop)*

An important addition to the presented results is that the measurements towards the general work of surgical assistants were executed at Sector 1. This sector has a sector assistant available for a great amount of the logistical tasks. At the other two sectors (Sector 2 and Sector 3), these tasks are executed by the surgical assistants. We therefore expect that the results of the MDWS technique, when executed at Sector 2 or Sector 3, would have been different. We expect a greater amount of *care related tasks* for the *Inside Walk Around* and a greater amount of *non care related tasks* (the greater part is logistical related) for the *Outside Walk Around*.

During a surgery a necessary needle-carrier was not working properly and *one* new needle-carrier needed to be collected *with haste*. The surgical assistant therefore left the operation room to pick up this necessary instrument. A few minutes later she however returned with a complete *instrument set*. Normally these instruments are also individually stocked, but the concerning surgical assistant could not find the requested instrument in the warehouse at the *Thorax shelves*. A present surgical assistant of the Orthopedic department however stated that they had enough individual needle-carriers stocked at the *Orthopedic shelves*. The concerning surgical assistant however was not aware of this possibility. It now unfortunately was too late to pick it up and the entire instrument set therefore was opened. This means that the entire instrument set must be decontaminated again (instead of only one instrument). Besides that, it also is possible that a too little amount of the concerning instrument sets is available for subsequent planned surgeries.



4.3.2 Amount of times out OR

As already mentioned, a surgical assistant with walk around function often needs to leave the operation room for logistical related tasks. To be able to create an overview of the extent of this practice, the amount of times –, duration – and reasons of leaving the operation room were measured. Table 31 presents the results of this study.

Amount of times out OR (N = 39) and average time out OR (N = 30) (*Omloop*)				
Items	Measures	Σ	μ	σ
Amount of times out OR		472	12,1	2,8
Average time out OR (sec.)		2190	73	46,56
Total average amount of time out OR (sec.)		1033680	883,3	

***Table 31**, Amount of times out OR and average time out OR*

The table shows that a surgical assistant on average leaves the operation room for 12,1 times per day. Based on the knowledge that the observed surgical assistants are present at on average two surgeries per day, the average amount of times out OR per surgery is 6.1. Taking into account the average time a surgical assistant is out of the operation room (73 seconds), the total average amount of time out OR for a surgical assistant is 883.3 seconds or 14.7 minutes per day.

Standardized reasons of leaving the operation room (N = 15)			
	%	Tday(sec.)	Tday(min.)
Collecting not present instruments // disposables // other necessary materials	41%	362,2	6,0
Filling Disposables Cart or Surgery Cart	19%	167,8	2,8
Collecting defective instruments // disposables // other necessary materials	11%	97,2	1,6
Short breaks or swaps	14%	123,7	2,1
Other (f.e. administrative)	15%	132,5	2,2
	100%	883,3	14,7

***Table 32**, Standardized reasons of leaving the operations room*

Table 32 subdivides the reasons of leaving an operation room in five standardized reasons. These standardized reasons are based on the different reasons that were given by surgical assistants when they left the operation room. The table shows that surgical assistants leave the operation room on average 6.0 minutes for collecting not present instruments, 2.8 minutes for filling the disposables and/or surgery cart, 1.6 minutes for collecting defective instruments, 2.1 minutes for short breaks (long breaks were not considered) and 2.2 minutes for other tasks. Considering the first three categories as logistical tasks makes it possible to conclude that surgical assistants leave the operation room on average 10.4 minutes per day for logistical tasks and that 71% of the OR leaves is logistical related.

4.3.3 Amount of door movements

Besides the surgical assistants with walk around function, there of course also are other employees walking in and out of the operation room. Table 33 and table 34 show the amount of door movements during Thorax surgeries and Orthopaedic surgeries. Table 33 shows that the average amount of door movements during Thorax surgeries is 33.1 per hour. Table 34 shows that the average amount of door movements during Orthopaedic surgeries is 2.40 per hour. This is a difference of 30.7 door movements per hour.

Specialism	Amount	Amount / hr.
Surgical Assistants	81	15,68
Anaesthesia	39	7,55
Perfusion	36	6,97
Other	15	2,9
Total	171	**33,1**
Total measurement time (min / hr.)	310	5,17

***Table 33**, Amount of door movements (Thorax)*

Specialism	Amount	Amount / hr
Surgical Assistants	5	1,00
Anaesthesia	7	1,40
Perfusion	0	0,00
Other	0	0,00
Total	12	**2,40**
Total measurement time (min / hr)	300	5,00

***Table 34**, Amount of door movements (Orthopaedics)*

The most important reason for this difference is that there are guidelines concerning the amount of door movements at Orthopaedic surgeries and that there are no guidelines concerning the amount of door movements at Thorax surgeries. During these operations employees walk into the operation room for social talks, checking out the progress of a surgery, unstructured swaps and executing logistical tasks without taking into account the sterile environment and patient safety.

A surgery is on beforehand planned as a replacement of the heart valves. During the surgery it however turned out that the heart valves were properly functioning and that a bypass surgery (with the radialus) would be a better solution. This last moment change of plans meant that different reusables and disposables were needed. A great part of the present materials namely only is used for replacement of heart valves. The surgical assistants therefore needed to leave the operation room to collect the necessary materials for a bypass surgery. Since they were not fully aware of the requirements and the locations of these requirements, it took a very long time and many door movements before all the materials were collected. Since the surgical assistants with walk around function had to collect the required resources, there were long periods that no walk around surgical assistants were present in the operation room.

4.3.4 Average materials preparation time

An important element of the current work content of surgical assistants is the preparation of the necessary materials for a surgery. In the current organization of the logistical processes at the operations center, the surgical assistants (or sector assistant at Sector 1) are responsible for these preparations.

Table 35 shows the average materials preparation time of the sector assistant of Sector 1 (Thorax surgeries). The table shows that it on average takes 9.2 minutes to prepare the necessary materials for a specific Thorax surgery. The table also shows that on average 31 different products, which are dispersed over 2 different warehouses, are required.

Average materials preparation time (Thorax, N=30)					
	Σ	μ	Min	Max	σ
Total time (min.)	274,74	9,2	6,5	11	1,14
Amount of products (x)	932	31	17	39	6,09
Amount of warehouses (x)	60	2	2	2	0

***Table 35**, Average materials preparation time (Thorax)*

An important addition to these results is that the results of the average materials preparation time study cannot be generalized to the other two sectors. As already indicated, at Sector 1 the materials are prepared by a sector assistant and at Sector 2 and 3 by the surgical assistants with walk around function. The preparation of the necessary materials is a core task for the sector assistant, but not for the surgical assistants. For the surgical assistants this is an extra task which should be executed in between the core care tasks. Out of the different interviews it became clear that a sector assistant therefore is better aware of the locations of the different necessary materials in the different warehouses which results in a lower average materials preparation time. Because the materials preparation task is an extra task for the surgical assistants and because it is executed in between other tasks, the surgical assistants do not always complete the preparation of a specific surgery but finish it later on. It therefore was not possible to measure the average materials preparation time of surgical assistants of Sector 2 and 3. Out of different interviews it however turned out that it on average takes **15 minutes** for the surgical assistants of Sector 2 and 3 to prepare the necessary materials for a surgery. This is due to not exactly knowing the locations of all the necessary materials and not completing the preparation of a surgery at once.
A final addition is that the surgical assistants do not always take the materials with the earliest sterility date. Because it is a task that interferes with their care tasks, it is executed as fast as possible. They just take all the necessary materials from the shelves without checking the sterility dates. This is also the consequence of not having tailor made picking lists (for a specific surgery) that indicate which materials must be picked.

> It often occurs that the sector assistant of Sector 1 reports herself ill. One of the main consequences is that surgical assistants now have to prepare the necessary materials for a surgery. Since they are not fully aware of the requirements and locations, this often results in collecting wrong or insufficient materials. When this is noticed during a surgery, the surgical assistant has to leave the operation room to collect the correct materials. The result is an absence of the surgical assistant and a possible postponement of the surgery for several minutes.

4.3.5 Job stress

As already indicated, it is important to realise that the health care professionalism has limits on how far labour flexibility can go. Too much worker responsibility, multi-skilling and job variety does not lead to better performance and, maybe even more important, to employee well-being. An often observed effect of handling workers too much responsibility and tasks is *job stress*.

Because surgical assistants with walk around function are supposed to execute a great amount of different tasks with a high level of responsibility, it is possible that they experience a high amount of job stress. We therefore kept a survey to discover the general health of employees, the Utrecht Burnout Scale, the job descriptive index (*work items*), possible stressors in the work of surgical assistants and the appreciation of the logistics at the operations center. *This measurement can also be perceived as 0-measurement on the eve of possible changes in the work design of surgical assistants with walk around function.*

4.3.5.1 General Health and Utrecht Burnout Scale

Table 36 presents a summary of the outcomes of the research towards the general health of the surgical assistants and the Utrecht Burnout Scale. A total overview per interviewee is presented in *Appendix Book XVIII*. The table shows that the general health of the surgical assistants (that was scored on a 4 points scale) has an average score of 2.49. This means that surgical assistants have *a bit more health complaints than usual.*
Figure 36 furthermore shows that 9 persons or 31% of the respondents have a score equal or above 3.0. This score indicates the amount of psychological unwell being whereby a score equal to – or above 3 indicates a need for extra attention and/or interventions. This means that 9 persons or 31% of the surgical assistants need extra attention or interventions.

Respondent	Score 0-12 Variabel minimum	Norm scores 1 = really low, 2 = low, 3 = average, 4 = high, 5 = really high			
		UBOS-A			**JDI**
	GHQ	*Exh.*	*Dep.*	*Pers.*	*Work*
Avg.	2.49	2.93	2.62	3.24	2.34
Score ≥ 3.0	9				
Score < 3.0	20				

***Table 36** , Summary of the outcomes of the survey*

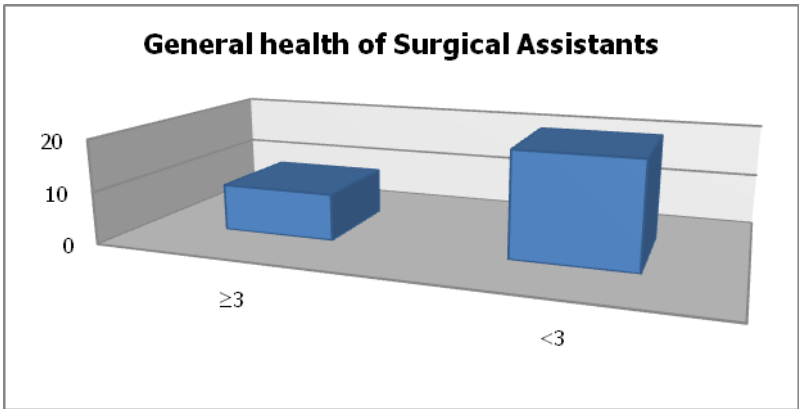


***Figure 36**, Psychological unwell being of surgical assistants (≥3)*

Table 36 further shows the scores of the surgical assistants on the three categories of the Utrecht Burnout Scale. With the help of norm table 10 it is possible to classify the average score of 2.93 of the surgical assistants on exhaustion as *high*, the average score of 2.62 on depersonalization as *high* and the average score of 2.34 on personal accomplishment as *low*. Since a high score on exhaustion and depersonalization in combination with a low score on personal accomplishment indicates a burnout, it is possible to conclude that 6 employees or 21% of the respondents show signals of a burnout.

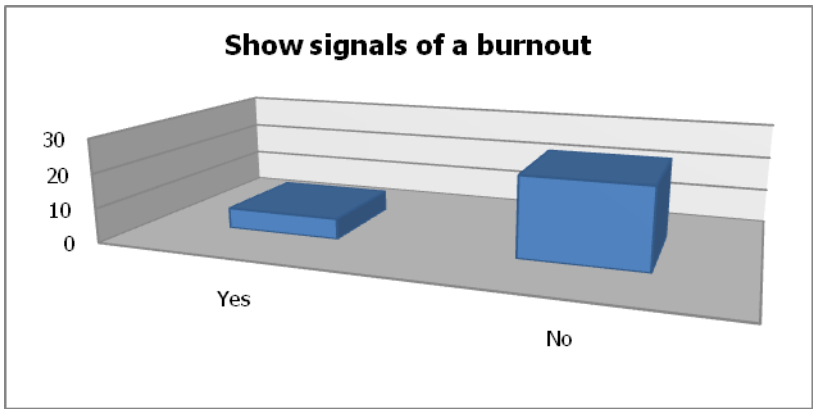


***Figure 37**, Amount of surgical assistants that show signals of a burnout*

4.3.5.2 Job descriptive index

Table 36 finally also presents the average scores on the job descriptive index (work items). The table shows an average job descriptive index for work items of 2.34 which means a score below the average of all the different professions in The Netherlands.

	Score 0-12 Variabel minimum	Norm scores 1 = really low, 2 = low, 3 = average, 4 = high, 5 = really high			
		UBOS-A			**JDI**
	GHQ	*Exh.*	*Dep.*	*Pers.*	*Work*
Avg. men	0.5	2.5	2.5	4	2.5
Avg. women	2.59	2.96	2.63	3.19	2.33

***Table 37**, General health of surgical assistants, scores on the Utrecht Burnout Scale and the Job Descriptive Index (work items) separated by gender*

Since there also are possible differences between men and women, table 37 shows the results separated by gender. Although there were only two male respondents, it is possible to see that the general health quality of the men is much better than the general health quality of the women. The table also shows better scores for men on exhaustion, depersonalization and personal accomplishment. It finally also shows that men are more satisfied with the work as surgical assistant than women. When regarding the norm scores of table 10 is however is possible to see that both scores are less than the average norm scores of men and women. This means that the male and female surgical assistants are less satisfied with their work than the average male and female employees in The Netherlands.

The different elements of the job descriptive index (work items) are presented in *Appendix Book XIX*. The elements that attract the most attention are:

- The reasonable low score on the element *creative*
- The reasonable low score on the element *respective*
- The high score on the element *tiring*
- The low score on the element *healthy*
- The reasonable high score on the element *frustrating*

4.3.5.3 Stressors

A stressor was defined as an agent, condition, or other stimulus that causes stress to an organism. In consultation with the management of the surgical assistants, eight different stressors, which might influence the stress experience of employees, were selected. Table 38 presents the results of the research towards these eight possible stressors. The different column numbers and statistical numbers are explained by table 39 and table 40. Based on the explanation of the statistical numbers, it is possible to conclude that an average number between 1 and 4 indicates the existence of a stressor.
The table shows that five of the eight selected stressors are scoring a mean between 1 and 4. These four stressors are recovery possibilities, vagueness of tasks, work speed and quantity, emotional strain and work strain. The table shows that emotional strain and work strain are the two most important stressors with a mean score of 3.24 and 2.69.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
N valid	29	29	29	29	29	29	29	29
N missing	0	0	0	0	0	0	0	0
Mean	3,66	4,41	4,45	3,79	4,97	3,38	3,24	2,69
Std. Error of mean	0,28	0,25	0,23	0,19	0,25	0,24	0,14	0,19
Median	3	5	4	4	5	3	3	3
Mode	3	5	4	4	6	3	3	3
St. Deviation	1,52	1,35	1,24	1,01	1,35	1,27	0,74	1,04
Variance	2,31	1,82	1,54	1,03	1,82	1,60	0,55	1,08
Minimum	1	2	2	2	2	1	2	1
Maximum	6	7	7	6	7	6	5	5

***Table 38**, Scores on the different researched stressors*

1	Recovery possibilities
2	*Cooperation with other departments*
3	Work content
4	*Vagueness of tasks*
5	Variation in work
6	*Work speed and quantity*
7	*Emotional strain*
8	*Work strain*

***Table 39**, Declaration of the column numbers*

Declaration of the statistical numbers						
Really negative	Negative	A bit negative	No influence	A bit positive	Positive	Really positive
1	2	3	4	5	6	7

***Table 40**, Declaration of the statistical numbers*

4.3.5.4 General logistical questions

The final part of the questionnaire consisted of several general questions (gender, age, working hours, etc.) and questions about the opinion of the surgical assistants concerning the logistics on the operations center. Together with the outcomes of the (semi) structured interviews with the managerial employees, it now is possible to create a total picture of the appreciation of the logistics on the operations center.

Table 41 shows the results of the general questions concerning the current organization of the logistics at the operations center at the UMCG. Table 42 shows the explanation of the five column numbers. The questions are scored on a 10-points scale.

	1	**2**	**3**	**4**	**5**
N valid	29	29	29	29	29
N missing	0	0	0	0	0
Mean	**6,24**	**5,34**	**4,86**	**7,07**	**6,24**
Std. Error of mean	0,36	0,36	0,29	0,37	0,46
Median	7	6	5	7	6
Mode	7	6	5	5	5
St. Deviation	**1,96**	**1,76**	**1,58**	**1,98**	**2,46**
Variance	3,83	3,09	2,5	3,92	6,05
Minimum	2	1	1	3	1
Maximum	10	8	7	10	10

***Table 41**, Scores on the different general questions*

1	Opinion concerning logistical tasks as surgical assistant
2	Enjoying logistical tasks as surgical assistant
3	Appreciation of current organization of logistics at the operations center
4	Preparing materials is part of the tasks of a surgical assistant
5	Logistical tasks at the operations center should be executed by logistical employees instead of surgical assistants

***Table 42**, Declaration of the column numbers*

The tables show that the average opinion of surgical assistants concerning the logistical tasks as surgical assistant is slightly positive (6.24). They however do not enjoy the logistical tasks, regarding the average opinion on question 2 (5.34). It also is evident that not all the surgical assistants see the logistical tasks as an element of their function regarding the slightly positive opinion on question 5 (6.24) and the high standard deviation (2.46).
The most remarkable outcome of these general logistics questions however is the opinion of the surgical assistants on question 3, the appreciation of the current organization of the logistics at the operations center. The surgical assistants reward the current organization with a really low mark of 4.86. Another remarkable outcome, which however is less remarkable than the previous, is that surgical assistants experience the preparing of materials, which does takes a lot of their valuable time, as part of their job. They state that they should execute these tasks to keep the necessary information of used products, stay aware of product locations in the warehouse and because they experience themselves as responsible for the quality and accuracy of the prepared materials.

Besides presenting the single outcomes of the general questions, it also is possible to combine certain of these general questions. The interesting outcomes are presented in figure 38 and table 42. Figure 38 shows the relation between the age and the appreciation of the logistics at the operations center. The graphics show that younger employees appreciate the logistics with a lower mark than the older employees.

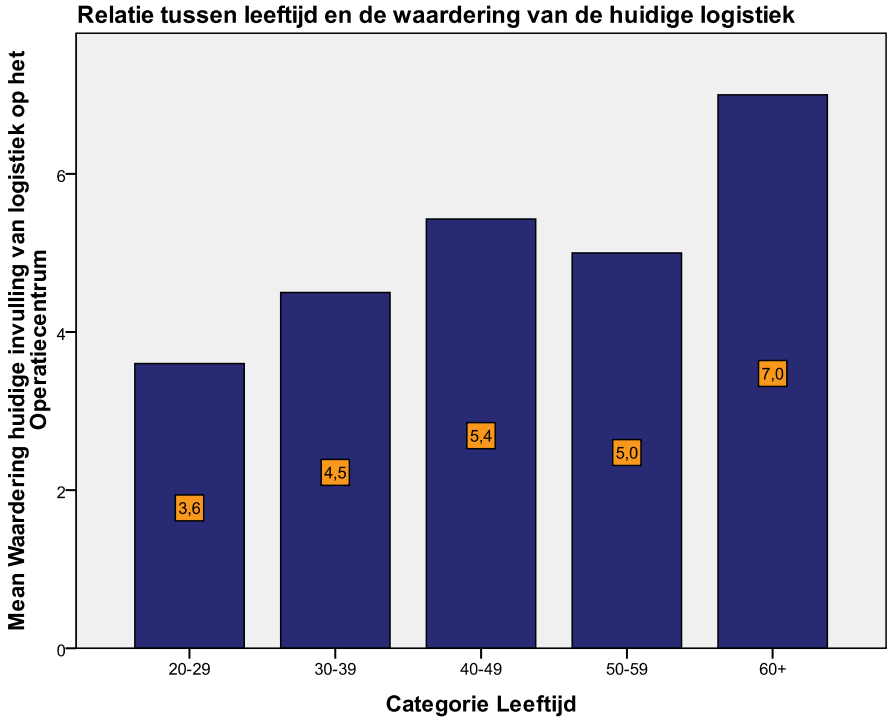


***Figure 38**, The relation between the age and the appreciation of the logistics at the operations center*

Table 42 shows the appreciation of the logistics at the operations center based on the employer history of the surgical assistant. The table shows that surgical assistants who have worked at a different hospital than the UMCG appreciate the logistics with a lower mark than surgical assistants who only have worked at the UMCG.

Appreciation of logistics based on employer history (N = 29)		
	Worked at a different hospital	Only worked at the UMCG
Amount	14	15
Average appreciation	4,57	5,07

***Table 42**, Appreciation of logistics based on employer history*

4.3.5.5 Sub Conclusions

Based on the discussion in this paragraph about the current content of the surgical assistant function, we can conclude that this function currently contains a great amount of logistical related tasks that interfere with their core care related tasks. As is evidenced by the different logistical studies in this research, the preparation of necessary materials, collection of missing materials, administrative tasks, laying out of materials and stock management takes a lot of time from the surgical assistants. The consequence first of all is that there is less time remaining for their core care tasks and that complete surgical assistant fulltime equivalents (*fte's*) are released for logistical related tasks (this while there are great shortages of surgical assistants in The

Netherlands). A second consequence is that the logistical tasks are executed with less speed and quality. This has a negative influence on the costs, quality and speed of the delivered care process. In line with the previous conclusion about the current suboptimal organization of the logistical processes, we can conclude that also the transition point from logistical – to care related tasks is placed at the wrong function. Placing the transition point at the surgical assistant function leads to a suboptimal execution of the logistical tasks, but also negatively influences the core care tasks of the surgical assistants. An even worse effect is visible on the health and stress experience of surgical assistants. The survey showed that high percentages of surgical assistants show serious health complaints and show clear signals of a burnout.
These effects are also personally supported by the surgical assistants. They first of all appreciate the surgical assistant function with a grade which is lower than the average appreciation of professions in The Netherlands. They secondly also appreciate the current organization of the logistics with a serious low grade. They not only dislike the current organization of the logistics, but also do not enjoy executing logistical tasks and think that logistical tasks should be executed by logistical employees instead of surgical assistants. The surgical assistant function thus requires rapid changes.

In the next paragraph we will present the results of our research towards the characteristics of the demand for surgeries and the resulting demand for materials and instruments. This research is necessary to be able to provide recommendations for a reengineering of the total process. The characteristics of the demand namely influence the possible organization, structure and lay-out of an improved logistical – and care related process.

4.4 How is the demand for surgeries influencing the organization of the logistical and care related processes?

To be able to create an impression of the amount of (logistical) tasks at the operations center and to be able to provide recommendations for a reengineering of this process, it is necessary to create an overview of the extent and characteristics of the demand for reusables and disposables. As already mentioned, the demand in this research originates at the operations center of the UMCG. The origin of the demand for reusables and disposables can be expressed with the following "formula":

Demand = [amount of surgeries] * [kind of surgeries] * [requirements per surgery] + [specific wishes of the surgeon]

The "formula" shows that different sorts of surgeries and their corresponding requirements plus the specific wishes of the surgeons lead to a certain demand for different reusables and disposables. The remaining of this paragraph will discuss the individual elements of the "formula".

4.4.1 Amount of surgeries

Table 43 and table 44 show the amount of surgeries over 2008. It is possible to distinguish four different sorts of surgeries at the UMCG:

- *Elective surgeries*: planned surgeries from the waiting list
- *Urgent surgeries*: must be executed within 24 hours
- *Emergency surgeries*: must be executed within 6 hours
- *Acute surgeries*: must be executed at once

aantal operaties uitgevoerd		2008/Jan	2008/Feb	2008/Mar	2008/Apr	2008/May	2008/Jun	2008/Jul	2008/Aug	2008/Sep	2008/Oct	2008/Nov	2008/Dec	Totaal
OCS1	Acuut - nu	10	13	8	12	8	27	16	7	10	6	13	11	141
	Electief	119	87	109	114	108	116	88	102	114	104	119	103	1283
	NB	0	0	0	0	0	1	0	0	0	0	0	0	1
	Spoed - binnen 6 uur	10	10	6	11	6	11	10	7	11	13	9	6	110
	Urgent - binnen 24 uur	2	1	1	0	0	4	1	1	6	2	4	3	25
	Totaal	**141**	**111**	**124**	**137**	**122**	**159**	**115**	**117**	**141**	**125**	**145**	**123**	1560
OCS2	Acuut - nu	13	14	13	17	23	18	20	20	20	11	13	12	194
	Electief	391	402	354	390	345	393	275	355	464	471	438	376	4654
	NB	0	1	0	0	0	0	0	0	0	0	0	2	3
	Spoed - binnen 6 uur	43	43	46	40	35	39	45	55	49	39	45	42	521
	Urgent - binnen 24 uur	48	43	51	54	58	60	69	54	45	57	36	51	626
	Totaal	**495**	**503**	**464**	**501**	**461**	**510**	**409**	**484**	**578**	**578**	**532**	**483**	5998
OCS3	Acuut - nu	25	18	21	27	25	22	36	27	26	26	22	24	299
	Electief	469	431	376	471	410	408	306	353	496	477	448	376	5021
	NB	2	6	3	3	2	2	0	4	5	1	2	2	32
	Spoed - binnen 6 uur	131	92	126	108	125	128	124	114	147	116	128	96	1435
	Urgent - binnen 24 uur	114	95	88	131	131	123	109	123	110	120	100	147	1391
	Totaal	**741**	**642**	**614**	**740**	**693**	**683**	**575**	**621**	**784**	**740**	**700**	**645**	8178
Totaal	**Acuut - nu**	**48**	**45**	**42**	**56**	**56**	**67**	**72**	**54**	**56**	**43**	**48**	**47**	634
	Electief	**979**	**920**	**839**	**975**	**863**	**917**	**669**	**810**	**1074**	**1052**	**1005**	**855**	10958
	NB	**2**	**7**	**3**	**3**	**2**	**3**	**0**	**4**	**5**	**1**	**2**	**4**	36
	Spoed - binnen 6 uur	**184**	**145**	**178**	**159**	**166**	**178**	**179**	**176**	**207**	**168**	**182**	**144**	2066
	Urgent - binnen 24 uur	**164**	**139**	**140**	**185**	**189**	**187**	**179**	**178**	**161**	**179**	**140**	**201**	2042
	Totaal	**1377**	**1256**	**1202**	**1378**	**1276**	**1352**	**1099**	**1222**	**1503**	**1443**	**1377**	**1251**	15736

***Table 43**, Amount of surgeries over 2008*

The table shows a total amount of 15.736 surgeries over 2008. This amount can be subdivided in 1560 (*9,91%*) surgeries at Sector 1, 5998 (*38,12%*) surgeries at Sector 2 and 8178 (*51,97%*) surgeries at Sector 3. The table furthermore shows that a total of 10958 (*69,64%*) elective surgeries, 2042 (*12,98%*) urgent surgeries, 2066 (*13,13%*) emergency surgeries and 634 (*4,03%*) acute surgeries were executed in 2008.

aantal operaties uitgevoerd (% van algehele totaal)		2008/Jan	2008/Feb	2008/Mar	2008/Apr	2008/May	2008/Jun	2008/Jul	2008/Aug	2008/Sep	2008/Oct	2008/Nov	2008/Dec	Totaal
OCS1	Acuut - nu	0,06%	0,08%	0,05%	0,08%	0,05%	0,17%	0,10%	0,04%	0,06%	0,04%	0,08%	0,07%	0,90%
	Electief	0,76%	0,55%	0,69%	0,72%	0,69%	0,74%	0,56%	0,65%	0,72%	0,66%	0,76%	0,65%	8,15%
	NB	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%
	Spoed - binnen 6 uur	0,06%	0,06%	0,04%	0,07%	0,04%	0,07%	0,06%	0,04%	0,07%	0,08%	0,06%	0,04%	0,70%
	Urgent - binnen 24 uur	0,01%	0,01%	0,01%	0,00%	0,00%	0,03%	0,01%	0,01%	0,04%	0,01%	0,03%	0,02%	0,16%
	Totaal	**0,90%**	**0,71%**	**0,79%**	**0,87%**	**0,78%**	**1,01%**	**0,73%**	**0,74%**	**0,90%**	**0,79%**	**0,92%**	**0,78%**	9,91%
OCS2	Acuut - nu	0,08%	0,09%	0,08%	0,11%	0,15%	0,11%	0,13%	0,13%	0,13%	0,07%	0,08%	0,08%	1,23%
	Electief	2,48%	2,55%	2,25%	2,48%	2,19%	2,50%	1,75%	2,26%	2,95%	2,99%	2,78%	2,39%	29,58%
	NB	0,00%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,02%
	Spoed - binnen 6 uur	0,27%	0,27%	0,29%	0,25%	0,22%	0,25%	0,29%	0,35%	0,31%	0,25%	0,29%	0,27%	3,31%
	Urgent - binnen 24 uur	0,31%	0,27%	0,32%	0,34%	0,37%	0,38%	0,44%	0,34%	0,29%	0,36%	0,23%	0,32%	3,98%
	Totaal	**3,15%**	**3,20%**	**2,95%**	**3,18%**	**2,93%**	**3,24%**	**2,60%**	**3,08%**	**3,67%**	**3,67%**	**3,38%**	**3,07%**	38,12%
OCS3	Acuut - nu	0,16%	0,11%	0,13%	0,17%	0,16%	0,14%	0,23%	0,17%	0,17%	0,17%	0,14%	0,15%	1,90%
	Electief	2,98%	2,74%	2,39%	2,99%	2,61%	2,59%	1,94%	2,24%	3,15%	3,03%	2,85%	2,39%	31,91%
	NB	0,01%	0,04%	0,02%	0,02%	0,01%	0,01%	0,00%	0,03%	0,03%	0,01%	0,01%	0,01%	0,20%
	Spoed - binnen 6 uur	0,83%	0,58%	0,80%	0,69%	0,79%	0,81%	0,79%	0,72%	0,93%	0,74%	0,81%	0,61%	9,12%
	Urgent - binnen 24 uur	0,72%	0,60%	0,56%	0,83%	0,83%	0,78%	0,69%	0,78%	0,70%	0,76%	0,64%	0,93%	8,84%
	Totaal	**4,71%**	**4,08%**	**3,90%**	**4,70%**	**4,40%**	**4,34%**	**3,65%**	**3,95%**	**4,98%**	**4,70%**	**4,45%**	**4,10%**	51,97%
Totaal	**Acuut - nu**	**0,31%**	**0,29%**	**0,27%**	**0,36%**	**0,36%**	**0,43%**	**0,46%**	**0,34%**	**0,36%**	**0,27%**	**0,31%**	**0,30%**	4,03%
	Electief	**6,22%**	**5,85%**	**5,33%**	**6,20%**	**5,48%**	**5,83%**	**4,25%**	**5,15%**	**6,83%**	**6,69%**	**6,39%**	**5,43%**	69,64%
	NB	**0,01%**	**0,04%**	**0,02%**	**0,02%**	**0,01%**	**0,02%**	**0,00%**	**0,03%**	**0,03%**	**0,01%**	**0,01%**	**0,03%**	0,23%
	Spoed - binnen 6 uur	**1,17%**	**0,92%**	**1,13%**	**1,01%**	**1,05%**	**1,13%**	**1,14%**	**1,12%**	**1,32%**	**1,07%**	**1,16%**	**0,92%**	13,13%
	Urgent - binnen 24 uur	**1,04%**	**0,88%**	**0,89%**	**1,18%**	**1,20%**	**1,19%**	**1,14%**	**1,13%**	**1,02%**	**1,14%**	**0,89%**	**1,28%**	12,98%
	Totaal	**8,75%**	**7,98%**	**7,64%**	**8,76%**	**8,11%**	**8,59%**	**6,98%**	**7,77%**	**9,55%**	**9,17%**	**8,75%**	**7,95%**	100,00%

***Table 44**, Amount of surgeries over 2008 in percentages*

Of the four different sorts of surgeries only the elective surgeries are planned. The other surgeries are based on short term demand. These other not planned surgeries are executed instead of the planned surgeries. This means that a planned surgery will be postponed to the next available moment.

As already mentioned, the planned surgeries are surgeries from the existing waiting lists. The patients on the waiting lists are discussed during the meetings of the concerning specialisms. The output of these meetings is the maximum waiting time of the patients. These maximum waiting times are transmitted to the planning department (there is a planning department for each specialism) who makes the concept planning. The concept planning is based on the following variables:

- Available operation rooms
  - There are 24 operation rooms
- Available time (based on the necessary time per operation)
  - The UMCG is using standard time slots per surgery. This means that the surgeon, assistants, ASA Code (Code 1-5, which is a code for the risk of the operation based on the condition of the patient) and surgery history are not taking into account
- Available employees

- Sometimes there are shortages in the amount of available surgical assistants and anesthetists
- Available intensive care beds (when necessary)
  - Sometimes there are shortages in the amount of available intensive care beds
- Available materials
  - Sometimes there are shortages in the stock of necessary materials or necessary materials are not delivered or missing

The concept planning for a surgery is visible in OK-plus (the used information system) at 12:30 pm. at the preliminary day of the surgery. Until 14:00 hr. it is possible to make changes to this concept planning and at 14:30 hr., the final planning is visible. It sometimes however happens that this planning is changed after the surgeon meetings of 17:00 hr. It can thus be concluded that the planning is really final around 18:00 hr.

The planning horizon of surgeries at the UMCG is presented in figure 39. When translating the demand for surgeries to the demand for materials and instruments, it can be concluded that the maximum materials preparation time is 17.5 hours. In case of last time changes after the surgeons meetings, the preparation time is reduced to 14 hours. Because surgical assistants, however, currently are working until 18:00 hr., they take the planning of 14:30 hr. as basis for their preparations. This reduces the preparation time even further to 3.5 hours. Last time changes then need to be carried through before the start of the surgeries next day. Because of the suboptimal working hours of the employees that are currently responsible for the preparation of the materials, a part of the surgeries is prepared on the day of the surgery.

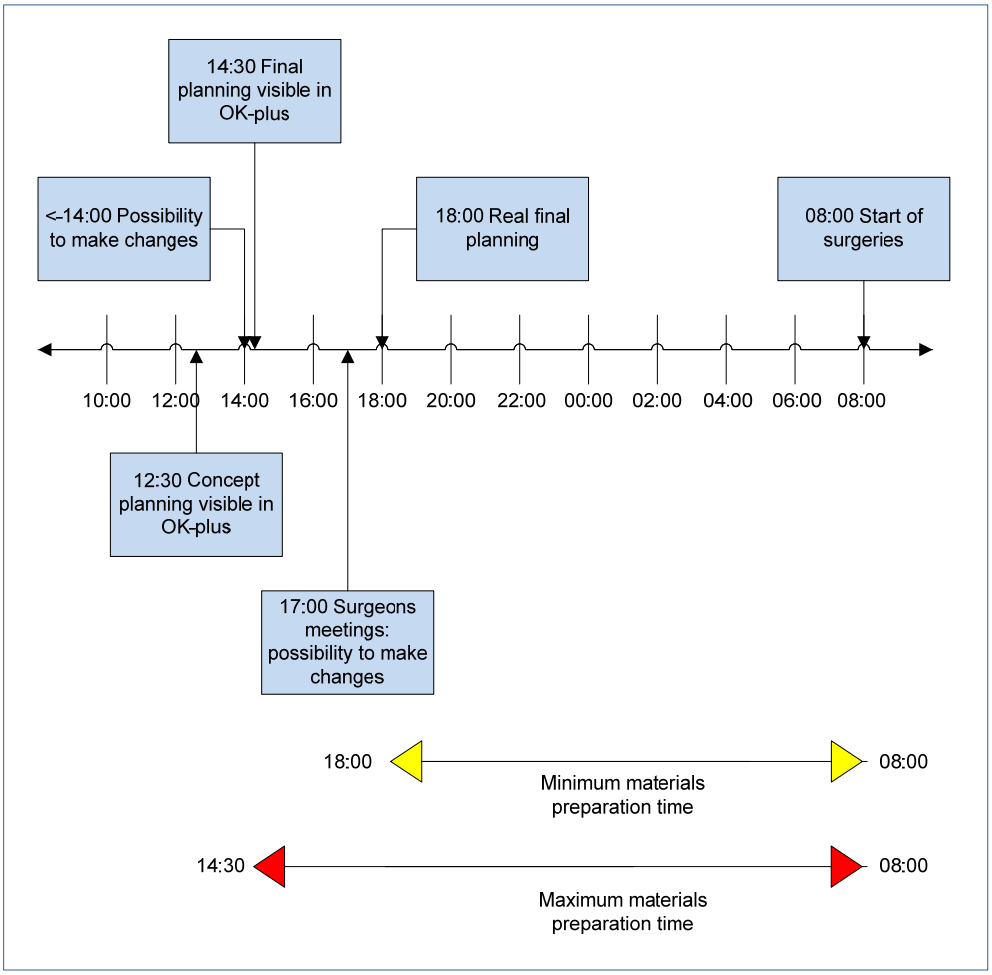


***Figure 39**, Planning horizon of surgeries*

4.4.2 Sorts of surgeries, requirements per surgery and specific wishes of the surgeons

Based on the planning of surgeries it is possible to prepare the necessary materials for the concerning planned surgeries. As already discussed, the preparing persons differ per sector. At sector 1, the materials are prepared by a sector assistant. At sector 2 and 3, the materials are prepared by the surgical assistants. The preparation procedure however is the same at all the three sectors.

The most important elements of the preparation procedure are the preparation protocols (*Dutch: klaarzetboeken*). Preparation protocols are standardized lists of the necessary reusables and disposables per different surgery. There are preparation protocols for all existing and known surgeries. Based on these preparation protocols, the preparing employee can collect all the necessary reusables and disposables at the different warehouses at the operations center. During the preparation he or she does has to take the specific wishes of the surgeons into account. Each surgeon namely has his own wishes concerning the usage of specific reusables and disposables. These specific wishes are also listed on the preparation protocols. Because there is no up to date overview of the locations of the necessary products, the concerning employee has to search through the warehouses to find the necessary products. This takes a lot of extra time. And because no specific picking lists are used, the preparing employees often also do not consider the perishable dates of the medical resources.

When all the necessary materials for a specific surgery are collected, the carts with all the materials are placed in front of the entrance of the operation rooms. Here they will wait until one of the surgical assistants starts with laying out the necessary materials in the operation room.

4.4.3 Sub Conclusions

Based on the discussion about the origin and characteristics of the demand for individual surgeries, it can be concluded that the greater part of the demand is stable and more or less predictable. Almost 70 percent of the surgeries namely is electively chosen from the waiting list. Almost a fourth part of the demand is reasonable stable and should be executed within 6 to 24 hours. This means that the logistical total process may take a maximum of 6 to 24 hours. The final 5 percent of the demand is highly variable and unpredictable since these surgeries should be executed at once. This means that there is little time for the total logistical process.

Based on the characteristics of demand of individual surgeries, it is possible to deduce the characteristics of the demand for the materials and resources. Based on the above discussion it can be concluded that also the demand for materials and instruments is reasonable stable and predictable. Based on these characteristics and the corresponding time until a surgery and the individual logistical process times, it is possible to determine the *Customer Order Decoupling Point* (*CODP*). The customer order decoupling point indicates until how far the actual demand penetrates into the total production or service process. Production upstream the CODP is based on forecasts and predictions and production downstream the CODP is based on actual demand.

For the organization of the logistical processes in the direction of an operation room this means that when the available time until a surgery is equal to – or greater than the total logistical process time, the total logistical process can be organized on the base of actual individual surgery demand. When the available time until a surgery is lower than the total logistical process time, a part of the logistical process should be based on forecasts and predictions. These forecasts and predictions are visible in different sorts of buffers (time, inventory, capacity). The most used buffer in the UMCG is *inventory*. The next paragraph discusses how the inventory currently is managed at the operations center. The discussion about the customer order decoupling point and

the necessity to use (which?) buffer is continued in the analysis chapter. It however should be clear that the characteristics of the demand and the resulting CODP are influencing the organization, structure and lay-out of the logistical process in the direction of an operation room (see also paragraph 6).

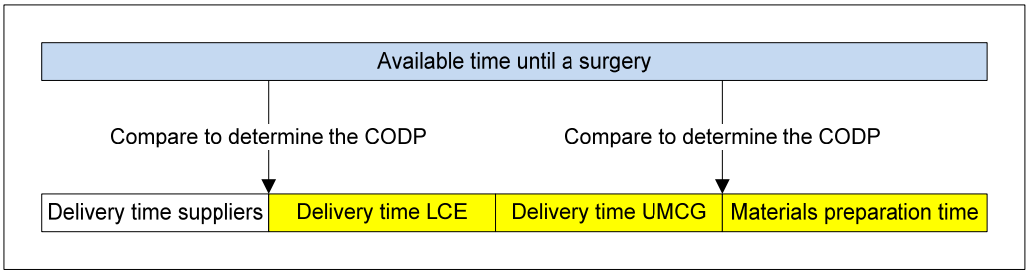


***Figure 40**, A comparison between the available time until a surgery and the total logistical process time (composed out of four different processes) determines the location of the Customer Order Decoupling Point. The yellow coloured process times are studied in this research*

4.5 How is the inventory at the operations center currently managed?

Inventory management professionals within the supply chain profession are vital to hospital performance and patient care quality. Hospitals need to store a great variety of medical and surgical supplies to be able to satisfy unpredictable, unstable and unexpected demand. It therefore is required that the right inventory items are available in sufficient quantity for the staff to use at all times.

As already mentioned in the previous paragraphs, the operations center of the UMCG has his own logistical department. This department is responsible for all the tasks that relate to the management of the inventory and the warehouses. Currently these tasks are executed by eight different employees. There is one general manager, one line manager and there are six operating logistical employees.

The different warehouses, where the disposables and reusables are stored, are managed by the operating logistical employees. These warehouses are dispersed over the operations center. The main types are:

- Sterile warehouses (4)
- Non sterile warehouses (3)
- Anesthetic warehouses (2)
- Perfusion warehouse (1)

Each logistical employee is responsible for one or two warehouses. This responsibility changes every month. This means that every month, a different logistical employee is responsible for all the different logistical tasks at a certain warehouse. Since there are 6 employees and 6 combinations of warehouse responsibilities, it takes a half year before an employee has worked at all the different warehouse combinations.
The logistical employees at the operations center are supposed to execute the following logistical tasks:

- Clearing away of ordered disposables and reusables
- Control of stock in hand and ordering replenishment stocks
  - Stock items
  - Non stock items
- Ordering new products (not yet in the assortment)
- Control of sterility dates of disposables and reusables
- Management of the warehouses (identification, location, …)

The remaining of this paragraph will discuss the content of the different logistical tasks.

4.5.1 Clearing away of ordered disposables and reusables

The clearing away of ordered disposables and reusables starts when the internal logistical department has placed containers with reusables and disposables at the goods receipt point at the operations center. Based on the transport roster, the logistical employees know at which times the containers are placed and when they should be transported to the warehouses. There are no visible or sound signals, the process functions with the help of the made agreements.
When the logistical employees have the impression that certain supplies will come in late, they start telephoning the logistical center Eemspoort, the internal logistical department UMCG or the sterile processing department to verify how long it takes before the supplies comes in. They

namely do not have a track and trace system at their disposal to verify this with the help of the internet or the used information system (OK plus). Besides that, there also are only limited amount of locations (only at the sterile processing department), where locations of materials are scanned.

The different containers with reusables and disposables are transported from the goods-receipt point to one of the warehouses at the operations center. As can be seen on photo 1 and photo 2 on the Picture Wall in *Appendix Book XXXVII*, the containers are not always directly transported to the warehouses. Based on several interviews, observations and the photos it can be concluded that containers are waiting at the goods-receipt point for several minutes and sometimes even several hours.

When the containers are transported to the warehouses, the different reusables and disposables are placed on the shelves of the warehouses by the logistical employees. This often takes a lot of time because:

- Items (especially disposables) are disorderly thrown in the used boxes by the employees of the LCE. It for example is not directly obvious how many items of the same sort are in the boxes
- The letters of content are also disorderly thrown in the used boxes. Since the logistical employees do not know the name and purpose of each material, it takes a lot of time to match the letters of content and the concerning materials (to verify whether the right – and the right amount of materials are delivered)
- The logistical employees do not know the exact location of all the ordered materials. This is due to the great amount of different materials in the warehouses and the monthly changes of responsibilities

4.5.2 Control of stock in hand and ordering replenishment stocks

The control of the stock in hand (amount of stock) is also executed by the operational employees of the logistical department operations center. Twice a week (Tuesday and Thursday) the responsible employee walks through "his" warehouses with a dossier established on a cart. The dossier consists of all the present materials in the concerning warehouse. A specific material is visible in the dossier by the corresponding identification card which normally also is attached to the location of the material on the shelves. There are two types of cards:

- Stock items: A card which mentions the name of the product and the bar code of the product
- Non stock items: A card which only mentions the name of the product

Behind the bar code card there is some space to fill in (with a pen) the amount of replenishment stocks. The order quantity (and safety stock) is determined by the responsible employee based on his experience and possible information about future surgeries (when this has reached the concerning employee). There is no support of an information system by calculation the order quantity and amount of safety stock and there also is no connection to the planning to forecast the amount of necessary materials based on the preparing protocols. All the decisions are grounded on experiences and discretion of the responsible employees. The employees also do not take the packaging amount of the materials into account. This means that not always complete packs are ordered and that consequently opened packs are stored at the LCE (also of low cost items).

When the responsible employee has completed his tour through the warehouse, the present amount of inventory is checked and the dossier is fully filled in, he walks to the office of the

operational logistical employees. Here there are two manners of ordering the replenishment stocks:

- Stock items: The logistical employee scans all the different bar codes of stock items in the dossier and types the amount of replenishment stocks (which were filled in with a pen behind the bar codes) in the used bar code scanner (old fashioned Intermec scanners). When this information is transmitted to the LCE before 11:00 am, they are delivered the same day with the second transport to the operations center. Since the replenishment stocks however come in at 16:00 hr., they often are cleared away the next day because the logistical employees are present until 16:00 hr. When the information is transmitted after 11:00 am, the replenishment stocks are delivered the subsequent day with the first delivery round. In practice this does actually does not makes a lot of difference.
- Non stock items: Non stock items are not scanned since they do not have a bar code on their identification cards. The different amounts of replenishment stocks are just manually entered in the (old fashioned) hospital information system (*Dutch: Ziekenhuis informatiesysteem; ZIS*) and then transmitted to the purchasing department. The purchasing department is responsible for ordering non stock items. It is not possible to check the status of a replenishment order for a non stock item.

A great risk of this way of working is that certain written replenishment stocks in the dossier are not noticed and that the responsible employee forgets to order this item. In practice this happens frequently. A second risk of this way of working, mainly because of the limited order frequency (twice a week), is stock outs. This also happens frequently. Especially during and after the weekend (when there sometimes have been a lot of extra unplanned surgeries) there often are stock outs. The main consequence of only ordering twice a week, is *a great amount of inventory*.

Incidentally, certain unique surgeries are planned. These unique surgeries are not executed very often and they also need specific medical specialists and materials. To make efficient use of these specialists and materials, these surgeries often are planned in a sequence.
Because the specific materials are not often used, they are stocked in very low quantities. It often happens that the specific materials for this sequence of surgeries are not available because it was not communicated to the logistical department of the operations center whereby as a result not enough materials were ordered. The logistical department of the operations center also has not created a possibility to know this, since the planning of surgeries is not connected to the preparation protocols and the current amount of inventory (which also is not digitally available/known)

4.5.3 Ordering of special, high cost non stock items (heart valves, prostheses, etc.)

A special and essential logistical process in the direction of an operation room is the stock control and ordering of different valves and prostheses. Valves and prostheses are used by different specialisms and need a tailor made logistical process because of:

- Limited sterility dates
- Limited amount of use per year
- Last minute determination of the used size (different sizes are available)
- High purchasing prices
- Special warehouse conditions and procedures

Because of these special characteristics, the UMCG is following a low stock strategy. This means that only a limited amount of these special non stock items are kept in stock. A specific special non stock item (for example a heart valve) is available in different sizes. The used size is dependent on the characteristics of the patient. Based on historic use, a minimal amount of stock is calculated. Sizes that are used frequently have a higher minimum amount of stock than sizes that are used occasionally. The specialisms are personally determining the minimum amounts of stock. In some cases, they even are managing the entire stocking and ordering process (instead of the logistical department) *because they are not convinced of the delivered quality of the logistical department operations center.*

One of the disadvantages of several surgeries is that only at the latest moment can be decided which special non stock item (heart valve, prostheses, etc.) is required. I have observed different of these kinds of surgeries. One of these was a replacement of a heart valve.
During this surgery the surgeon indicated at a certain moment which size heart valve was required. When the surgical assistant wanted to extend the required heart valve, she noticed that the required heart valve was not present in the cart with all the different sizes heart valves (this already indicates that the completeness of the cart was not checked in advance of the surgery). Since all the valves are stocked in this cart, this meant that the required heart valve was not in stock at that moment. This of course may never appear, since a service level of 100% (not less) is required.
Because the patient was laying "open" on the table, the surgeon was forced to use a different and thus sub optimal size heart valve. This of course is really harmful for the recovery and future of the patient. Waiting for the delivery of the right size heart valves or closing the patient however was not an option at that moment.
Since it may never occur that a specific size heart valve is not available, this situation was thoroughly analyzed. It ultimately turned out that one of the surgical assistants had placed the registration form in the wrong box at the welcome of the operations center. This resulted in a halt of the replenishment cycle and (also because only one item of the concerning size was kept in stock) an out of stock situation. Because there is no inventory management system present at the operations center, the out of stock situation could only be noticed by the logistical employees of the surgical assistants. This unfortunately however did not happened.

Figure 41 shows the logistical cycle of the special non stock items. The cycle starts when the surgical assistants start preparing a surgery and transport a set (different sizes) of a specific special non stock item to the operation room. Since the surgeon decides at the latest moment which size is needed for a specific patient, an entire set of sizes must be present in the operation room. After choosing a size, four different bar codes of the used special non stock item are scanned for internal use. When something happens with a patient or something is wrong with a special non stock item, the patient and/or special non stock item can always be traced. This scanning is thus *only for internal usage.*

To start up the replenishment stock cycle of a special non stock item, the surgical assistant must fill in a paper registration form. Every special non stock item has a specific registration form (two examples are presented in *Appendix Book XX*). The surgical assistant fills in the asked information and sticks the bar codes of the patient and the concerning special non stock item on the

registration form. This registration form must be thrown in a one of the different boxes at the welcome of the operations center. To keep the replenishment stock cycle as short as possible, the registration form must be thrown in the concerned box as quickly as possible. In practice this however not always happens because it actually is not allowed to leave the operation room during a surgery. In theory a surgical assistant therefore has to wait until the surgery is completed. Since certain surgeries take several hours (sometimes even 5, 6 or 7 hours), the replenishment cycle is substantial postponed.

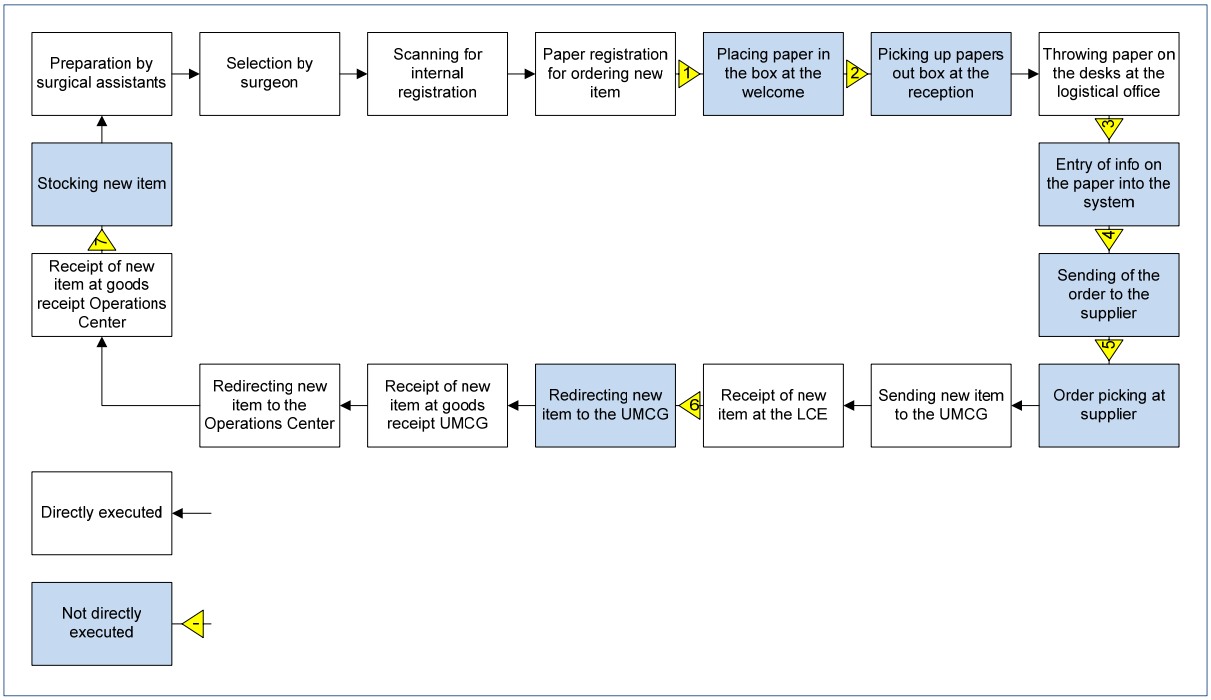


***Figure 41**, Replenishment cycle of special non stock items*

The replenishment cycle continues when one of the logistical employees empties the special box at the welcome of the operations center. There are no standard times when the box is emptied. It just takes place when one of the employees remembers it. The box therefore sometimes is not emptied for several hours. After emptying the box, the logistical employee brings the forms to his office where they are thrown on the desk of the responsible employees. Since the special non stock items are stocked in different warehouses, replenishment stocks must be ordered by the logistical employee who is responsible for the concerning warehouse. Because the responsible employee is not always present at the office when the forms come in and because they do not always feel like doing it immediately, this again is a step that postpones the replenishment cycle.
When the logistical employee has entered the info on the form into the system, the purchasing department will order the replenishment stocks at the supplier. This also is not always executed directly. There is no information available on how long this takes, but the interviews showed that the forms lay here untouched for several minutes or hours.

When the replenishment stocks of the special non stock items are ordered by the purchasing department, the internal logistical process of the supplier starts. This process is outside the scope of this research, but the appointment between the UMCG and the suppliers is that when the special non stock items are ordered in time, they are delivered within 24 hours. The special non stock items are delivered at the LCE. This is the location where the special non stock items enter the regular disposable cycle. They are not treated with priority. The disposable cycle is already described in paragraph 4.1.

It can be concluded that the current organization of the replenishment cycle of the special non stock items is postponed at several points. These points are also visible in figure 41 (blue coloured):

1. Placing the registration form in the special box at the welcome of the operations center
2. Picking up the registration forms by the logistical employees
3. Entry of information on the registration forms into the system
4. Sending the replenishment order to the supplier
5. Order picking at the supplier
6. Redirecting the replenishment stocks to the UMCG
7. Transporting and stocking the replenishment stocks in the warehouses

All the different mentioned postponements lead to a total postponement of the replenishment cycle of special non stock items of several hours and often even several days.

> During a day at the logistical department of the operations center one of the logistical employees entered his office with the question whether one of the employees had seen "his" special non stock item registration form. He thought he had thrown it on his desk, but it was disappeared and he actually wanted to order the specific special non stock item before he went home. After a moment of searching one of the logistical employees remembered he already had ordered this specific item. He had nothing to do for a while and had decided to order the specific item for his colleague. He only was forgotten to mention it…

4.5.4 Management of the warehouses

In the current organization of the logistics at the operations center, the logistical department operation center is responsible for the management of the warehouses. This means that they are responsible for the determination of the locations and the identification of the materials.
Out of the different interviews it turned out that *the locations of the materials in the warehouses are often changing*. This is the result of:

- The continuous addition of new materials to the assortment
- High stock levels
- Shortage of space in the warehouses
- High duplication of materials in the different warehouses

It was already indicated that there are a great amount of different suppliers in hospital logistics. The two main reasons are the profitability and development of the market. The hospital market is an always developing market with a lot of money in it. Each year thousands of new products and applications are invented by the suppliers. Since the medical specialists have a preference of working with the newest products and applications, each year also hundreds of new products are added to the existing assortment of a hospital. This also is the practice at the UMCG. One of the problems and reasons of the shortage of space in the warehouses is that the "old" products are not removed from the assortment. They keep stored in the warehouses for long time in large quantities. Different reasons can be mentioned:

- Since the UMCG is not using a traceability system or a stock control system, this is not noticed by the logistical employees
- The logistical employees have a serving function concerning the specific materials of the departments. They are not leading and are only following the commands of the specialists

- The lack of proper communication between the care related employees and the logistical employees. It often is not communicated that a specific material is not used anymore
- It often happens that a great percentage of the specialists start using a new material and that a few (old fashioned) specialists prefer to keep using the old material

A second and third reason of changing locations are the high stock levels and the resulting shortage of space in the warehouses. Since there is no insight the height and turn-over rate of materials, the average stock levels are much too high to be able to keep on guaranteeing the required service level of 100%.
The fourth and final reason, which also is connected to the third reason of shortage of space in the warehouses, is the high duplication rate of materials at the operations center of the UMCG. Since there are two identical anesthetic warehouses, three identical non sterile warehouses and four identical sterile warehouses, a great amount of identical products is stored. Unfortunately there are no numbers available of these percentages, but based on interviews and observations it can be concluded that the percentage is really (too) high. This also is the consequence of the logistical strategy of the operations center by which the care related employees must be able to collect the necessary materials (personally) as quickly as possible.

The consequence of the above reasons is a great puzzle for the logistical employees to find a suitable location for new materials. Often they also have to take into account the specific location preferences of the surgical assistants which leads to an even more complex puzzle and frequent location changes. These regular changes of material locations are of great influence on the "searching time" of the surgical assistants. They often have to search through the entire warehouse to find the location of a certain material when they are preparing a surgery or when they are collecting missing materials during a surgery.

An additional problem to the frequent changes of locations is the poor identification of the materials in the warehouses. Materials:

- Are missing a identification card
- Are having identification cards
- Are having unclear identification cards

This firstly hinders the finding of materials for surgical assistants and secondly hinders the clearing away of materials by logistical employees (replenishment stocks) and surgical assistants (remainings of a surgery).

Different elementary materials are stocked outside the operations room at the *Uitleiding* (all because of imaginary lack of space in the operation room). During a surgery, the surgical assistant had to leave the operation room to collect *double components glue* (one of the materials that is stocked outside the operation room). During the collecting the concerning surgical assistant noticed that there was no more stock at the *Uitleiding*. This, as was found out later on, was caused by a reduction of the amount of stock of two components glue. The logistical employees namely thought that this glue was not used very often and that the amount of stock could be reduced. This was executed without communication to the surgeons and surgical assistants. Since, however, a new professor was instituted, the surgeons just had decided to start using this glue more often. The lack of stock resulted in a postponement of the surgery and an absence of the surgical assistant for or several minutes since the surgical assistant had to go to a different warehouse (further away) to collect the necessary glue.

4.5.5 Ordering new products (not yet in the assortment)

Besides the ordering of stock items and non stock items that are already part of the assortment, the logistical department operations center also is an important link in the ordering of the earlier mentioned new-assortment-items. A request for a new-assortment item is often the consequence of the invention of a new product or application. A new-assortment item is added to the assortment at the request of a specific specialism.
The procedure of adding new items to the assortment starts with filling in the "Appeal of a medical resource Form" (*Appendix Book XXI*). This form should be filled in by the requesting specialism. Necessary elements that should be filled in are:

- Information about the requesting specialism
- Information about the requested article
- Information on behalf of storage in the warehouses
- Possible information about a (possible) test of a surgeon
- Possible comments

The first two and last two elements can be ignored since they are not of real importance. The most important element of this form is the requested information on behalf of the storage in the warehouses. The red lined part of *Appendix Book XXI* shows that the appealing specialism is asked to extend information about:

- Estimated consumption per year
- Wanted amount of stock
- Wanted location in the warehouse

This important element of this form is a clear example of the current working method at the operations center of the UMCG whereby *the care related employees determine the amounts of stock and locations in the warehouses*. The logistical employees are just executing these wishes without implementing procedures on own initiative. And because there is no inventory management system present, the requested amount of stock is never adjusted to the real (*werkelijk*) usage by the specialisms. Since the departments on beforehand often do not know how much of the concerning material they will use, and they therefore often demand for a high amount of stock to be able to trust on a service level of 100%, the amount of stock per product is (often far) too high. The missing possibility to adjust the amounts of stock, the high amounts of stock and the continuous addition of new catalogue items leads to a growing amount of stock in the warehouses at the operations center.

4.5.6 Control of sterility dates of disposables and reusables

The control of sterility dates of disposables and reusables is also an important element of the different tasks of the logistical employees of the logistical department operations center. Almost all the used medical products have a sterility date. This is mainly due to a maximum amount of days of sterility. The amount of days of sterility differs per product and is mentioned on the packaging of the products.

There are two reasons which make it very important for the logistical employees to frequently control the sterility dates:

- The surgical assistants often do not check the sterility dates of the products when preparing the materials for a surgery
- Since the products are not scanned when they enter the warehouse, it is not possible to digitally control the sterility dates of the different products

As already mentioned, the two different types of products (disposables and reusables) all have a sterility date. Since the sterility dates of the reusables expire earlier than the sterility dates of the disposables, the reusables are checked more often than the disposables. The reusables are checked once a month and the disposables are checked once a year. Unfortunately there are no numbers of the amount of materials that are thrown away because of expired sterility dates. Different employees however indicated during the interviews that several carts with products are returned to the SPD (reusables) or thrown away (disposables) after each check. The interviews furthermore also indicated that especially the yearly check of the sterility dates is not waterproof. This is mainly caused by the great amount of stocked materials and the tediousness of the work. Since the materials (with different sterility dates) are mixed up at the shelves, the checks however are very important.

Based on the above description of the current controlling and ordering of stocks in combination with the current organization of the preparing of necessary materials for a surgery, it is possible to conclude that the care related employees (surgeons, surgical assistants and anesthetists) currently are the *leading* actors in the organization of the logistics at the operations center. The logistical employees are *following* en *facilitating* and the management of the operations center is *paying*.

- The surgical assistants are preparing the materials
- The surgical assistants clear away remaining of a surgery
- The surgical assistants determine what and how much is stocked
- The surgical assistants determine the location of stocks in the warehouse
- The surgical assistants can take any material out of the warehouses when they want, without registration

The logistical employees just have to control and estimate (without knowing the amount and kind of surgeries) what is stocked, where it is stocked and whether there is sufficient stocked.

4.5.7 Sub Conclusions

Based on the discussion in this paragraph about the current management and organization of the inventory at the operations center at the UMCG, it can be concluded that this current management and organization leads to high costs, low speed and low quality of the total logistical and care related process.
We first of all can conclude that there actually is no inventory management strategy at the operations center. The different logistical employees just are doing those things of which they think it will lead to a sufficient amount of inventory. Important determinants of an inventory management strategy as characteristics of demand, characteristics of the total surgical process, involved persons and departments and the logistical concept/strategy are not taking into account and applicable concepts out of the environment (assistance of information systems, calculations of inventory parameters, usage of scanning systems) are not used. This leads to a suboptimal execution of the different logistical tasks (clearing away of ordered disposables and reusables, control of stock in hand and ordering replenishment stocks, ordering new products, control of sterility dates and management of the warehouses). Stock outs, postponements, emergency orders, disturbed relations, stress and uncertainty are therefore the order of the day.
A second important conclusion is that in the current organization of the logistical process, not the logistical employees but the care related employees are the leading party. All the inventory related practices are adjusted to – or determined by the care related employees. They actually are the most important party in the management and organization of the inventory. The logistical employees are only facilitating this situation. It therefore never will be possible to create an effective and efficient inventory management policy.

The next paragraph will bring together all the different concepts that have been discussed until know. The concrete structure and layout of the operations center (locations of resources and warehouses) should namely be determined by the characteristics of the total process (interdependencies), involved persons and departments, characteristics of demand and the used inventory management strategy. All these concepts are input to the development of an effective and efficient lay-out. The next paragraph will present the current lay-out of the operations center of the UMCG and will present the consequences of this current lay-out.

4.6 At which locations in the (researched part of the) hospital supply chain should resources be stored and warehouses be placed?

As already mentioned at the theoretical framework section, a hospital supply chain often consists of multiple stock locations. Some are inside the hospital and others are outside the hospital. A second characteristic of the hospital supply chain was the presence of different large central warehouses inside the hospital at the different patient care units and surgical areas. These two characteristics result in excess costs, waste, time and emergency orders.
The structure of the supply chain of the UMCG is already partially discussed in the previous paragraphs. In this last paragraph of the results section, we would like to study the locations of the warehouses, the lay-out of the warehouses and the strategy behind the chosen structures.

4.6.1 The locations of the warehouses

As already mentioned at the previous paragraph, there are different stock point locations in the UMCG supply chain. When regarding the different stock point locations, it is necessary to make a distinction between the disposables and reusables. Within the reusables it furthermore is necessary to make a distinction between "normal disposables" and anaesthetic disposables.

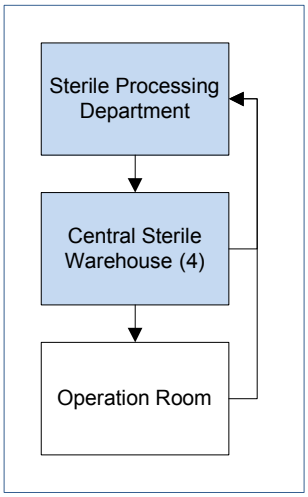


***Figure 42**, Stock locations in the reusable cycle*

Figure 42 presents the current stock locations in the reusable cycle (blue colored). The figure shows only two different stock locations. First of all there is a small warehouse at the sterile processing department. This warehouse is completely filled with not used instruments. These instruments are used to fill up incomplete instrument sets (because of maintenance, damages or deprecation) or to create new instrument sets. The employees of the SPD are not fully aware of the amount and sorts of materials that are present in this warehouse.
The second stock location in the reusable cycle is at the operations center in the central warehouses. There are four different central sterile warehouses spread around the operations center. Each warehouse is filled with instruments and instrument sets that are used by the specialisms that are operating nearby the concerning warehouse (specialisms often are operating in the same operation rooms). The reusable instruments and instrument sets lay in the warehouses until they are used or until their perishable dates have passed. They then return to the sterile processing department for a new decontamination process. Subsequently they are transported to – and stocked at the operations center again.

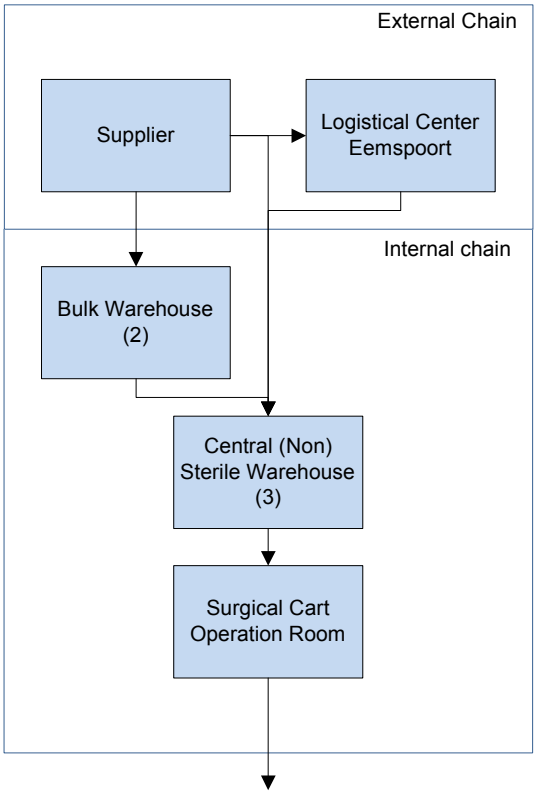


***Figure 43**, Stock locations in the disposable cycle of "normal disposables"*

Figure 43 presents the stock locations in the disposable cycle of the "normal disposables". This normal disposables are all the disposables with the exception of disposables that are used by anesthetists. The figure shows two different chains: an external chain (outside the UMCG) and an internal chain (inside the UMCG).
The external chain starts at the supplier where an unknown amount of a certain disposable is stocked. From the supplier, the disposables are transported to:

- Logistical center the Eemspoort (stock items)
- Central warehouses at the operations center (non stock items)
- Bulk warehouses at the operations center

As already mentioned in the first paragraph of this chapter, different low cost and frequently used disposables are stocked at logistical center the Eemspoort. From here they are, after an order from the logistical employees of the logistical department operations center, transported to – and stocked at the central non sterile – and central sterile warehouses at the operations center. The non stock items (which are more expensive and less frequently used) on the other hand are not stocked at the LCE, but directly transported to – and stocked at the operations center.
A third and last link in the sequence from the supplier are the bulk warehouses at the operations center. This are two special warehouses for products:

- That are frequently used at the operations center, but not frequent enough to be stocked at the LCE
- That are purchased in large quantities (non stock items) to be considered for quantity discounts but cannot be stocked in the normal (sterile or non sterile) warehouses because of lack of space
- That are tested by surgeons or other care related employees

Products that are stocked at the bulk warehouses often also are stocked at the sterile or non sterile warehouses. There are four different sterile warehouses – and three different non sterile warehouses at the operations center.

A limited amount of disposables is also stocked at a special surgical cart in each operation room. This are frequently used disposables as gloves, sutures and injections. After use, these disposables are thrown away.

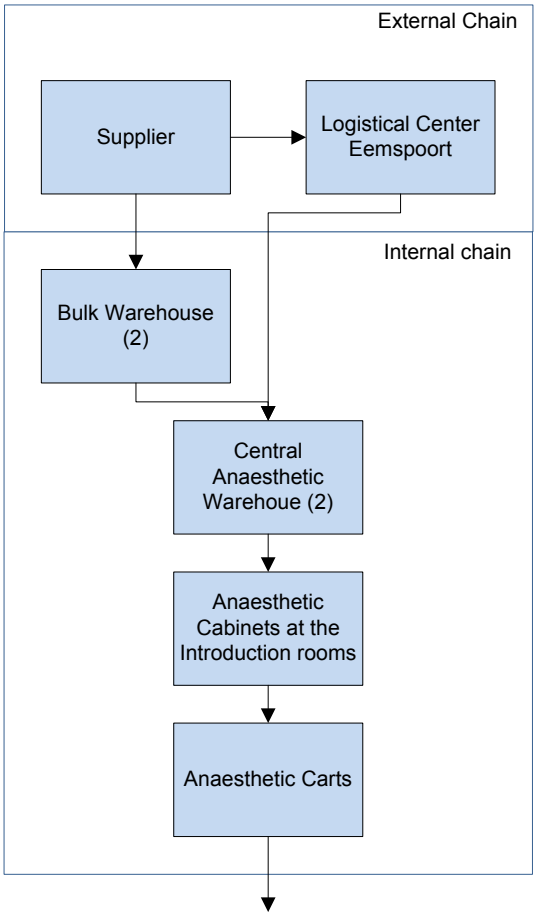


***Figure 44**, Stock locations in the disposable cycle of "anaesthetic disposables"*

Figure 44 presents the stock locations in the disposable cycle of the anesthetic disposables. This are disposables that are only used by the anesthetics. The figure shows two striking differences with the previous figure:

- Special central anesthetic warehouse
- Special anesthetic cabinets and carts

The anesthetic disposables are not stocked in the sterile or non sterile warehouses, but are stocked in special anesthetic warehouses. These two warehouses only consist of anesthetic disposables. The amount of stock is controlled and managed by the logistical employees of the logistical department operations center. They are also responsible for the control of the special anesthetic cabinets. All 24 introduction rooms consist of an anesthetic cabinet. The introduction room is the location where the patients are prepared for a surgery (anaesthetizing, injections, attaching monitoring devices, etc.). The necessary materials for the introduction of a patient are stocked in the anesthetic cabinets.

When the patient is prepared, he or she is transported to the operation room. Since the doors of the operation room should stay closed during a surgery, the anesthetics take the necessary materials with them in a special anesthetic cart. This cart consists of all the possible necessary materials during a surgery. Since there are 24 operation rooms, there also are 24 anesthetic carts. In practice it however often happens that the anesthetic leaves the operation room to pick up medical resources that are not present at the anesthetic cart. This often is due to the lack of checking the completeness of the anesthetic carts before a surgery.

4.6.2 The lay-out of the operations center and warehouses

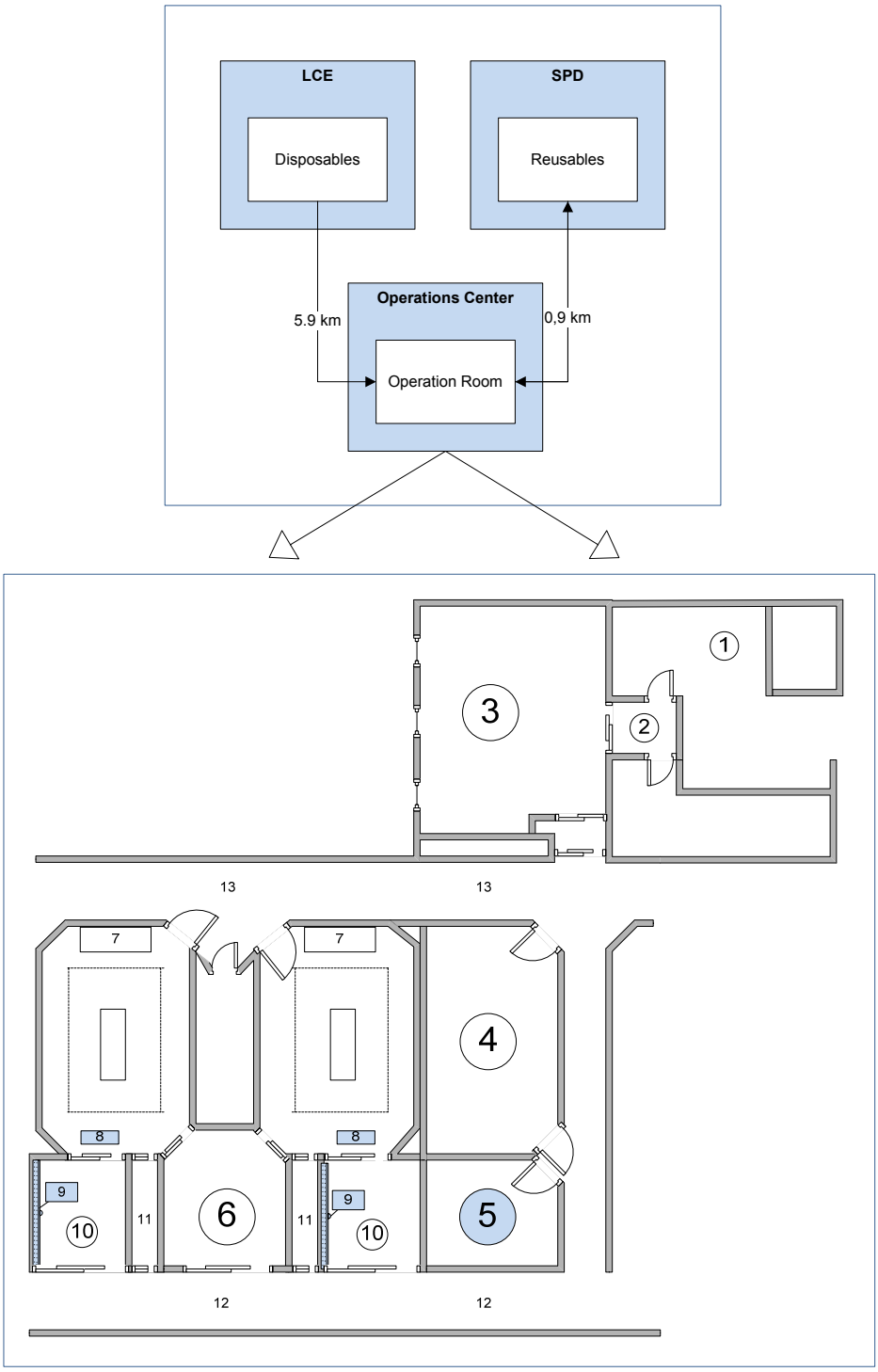


***Figure 45**, Current lay-out of a part of the operations center*

Figure 45 presents the floor-plan of (a part) of the current lay-out of the operations center. Table 45 provides a declaration of the mentioned numbers.

Number	Meaning
1	Rising point Operations Center
2	Bulk Warehouse
3	Sterile Warehouse
4	Non Sterile Warehouse
5	Anaesthetic Warehouse
6	*Uitleiding* room
7	Surgical Cart
8	Anaesthetic Cart
9	Anaesthetic Cabinet
10	Introduction (*inleiding*) room
11	Cleaning & washing room
12	"Clean" Corridor
13	"Dirty" Corridor

***Table 45**, Declaration of the numbers*

The presented floor-plan is a part of the total floor-plan, but is comparable to the total floor-plan of the operations center. The warehouses are located in the center of building part 35. On both sides of the warehouses, four different operation rooms are located. The structure of the first floor is almost equal to the structure of the third floor. 16 operation rooms are located in building part 35. The other 8 operation rooms are located in the adjacent building part 36. 5 operation rooms are located on the first floor and 3 operation rooms are located on the third floor. The first floor of building part 36 also carries a sterile – and non sterile warehouse. The third floor of building part 36 only carries a sterile warehouse.

The different reusables and disposables enter the operations center by elevator at the rising point (1). The carts are placed outside the elevator. Here they stand until the logistical employees start with clearing away the products to the warehouses. The products are transported to:

- One of the two bulk warehouses (2)
- One of the four sterile warehouses (3)
- One of the three non sterile warehouses (4)
- One of the two anesthetic warehouses (5)
- The perfusion warehouse (1)

The reusables and disposables in the bulk warehouses, sterile warehouses and non sterile warehouse are transported to an operation room with a special cart by the surgical assistant who has prepared the specific surgery. These carts are placed across the operation room where the concerning surgery is executed. The surgical assistant is also responsible for the control – and filling of the surgical cart (7) in the operation room.
The products in the anesthetic warehouse are transported to the anesthetic cabinets (9) by the logistical employees. They are responsible for the stock control of the anesthetic cabinets. The anesthetics are filling the anesthetic carts (8).

A patient enters the operations center via the "clean" corridor (12). He or she is transported to the introduction room (10) where he or she is prepared for a surgery. In case of certain surgeries it is not possible to prepare the patient in the introduction room. The anesthetics then have to

wait until the materials are placed ready. In the UMCG, the materials are always placed ready in the operation room. This often leads to a postponement of the start of a surgery.

After a surgery, the patient is transported to the *uitleiding* (6) where he or she is prepared for transport to a nursing department. The dirty materials leave the operation room via the "dirty" corridor (13). The reusables are placed in a special cart. This cart stands outside the operation room until it is picked up by employees of the sterile processing department. The disposables are thrown away in garbage bags. These garbage bags are thrown in special containers outside the operation room. These containers are emptied and changed a few times per day.

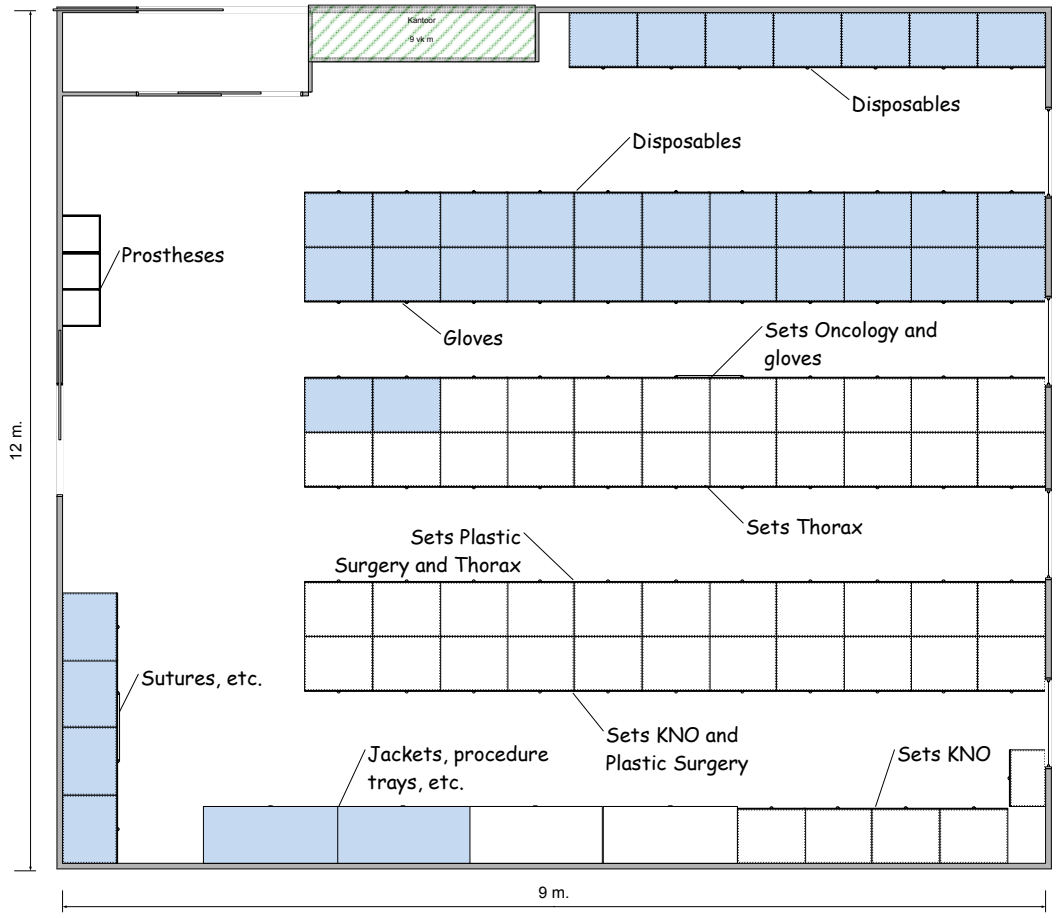


***Figure 46**, Floor-plan of the sterile warehouses*

Figure 46 presents the floor-plan of the two sterile warehouses in building part 35 of the operations center. The structure of these warehouses is comparable to the structure of the other two sterile warehouses.

The figure shows that the warehouses are filled with different reusables, disposables, prostheses, sutures, jackets and procedure trays. All the reusables of a certain specialism are located close to each other on the shelves. Also the different disposables are located close to each other. The different instruments and instrument sets (regardless of the standard surgical instruments and instrument sets) are unique for a specialism and are only stocked in one warehouse. This also applies to a part of the disposables. A great amount of the disposables is however stocked in all the four sterile warehouses. This part is blue shaded in figure 46.
The mentioned procedure trays are complete packages of necessary disposables. The individual items are stocked and packaged at the supplier. Instead of stocking the items loose on the

shelves, they are now already combined in a package. At this moment, the UMCG is not using much procedure trays. The gross of the products is loosely stocked at the shelves.

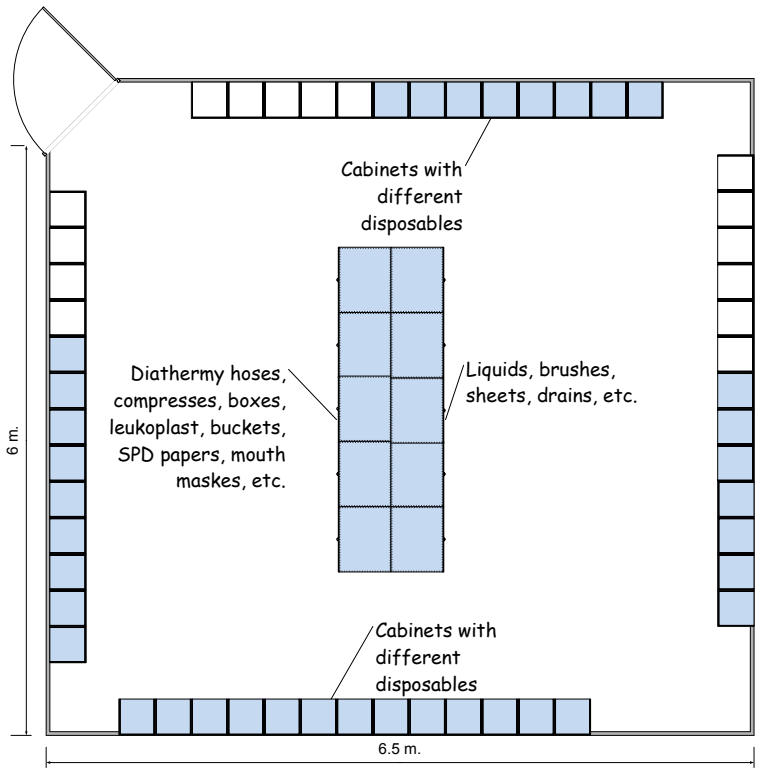


***Figure 47**, Floor-plan of the non sterile warehouses*

Figure 47 presents the floor-plan of the two non sterile warehouses in building part 35 of the operations center. The structure of these warehouses is comparable to the structure of the other non sterile warehouse in building part 36.

The figure shows that the warehouses are filled with different sorts of disposables. The most frequently used disposables are stocked at the shelves in the center of the warehouse. The cabinets on the side of the warehouses are stocked with less frequent used disposables. The blue shaded shelves show the disposables that are stocked in all three the warehouses.

Figure 48 finally presents the floor-plan of the two anesthetic warehouses. The figure shows that the warehouses consist of different shelves with anesthetic disposables. A part of the disposables is stocked in the boxes in which they were transported to the operations center. An other part is unpacked and placed loosely on the shelves. These loose items then are used to fill the anesthetic replenishment cars (1). The anesthetic replenishment cars are used to fill the anesthetic cabinets in the introduction room. The content of an anesthetic replenishment cart is equal to the content of the anesthetic disposables on the shelves and in the boxes, the anesthetic disposables in the anesthetic cabinets and the anesthetic disposables in the anesthetic carts. The anesthetic disposables thus are stored on the following six locations:

1. Logistical center the Eemspoort
2. Anesthetic warehouse (boxes)
3. Anesthetic warehouse (loose on the shelves)
4. Anesthetic warehouse (on the replenishment car)
5. Anesthetic cabinets (in the introduction room)
6. Anesthetic carts (in the operation room and reserves (2) in the anesthetic warehouses)

The content of the two anesthetic warehouses on the first and floor are completely identical (blue colored).

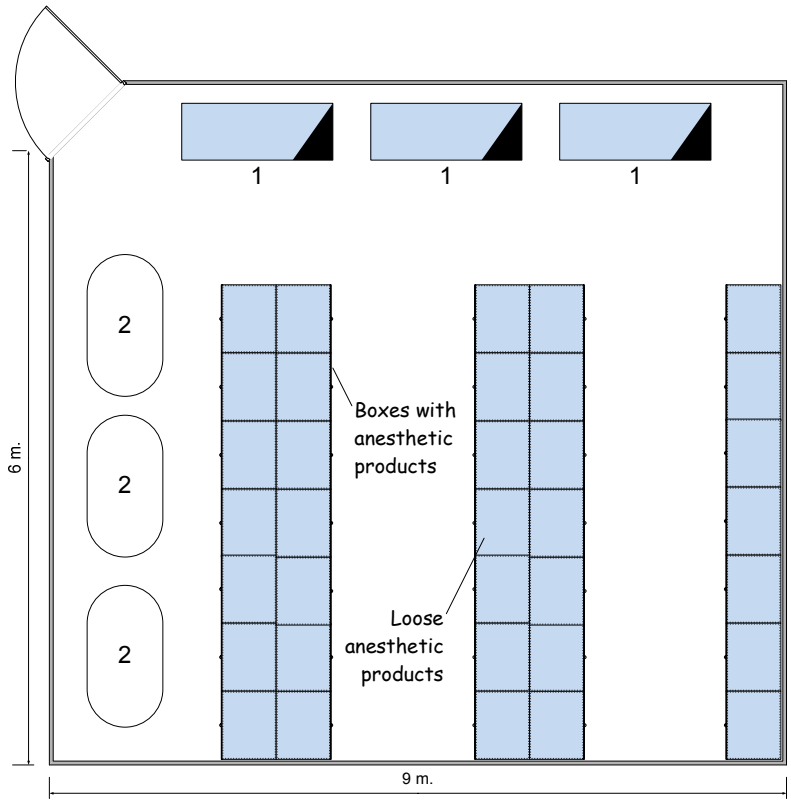


***Figure 48**, Floor-plan of the anaesthetic warehouses*

4.6.3 The strategy behind the structure and lay-out of the operations center and warehouses

The above described structure of the supply chain and lay-out of the operations center are the consequence of the current logistical strategy of the UMCG. In the current organization of the logistics at the operations center, the surgical assistants are responsible for the preparation of the surgeries and the collection of missing materials during a surgery. Since it frequently happens that new or different materials are needed during a surgery, it is important that a warehouse is located close to an operation room to minimize the amount of time a surgical assistant is out of the operation room. Because there are 24 operation rooms at the operations center, it currently is necessary that there are several warehouses dispersed over the two floors of the operations center. Only then it is possible minimize the amount of time a surgical assistant is out of an operation room.
Because the surgical assistants also are responsible for collecting missing materials, it also is necessary that a great amount and assortment of materials is available in each single warehouse. The consequence is that a great amount of mainly disposables (also a little percentage of the reusables) is double, thrice or even quadruple stocked. Since the assortment of the disposables and reusables is still growing, this results in a shortage of storage space and an increase of the percentage of space of the operations center that is used for the storage of materials (when related to the percentage of space that is used for care related tasks; figure 49).

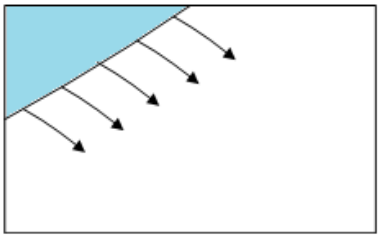


***Figure 49**, Growing amount of space that is used for storage of materials*

4.6.4 Sub Conclusions

Based on the discussion in this paragraph about the locations – and layout of the warehouses at the operations center of the UMCG, we can conclude that the current layout is totally adjusted to the used logistical strategy at the operations center. Since the surgical assistant function currently is the transition point from logistical tasks to care related tasks, the layout is totally adjusted to the different work places of the surgical assistant. When regarding the layout and the amount of warehouses, the picture in *Appendix Book V* is confirmed. This picture already presented a great amount of warehouses at different locations in the supply chain. The discussion in this paragraph showed that also the UMCG has a great amount of warehouses at different locations in the supply chain. At the operation center we for example already count a total amount of fifteen (15) central/large warehouses. Besides these central warehouses there also are different stock points at the patient care units and points of care.

When considering the discussion in the preliminary paragraphs, we have to conclude that the current structure and layout of the warehouses at the operations center is ineffective and inefficient. Since we already showed that the current organization of the total logistical – and care related processes (§1), the insight in the total process (§1), the organization based on the interdependency between the involved persons and departments (§2) and the location of the transition point (§3) are of suboptimal form and that the UMCG is not taking into account the characteristics of the demand for individual surgeries and has not stated a qualitative inventory management strategy it is strange and not advisable to adapt the locations and layout on these suboptimal concepts, strategies and realizations. This leads to very high costs (great amount duplicate items), low speed (extra time with preparing surgeries and clearing away instruments) and low quality (passed sterility dates and frequent out of stock situations).

We can thus conclude that the current organization of the logistical – and care related processes in the direction of an operation room needs to change to be able to improve the quality and speed and decrease the costs. This change has to be applied to all the different subjects that were discussed in the previous paragraphs. A reengineering of the total process should ultimately lead to a different organization of the total process, improved insight in the processes, improved communication and cooperation, a process that functions in sequential way, a different location of the transition point, improved consideration of the characteristics of demand and finally an effective and efficient inventory management strategy and organization and layout of the warehouses and operations center. The next chapter will describe which changes and revolutions are necessary.

5.

- Analysis -

In this chapter, the different results of this research will be further analyzed. The analysis will be executed by comparing the theoretical framework (chapter 3) with the most outstanding results of chapter 4, as described in the different sub conclusions. This chapter will proceed with the used structure in the previous chapters. This means that the analysis is executed for each distinctive sub question. The order of rank of the sub paragraphs is based on the rank of appearance in the results section.

5.1 How are the logistical and care related processes in the direction of an operation room currently organized and what is the quality of the current insight into the different steps of the total process?

5.1.1 Amount and times of supply rounds

In the theoretical framework, it was stated by Ansari and Modarress [1986] that one of the main requisites of a just in time strategy, which is the strategy the UMCG is aiming for, is frequent deliveries by the supplier. In case of the UMCG, this is the logistical center at the Eemspoort. Ansari and Modarres [1988] further list small purchase lot sizes compared to traditional large batch delivery as one of the major JIT practices. Das and Goyal [1989] commented that reducing delivery lot sizes requires an increase in the frequency of delivery and that therefore having a dependable source of transport is essential for the JIT supplier. Manoochehri [1984] finally added that the deliveries should be synchronized with the buyer's production schedule. We can thus mention the following conditions for a lean hospital supply chain:

- Frequent deliveries
- Small lot sizes
- A dependable source of transport
- Deliveries synchronized with the buyer's production schedule

The results of paragraph 4.1 show that in the current situation there are only 2 supply rounds per day in the direction of the operations center. These less frequent deliveries lead to ordering and delivering a greater amount of products per delivery (greater lot sizes) to be able to anticipate to the periods without new deliveries. Since then also a greater amount of products must be stored at the warehouses, this also leads to a need for greater warehouses. This is shown in figure 50, where it is possible to see that the amount of delivered products per delivery is much higher in case of two deliveries, than when delivering for example eight times. The amount of products

also gets lower in case of more frequent deliveries because of a more precise notion of the necessary products. The amount of *anticipation stock* now can be lowered.
We can thus conclude that a higher frequency of deliveries in combination with small lot sizes can lead to lower inventory and thus to lower inventory costs. Since the UMCG lets DHL, which can be regarded as a dependable transport operator, execute the deliveries and DHL is already delivering eight times per day, there are no extra transport costs involved.

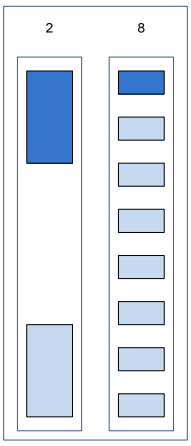


***Figure 50**, Greater amount of delivered products in case of less frequent deliveries*

The results of paragraph 4.1 further show the current times of delivery. In the current situation the two deliveries in the direction of the operations center leave the LCE at 09:00 am. and 15:00 pm. and arrive at the operations center at 10:00 hr. and 16:00 hr. Figure 51 compares these times with the working times of the logistical employees at the operations center, who clear away the different deliveries. These employees normally are present between 08:00 am. and 16:30 pm.

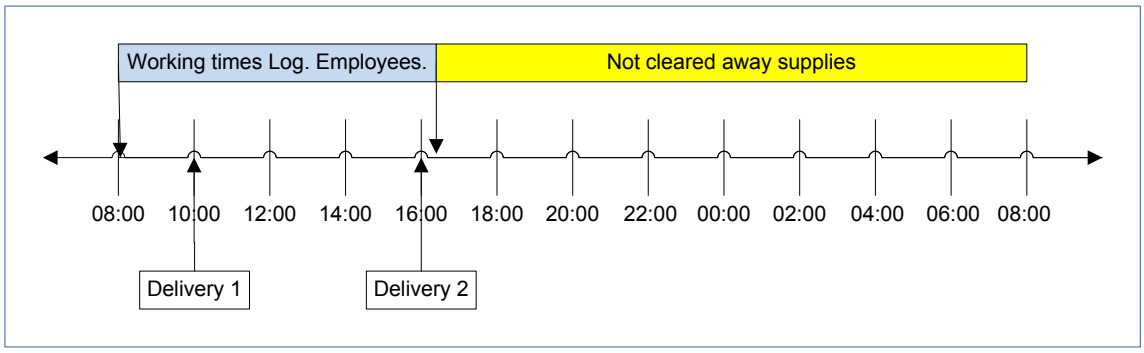


***Figure 51**, Synchronization of delivery times and working times of logistical employees operations center*

The figure clearly shows that the current supply times of the LCE do not adapt to the working times (or production schedule) of the logistical employees at the operations center (or vice versa). Because the logistical employees almost go home when the second delivery round enters the operations center, they do not clear away these ordered materials. Other present employees also do not clear away these supplies because of the differentiated responsibilities per warehouse. The result is that these new supplies often stand untouched at the goods-receipt point of the operations center from 16:00 until 08:00 hr. next day. The possible consequences are stock outs of different medical resources. One important, and also used, way to anticipate to possible stock outs is keeping higher amounts of inventory. A better synchronization of the deliveries with the production schedule of the logistical employees would thus give a possibility to lower the amounts of inventory at the operations center.

5.1.2 Involved persons and departments and locations of involved persons and departments

When regarding the process maps of the goods flows from the LCE and SPD to an operation room (figure 27 and figure 28), it is possible to see that in total 6 different persons and/or departments are involved, that the goods flow over five different floors, that the total length of the processes are 5.9 and 0.9 kilometers and that the processes can be identified as sequential. Thompson **[**2008**]** stated that reciprocal processes and important sequential processes should be located nearby each other in the organization. This especially applies to departments with numerous interactions. At the UMCG there are numerous interactions between the different persons and departments that are involved in the logistical process in the direction of an operation room. Locating these departments close to each other thus has significant influence on the performance of the supply processes. First of all, employees need to bridge shorter distances, which influences the speed and costs of the total supply process. Secondly, because of the shorter distances, there is a lower chance of possible mistakes and damages. This influences the costs, but also the quality of the supply process **[**Shiver, 2007**]**. It can thus be advised to reengineer the logistical processes in the direction of an operation room to an integrated logistical service center.

Such an integrated logistical service center is already visible in the Deventer Hospital and the Medical Center Leeuwarden. The floor plans of these medical centers are presented in *Appendix Book XXII***.** Both floor plans show that the central warehouse, the sterile processing department and the operation rooms are located nearby each other. This leads to a reduction of the transport times and distances, a reduction of the amount of process steps, a reduction of the amount of involved persons and departments and finally a better overview of the different logistical processes. This all positively influences the quality, costs and speed of the total logistical process in the direction of an operation room.

When regarding figure 28 again and now focusing on the involved persons, it is possible to see a sequence of involved persons and departments. The goods and information flow in one direction whereby the output of a certain process step is the input for the subsequent process step. One striking process step in this logistical process is the presence of employees of the sterile processing department (which is located 0.9 kilometers from the operations center) at the operations center to transport carts with dirty sets to the elevator. There are different reasons to mention this as striking:

- There are labor shortages at the sterile processing department. Frequent rides to the operations center by SPD employees interferes with – and hinders the execution of daily SPD tasks
- It currently is not possible for the SPD employees to notice that a specific surgery is finished and which instruments and/or instrument sets were used during a surgery. This means that SPD employees never know whether they enter (and leave) the operations center at the right moment. It for example can happen that a surgery is finished a few minutes after they have left the operations center. This means that the dirty sets stand for an unknown amount of hours (there is no standard scheme of visiting moments) outside an operation room. Since certain instruments require immediate decontamination because they need to be used during a subsequent operation, this way of working can lead to postponement of certain surgeries, the obliged use of sub optimal instruments by surgeons or unnecessary emergency orders.
- There are different persons/departments present at the operations center who can transport carts with dirty sets to the elevator to *keep the materials flowing through the process*. The most obvious employees to execute these tasks are the logistical employees of the operations center. You might even say that these tasks are part of their task description. In the current situation they however experience it as a task

that interferes with their current tasks. They thus take the stand that they are not the suitable department to execute these tasks.

Based on the above discussions, it now is possible to indicate the process steps that postpone the disposable – and reusable cycle. Between brackets we have tried to estimate the total postponement time.

- Transport of disposables from the LCE to the UMCG (0 – 6 hours)
- Transport of disposables and reusables to the warehouses (0 – 16 hours)
- Transport of used reusables to the elevators (0 – 2 hours)
- Transport of unused disposables back to the warehouses (0 – 4 hours)

This leads to a total possible postponement of the logistical process of reusables that are flowing to an operation room and back to the SPD of **0 – 18 hours**. The total possible postponement of the logistical process of disposables is **0 – 26 hours**. Since the different process steps of the medical resources are not scanned (as will be discussed later on in this chapter), it is not possible to indicate the exact postponements. It however is obvious that the current structure of the logistical process in the direction of an operation room leads to significant postponements. Stalk and Hout **[**1990**]** already stated that time is the most competitive weapon of the modern firm. They then also suggest firms to reduce the elapsed time involved in the performance of and between their key business processes. This advise also applies to the logistical process in the direction of an operation room at the UMCG.

5.1.3 Ownership of the different sorts of medical resources

Based on the diverse interviews it was possible to conclude that the ownership of the different sorts of medical resources is dispersed over three different departments: the sterile processing department (standard instrument sets), the operations center (standard stock items) and the specific specialisms (special non stock items). The consequences of these dispersion of ownership are:

- No clear separation of ownership. Employees and departments do not know which department is responsible for a certain sort of medical resource.
- In combination with the later on discussed lack of communication of involved departments, this leads to interference of tasks. Especially the logistical manager at the operations center is interfering with the tasks of the purchasing department. Because the logistical manager is responsible for the standard products at the operations center, he also is trying to execute a part of the strategic/tactical purchasing. Contracts with suppliers are unexpectedly changed or entered. This leads to unexpected changes in the assortment and stocks of identical medical resources of different suppliers. Especially the unexpected changes can lead to dangerous situations in the care of patients when surgeons and surgical assistants are not abreast of these changes.

It furthermore also is important to consider that although the ownership of the different sorts of medical resources is dispersed, the UMCG is responsible for the inventory costs of all the different medical resources. This means that there is no incentive to keep the amount of inventory as low as possible.

5.1.4 Insight into the different logistical processes

Little and Coughlan [2008] already stated that department managers require visibility of costs, locations and usage of products. A lack of insight often is the result of the lack of an inventory management policy. Lack of an inventory management policy namely often leads to invisible consumption and invisible movements of products [Jones, 2008].

Figure 30 shows that currently there only is insight in the four different steps at the sterile processing department. All the other process steps of the logistical process in the direction of an operation room are "invisible". This means that employees cannot trace the location of a specific (necessary) instrument or disposable. This can lead to the following problems:

- Extra actions of employees which postpone the total process (discussed later on when reviewing the inventory management policy of the UMCG)
- Medical instruments get lost somewhere in the logistical process
- Impossibility to find or trace necessary instruments
- Lack of necessary management information (discussed later on when extending recommendations)
    - Which items are used during a surgery
        - Possibility to adjust preparation protocols
        - Possibility to create procedure trays
    - How many and how often are items used during a surgery
    - How long does it take for a disposable or reusable to flow through the disposable – or reusable cycle
- No reliable cost-price for calculating the total price of specific surgeries

These problems can finally lead to lost and misplaced materials and finally to postponement of surgeries. It has been shown that lost or misplaced instruments can cost a 500 bed facility roughly **€200.000** annually. Surgical delays that are the result of incorrectly packed or unavailable instruments can cost hospitals an average **€1500** per hour [Williamson, 2006].

Jones [2008] stated that the visibility of products in hospitals can be improved by implementing a *digital control system,* as used in the retail and grocery industry. Implementing a digital control system practically means scanning all the medical resources at the different process steps as visible in figure 30. This can help in terms of accountability and facility-wide visibility and can help to improve quality on many levels. One of the greatest benefits of scanning medical resources is the ability to provide an accurate snapshot of current inventory and following locations of inventory across the organization with a few simple strokes on the computer keyboard. Such visibility can significantly reduce unnecessary instrument replacements and valuable time spent on searching missing instruments [Williamson, 2006].

This product scanning is already executed at the retail and grocery industry where products are scanned at every process step and managers have a clear insight in the locations of the different products. Instruments can be tracked on an individual level via adhesive barcode labeling (the InfoDot), laser etching or TherMark laser marking by which a laser bonds a barcode onto a product and creates a smooth and permanent mark [Williamson, 2006]. As can be seen at table 46, there already are a reasonable amount of hospitals with an instrument tracking (scanning) system.

Presence instrument tracking system? (N=100)	
Yes, per set	28%
Yes, per instrument	3%
Different	9%
No	59%
Unclear	1%

***Table, 46**, Presence of an instrument tracking system (source: Rapport inspectie ziekenhuizen, October 2006)*

Besides preventing the mentioned problems that result of having no insight in the logistical processes, implementing a supply chain barcode scanning system also has some other significant advantages for the UMCG:

- Different advantages in case of a product recall (by the hospital or a supplier). Without visual checks it now is possible to see how much of the involved material is in stock, where the involved materials are stocked and which patients have been in touch with the involved materials
- The information of the digital control system can be an input for subsequent processes. The information can especially be useful for the sterile processing department. Scanning the moment that a surgery is ready will provide the SPD the information that certain instruments are on their way back for decontamination. The SPD then for example can adjust the planning and processes to this information
- The barcode scanning system can be integrated with a materials management or inventory management system. When scanning all the incoming and outgoing materials in a warehouse, it is possible to create real time inventory levels and inventory locations. Tracking of constant inventory levels leads to more efficient and accurate picking and packing operations and less out-of-stock (OOS) situations due to continuous and automatically checking of the shelves **[**McFarlane and Sheffi, 2003**]**
- An integrated barcode scanning system and inventory management system can make it possible to generate intelligent storage and removal strategies. When using this functionality, the system indicates the location of specific products. This can lead to high filling - and high turnover rates. In case of highly advanced systems it theoretically even is possible to change locations of products when their turnover rate is changing. The system for example can advise to remove a product with a declining turnover rate from a valuable location to a less valuable location to facilitate efficient clearing and picking strategies **[**Williamson, 2004**]**
- When using the integrated barcode scanning system in combination with an inventory management system, it also is possible to create up to date picking lists for every individual surgery. Since all the locations, amounts of stock and preparation protocols are present, the system can generate a picking list for all possible surgeries (figure 52). It then however is important that all the locations, amounts of stock and preparation protocols are up to date present in the system.

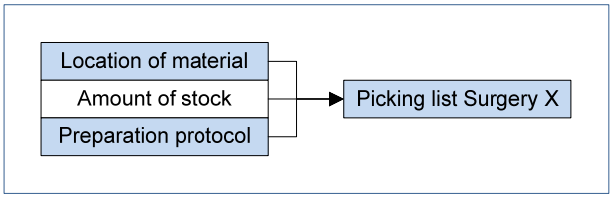


***Figure 52**, Necessary inputs for an up to date picking list for surgery X*

- Besides generating picking lists, the system also can indicate the location of individual materials. This for example can be useful during the nights when no logistical employees are present at the operations center. When a surgical assistant then has to go to the warehouse to collect some missing or extra materials, the system easily can indicate where the required materials are stocked
- Since a barcode can carry different sorts of information, it also is possible to add information about the sterility dates to the products. When this is used it first of all is possible to reckon with the sterility dates when generating picking lists. It furthermore then also would be possible to generate picking lists of products with passed sterility dates. It now is necessary to periodically check all the products in a warehouse. When using this functionality, this can be reduced to once or twice a year. This creates a great saving of time for the responsible employees
- Management information about the usage of each distinct product. Based on these usage history, it is possible to define reliable stock levels
- Automatic reordering of defined products when the stock falls below a stated stock level. This stock level is based on the historical use of the product (which is available because of the scanning of the products) and can be temporally adjusted when special "actions or sales" are planned. The system automatically generates a proposal for the replenishment amount of each distinct product. The manager only has to check this amount (and sometimes adjust it) and sends it through to the distribution center at the arranged moments. This functionality makes the operational purchasing employees redundant
- When the used instruments and materials are scanned when they are used in the operation room, it is possible to connect these to the present patient and employees. The used information system at the operation room (OK plus of Chipsoft) already contains the information about the patient and present employees and also has the functionality to record the used instruments and materials. When using this functionality it always will be possible to:
    - Trace the present employees at a specific surgery when the used instruments or instrument sets contain damages
    - Indicate that a used instrument or instrument set contains damages or is not sharp enough anymore and thus needs maintenance. This will be visible at the SPD when a product enters the first step of the decontamination process, the disinfection dirty. Since the SPD is responsible for maintenances, they can pick out these instruments and send them on for maintenance
    - Trace a patient when something turns out to be wrong with a places heart valve, vessel or prosthesis

As already indicated in paragraph 4.1, the UMCG currently is using paper labels, which are attached to each instrument and instrument set, to create the information about the employees that used the instruments and to indicate a need for maintenance. When using the mentioned scanning system, it is possible to eliminate this paper-based system **[**Williamson, 2004**]**. This can lead to significant savings.

Amount of Surgeries OZO / 2008	15736
Avg. amount of sets per surgery	5
Total amount of sets OZO / 2008	78680
Costs per label	€ 0,08
Total costs OZO blue paper label	€ 6.294,40

***Table 47**, Possible savings when eliminating paper-based systems*

Table 47 shows that one blue paper label has a cost price of €0,08. Based on the knowledge that each instrument and instrument sets contains a blue label, that on average around 5 blue labels are used during a surgery and that there were 15736 surgeries at the operations center in 2008, eliminating the paper labels leads to a saving of €6.294,40 for blue labels at the operations center. Since the blue labels are also used at other locations in the hospital and also red, green and black labels are used, the yearly saving amount probably will be over **€10.000,-**. These savings possibly can for example be used for the investments in the new scanning system.

5.1.5 Communication between involved departments

As was indicated by Thompson **[**2008**]**, sequential interdependence creates a greater need for horizontal mechanisms, such as integrators and/or task forces, and communication between linked plats or departments. It however is known that communication between departments in organizations is a much more difficult problem than intra-departmental communication. In an organization striving to maintain profits, the need to work in harmony is essential. Working in harmony depends on how well each department contributes to the organizational goals and understands how to contribute to the proper functioning of other departments **[**Boyd, 1966**]**.
Communication can thus be regarded as the lifeblood of an organization. In healthcare organizations this, however, has a literal life-and-death implication. Without accurate information, practitioners cannot provide optimal care. Even at the nonclinical level, communication is critical to a hospital's functioning **[**Haeuser and Preston, 2005**]**.
In practice, however, different roadblocks to inter-departmental communication can be mentioned. Examples are lack of understanding of the responsibilities, needs and problems of other departments, ill defined channels of distribution of information, educational differences, jealousy and personality differences and vague organizational structures **[**Boyd, 1966**]**.

Since the logistical process in the direction of an operation room at the UMCG can be regarded as a sequential process, integrators and/or tasks forces and optimal communication are thus important for an optimal functioning of the process. When analyzing the current organization of the logistical process in the direction of an operation room it however is possible to mention two main problems concerning the inter-departmental communication. First of all, because of the vague organization structure, there is a lack of proper communication between the different involved departments. Secondly, there are no integrators or task forces with a multiform view of the complete logistical process.

As was visible at figure 27 and figure 28, different persons and departments are currently involved at the logistical process in the direction of an operation room. Especially at the supporting departments (LCE, logistical department UMCG and logistical department operations center), there is a lack of mutual communication. This lack is especially visible in the communication between the LCE and the logistical department operations center and between the logistical department UMCG and the logistical department operations center (figure 53). Some striking examples are:

- The statement of one of the supervisors of the logistical department UMCG that he did not had visited the operations center (which is the subsequent step in the process) and spoke to employees of the operations center for more than eight years
- The rigid delivery of carts at the rising point (this also applies for employees of the sterile processing department)
- The inefficient and ineffective packaging of carts at the LCE for unpacking by employees of the logistical department operations center
- The great amount of emergency appeals of different sorts of products

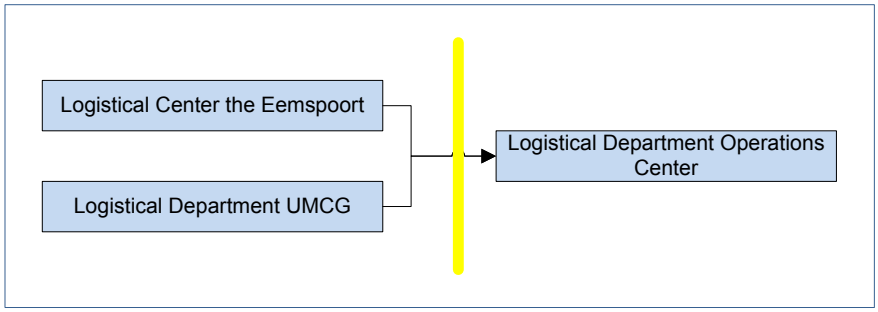


***Figure 53**, Lack of communication between three logistical departments*

The main reason for this lack of communication is the vague organizational structure of this logistical process. The results already showed that in the current organization, two comparable departments are responsible for the logistical processes in the direction of an operation room. This is very strange since:

- They are supposed to execute comparable tasks (stockpile management, location management, reordering, etc.)
- They are successive steps in the logistical process in the direction of an operation room

The result of this lack of communication and the division of responsibility in the organizational structure is a sub-optimal fulfilment of the logistical function in the direction of an operation room. Each logistical department only has an eye for (the development of) his own processes and does not consider the preliminary or subsequent logistical processes. This has resulted in two complete different fulfilments of the logistical function.
Out of different observations and interviews it turned out that the logistical department UMCG is trying to modernize its logistical processes. They are already trying to incorporate some of the best practices of external commercial sectors. The recruitment of a former logistical manager of Blokker (commercial chain of shops with domestic products) and the investments in a track and trace system are evident examples.
The logistical department operations center, on the other hand, still operates in accordance with history. Striking examples are:

- Use of paper registration forms
- Inefficient registration and replenishment processes
- Inefficient and ineffective division of tasks (as discusses later)
- Lack of a digital track and trace system
- Lack of support of information systems (inventory management, materials management, etc.)
- Inefficient and ineffective structure/lay-out of the operations center (as discussed later)
- Hindering developments towards a more modern fulfilment of the logistical function
- *Developments towards a more modern fulfilment of the logistical function are initialized by care related employees (surgical assistants)*
- *Being of opinion that the current organization of the logistical function is modern, of good quality and an example for other hospitals in The Netherlands*

These examples are striking and confronting. They, however, partly can be explained. The logistical department operations center is a small department with only 8 employees, the greater part of these employees does not has a logistical background and/or education and the responsible manager is more focused on the care related processes than on the logistical

processes. This last explanation leads to a situation where the logistical department almost can do everything they want. There is no proper directing by the responsible management.

The above described situation leads to worrisome and alarming situations at the operations center of the UMCG (as discussed at the different case examples in the results section). Stock outs, surplus of inventory, emergency orders, not present essential non stock items (heart valves, prostheses) are common practices. We think we can state that the current organization of the logistics can endanger the lives of the patients.

To increase the communication at the operations center and to create an environment of logistical change, it is important that the logistical department UMCG and the logistical department operations center are combined into one logistical department. As also will be discussed in the subsequent chapter, it is necessary to create a hard cut between the supporting functions (including logistics) and the core care functions. Combining the two logistical departments will create a department which is fully focused on logistical tasks, has managers with a logistical background and/or education and proper ideas about future developments. The care related employees, besides that, will then be able to completely focus on their core care tasks (figure 54).

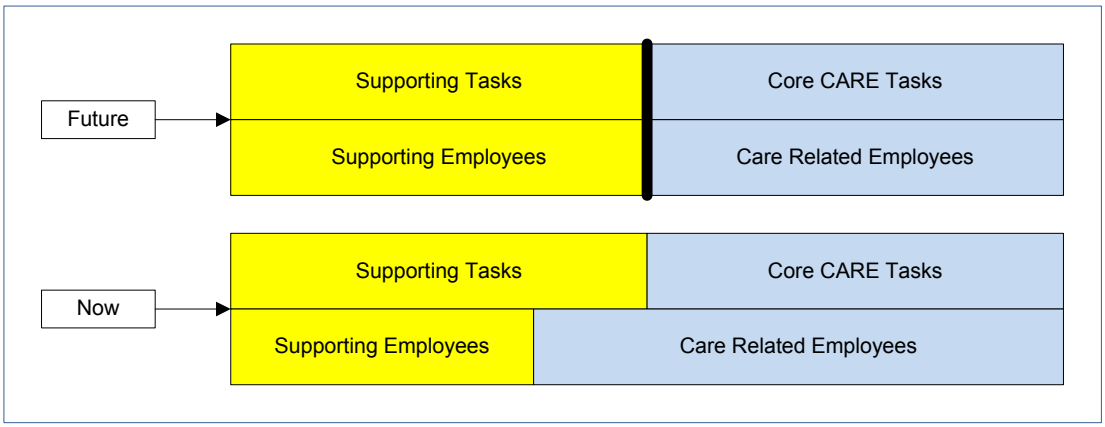


***Figure 54**, A hard cut between supporting tasks and core CARE tasks*

Besides reengineering the structure and organization of the logistical processes in the direction of an operation room, it also would be wise to recruit one (or several) full time integrators. Where organizations that are facing simple environments can rely primarily on the hierarchy, more complex organizations, like a university medical center, require more elaborate integration designs. A full time integrator is a position solely created for the purpose of coordination. These persons are located outside the department with the responsibility of coordinating various departments and processes. They are boundary spanners between departments and must be able to get people together, maintain their trust, confront problems and resolve conflicts and disputes **[**Mintzberg, 1985**]**.

In the current organization of the logistical processes in the direction of an operation room, there is no person with a multiform view of the complete process. Each departmental manager is optimizing his own processes, and the general manager is too busy with the general lines. It would thus be wise to recruit a full time integrator who can totally focus on the integration of – and the communication between the different concerned departments in the logistical process in the direction of an operation room. This full time integrator furthermore can initialize different lean/six sigma projects and can be the encourager and contact point for future developments.

5.2 How great are the interdependencies between the different involved persons and departments?

We already indicated that, *on paper*, the logistical process in the direction of an operation room could be categorized as a sequential process. When interdependence is of sequential form, parts produced in one department become inputs to another department. Although there are no products produced in this process, disposables and reusables that are processed by a certain employee or department become input to the subsequent department.
To be able to criticize whether the current functioning of the logistical process in the direction of an operation room is of sequential form, we examined the amount of emergency appeals. The amount of emergency appeals also are an indication of the current quality of the organization and functioning of the logistical process in the direction of an operation room.
We will continue this paragraph just like the results paragraph; we will look at the emergency appeals for non stock items, stock items and reusable items.

5.2.1 Emergency appeals for non stock items (*disposable cycle*)

The results of paragraph 4.2.1 showed a reasonable increase of the amount of emergency appeals for non stock items to an amount of 1429 in 2008. The different causes of the emergency appeals over 2008 were presented in table 21.
When analyzing the different causes of these emergency appeals for non stock items, it is possible to indicate whether these causes are preventable or unpreventable. The results are presented in table 48 and figure 55.

1	Late request/confirmation by appealing department	39%	Partly Preventable
2	Shortage in the warehouses	2%	Preventable
3	Crossed delivery period by suppliers	4%	Unpreventable
4	Irregular usage of products	25%	Preventable
5	Appeal to long at purchasing department	2%	Preventable
6	Patient commited product	9%	Partly Preventable
7	Part due to emergency repair	3%	Unpreventable
8	Remaining, not possible to specify	16%	Partly preventable

***Table 48**, Possible preventability of the causes of the emergency appeals over 2008*

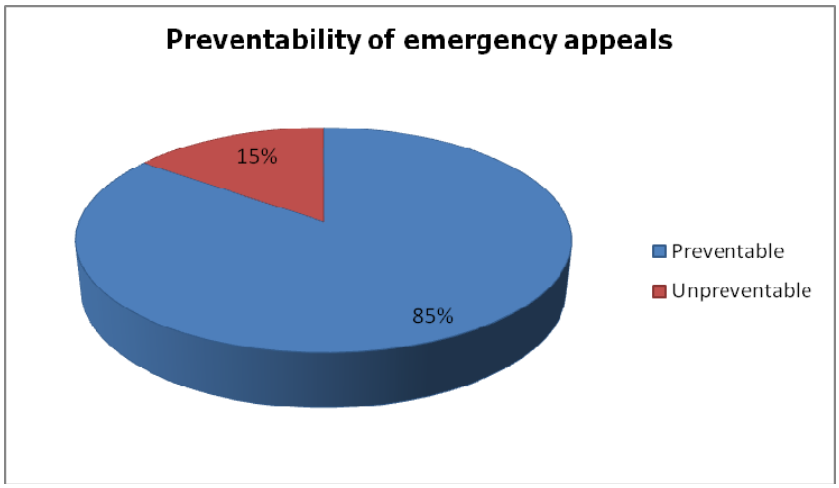


***Figure 55**, Possible preventability of the causes of the emergency appeals over 2008*

The table and figure show an indication of a possible preventability of maximal 85% of the emergency appeals. To be able to obtain this preventability amount, different changes have to be committed at the logistical processes in the direction of an operation room. The two main changes are:

- The already mentioned usage of a digital scanning system in combination with an inventory – or materials management information system
- Connecting the planning of surgeries to digital preparation protocols and a digital overview of the planned amount of inventory (figure 56)

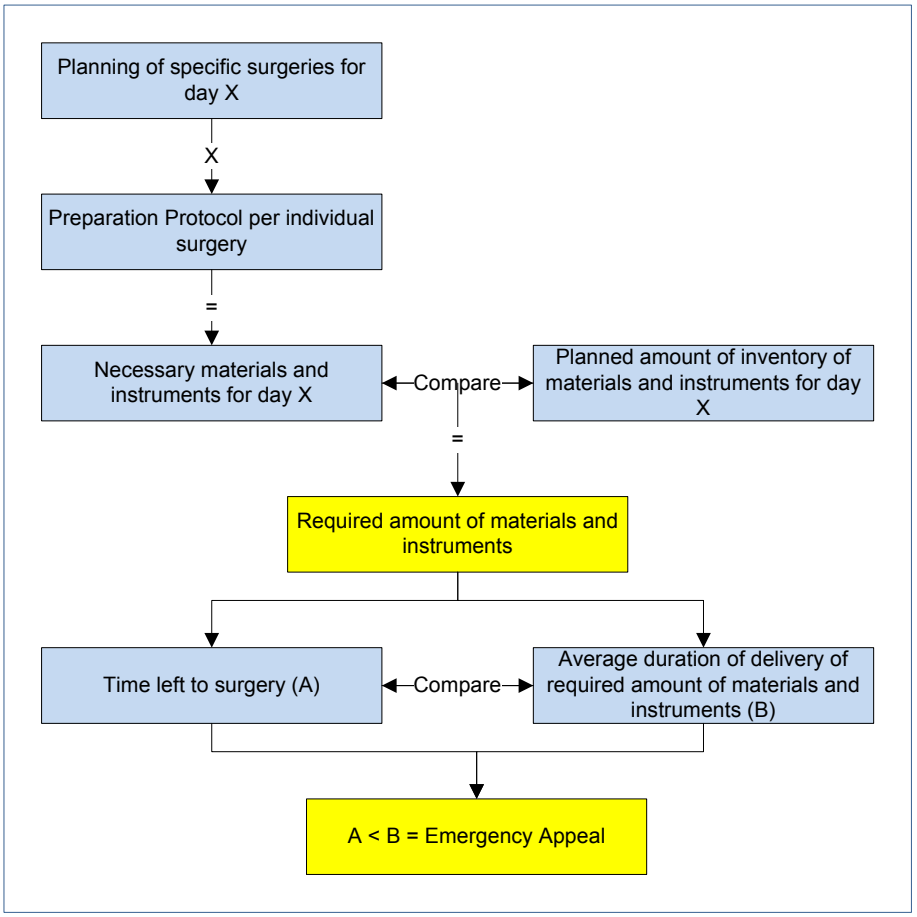


***Figure 56**, Connection between planning of surgeries, preparation protocols and planned amount of inventory*

Figure 56 shows the concept of connecting the planning of surgeries, the preparation protocols and the planned amount of inventory. The concept starts with the planning of a particular amount and sorts of surgeries on day X. Since it is possible to create a preparation protocol for each surgery, combining these data would provide an overview of the necessary disposables and reusables for day X.

When the operations center also is using the already mentioned digital scanning system in combination with an inventory – or material management information system, it would be possible to create real time overviews of actual (currently at the shelves) and planned (currently at the shelves plus planned replenishment supplies) amounts of stock.

The presence of both information systems provides the opportunity to make a comparison between the necessary products and the planned amount of inventory. The outcome of this comparison is an overview of necessary disposables and reusables that will not be present at the operations center on day X for surgery X. This information should easily be obtained by a simple check of the used information system (Chipsoft). This check should be executed several times a day. The outcome of this check is an input for possible next steps.

When it turns out that particular necessary disposables and/or reusables will not be present at the operations center on the day of the surgery, the responsible employees have the following options:

- Contact the specialism (surgeon or surgical assistants) whether other disposables or reusables can be used for the particular surgery
- Contact the supplier or SPD whether it is possible to deliver the necessary disposables and/or reusables before the day of the surgery without extra costs
- When the above two options are not possible, an emergency order can be created

The success of this system is dependent of the following factors:

- Quality and accuracy of preparation protocols
- Support of care related employees by the creation of the preparation protocols and by consultations in case of unique, not standardized surgeries
- Quality and accuracy of the used information system
- Quality and accuracy of the scanning process

The usage of this system will prevent emergency appeals because:

- Late requests or confirmations by appealing departments will be prevented. The connection between the planning and preparation protocols provides a timely overview of necessary materials for particular surgeries. Timely and effective consultations about unique or not standard operations furthermore will close the possible gaps that are the result of incomplete and/or inadequate preparation protocols (➔ possible maximum prevention of 39%)
- Shortages in the warehouses are monitored by the used inventory management system. Threatening shortages are communicated so that correcting actions can be executed (➔ possible maximum prevention of 2%)
- Irregular usages of products are also monitored by the used inventory management system and are timely noted because of the connection between the planning, preparation protocols and planned inventory (➔ possible maximum prevention of 25%)
- Patient committed products are also timely monitored because of the connection between the planning and the preparation protocols (in combination with timely consultations with surgeons and/or surgical assistants) (➔ possible maximum prevention of 9%)

Since the amount of emergency appeals for non stock items were expressed in monetary values, it also is possible to express the possible maximum preventions in monetary savings (table).

	Found emergency appeals	**Possible** total amount of emergency appeals
N	99	1214
Σ	€ 24.301,42	€ 296.601,99

***Table 49**, Possible maximum monetary savings*

The table shows that preventing 85% of the 117 found expenses on emergency appeals results in a decrease of the amount of emergency appeals of 99 and a saving of the amount of courier costs of €24.301,42. When we apply the percentage of 85% on the possible total amount of emergency appeals over 2008, we can present a possible decrease of the amount of emergency appeals of 1214 and a saving of the amount of courier costs of 296.601,99. We again would like to state at this point that the amount of 1214 emergency appeals is not a reliable number and that the 85% is a *possible maximum amount of saving*. In practice this probably would be a bit less.

5.2.2 Emergency appeals for stock items (*disposable cycle*)

The results in paragraph 4.2 show a total of 29 emergency appeals for 35 different products over the first six months of 2009. In total 7040 products with an average cost-price of €0.88 and a total cost-price of €6179.14 were transferred with haste from the LCE to the operations center.

When analyzing the aiming of the emergency appeals, the stock items, we can conclude that this generally are frequently used products with low purchasing prices. Examples are gloves, surgical caps, soap and sutures. This are products that make up a large part of the product range but only account for a small part of the inventory value. In terms of an ABC classification, these items can be defined as C items.
The ABC classification allows an organization to classify stock keeping units (SKU) into three different categories: A (very important), B (important) and C (least important). The efforts, amount of time and resources spent on inventory control should be in the relative importance of each item. By classifying an organizations inventory into different categories, managers can focus on the items that account for the majority of the inventory **[**Onwubolu and Dube, 2006**]**.
High priority A items have tighter controls on inventory records and more frequent reviews of forecasting, demand requirements, order quantities and safety stocks. Medium priority B items have similar controls compared to A items, but they take place less frequently. Low priority C items have the simplest controls. They are only important if there is a shortage of one of them. Therefore, lower value C items can be ordered in larger quantities and have higher safety stocks **[**Onwubolu and Dube, 2006**]**.

In practice it, however, is important that C items are always available. Under no circumstances should an item that costs only a few cents be allowed to delay a process which costs hundreds or thousands of Euros **[**Schönsleben, 2007**]**. When analyzing the results of the amount of emergence appeals of stock items, we unfortunately have to conclude that it does happens that these C items are (almost) out of stock and that emergency appeals are necessary.

To be able to prevent these situations to occur, a solution can be to implement a "two bin" or "topping up" system **[**Van Bokhoven et al, 2000**]**. In practice this means that the consumption of a package with C items automatically generates an order for a new package of these C items. This system minimizes the possibility of empty shelves and because of the simplicity of these systems, also the extent of work of employees is reduced. By using the two bin or topping up system in combination with automatic supply systems, the administrative processes are also minimized. The amount of inventory can be based on the historic use of the products whereby the amount should not be stated to tight.

5.2.3 Emergency appeals for reusable items (*reusable cycle*)

The results in paragraph 4.2 show a total amount of 1140 emergency appeals for reusable items over 2008. This means an average of 21.92 emergency appeals per week. Since the appealed instruments receive priority during the decontamination process, this great amount of emergency appeals disturbs the decontamination process in great extent.

When analyzing the origin of the emergency appeals we can indicate two main causes. We first of all can conclude that only 12% of the emergency appeals actually are emergencies and that 88% of the emergency appeals are orders and a form of *uncertainty reduction*. This means that appealing employees do not know and cannot see whether the required instruments are decontaminated in time. To be sure that they will be available in time, they will place an order at the sterile processing department. A lack of visibility of location and usage of reusable instruments, thus leads to a great amount of emergency appeals **[**Little and Coughlan, 2008**]**.

The second cause of the emergency appeals is not taking into account the available amount of certain necessary sets when planning the surgeries. We found that it often are the same instruments and instrument sets that need an emergency appeal. This means that:

- There is a too small amount of certain instruments and instrument sets, or
- The planning department does not reckon with the agreed decontamination time of 12 hours. The agreement between the SPD and the operations center is that a used set will be back on the shelves within 12 hours. This means that a used set is not available for a maximum of 12 hours. This furthermore means that an instrument and/or instrument set can be used only once a day

To prevent and reduce the occurrence of emergency appeals for reusable items, it can thus be concluded that a greater amount of visibility (for SPD employees, care related employees and the planning department) is required. A solution can be the earlier mentioned implementation of a digital control system, as used in the retail and grocery industry, and a connection of this system with the planning, the preparation protocols and the actual inventory.

On day X different surgeries are planned. Based on the preparation protocols it is possible to determine which instruments and instrument sets are required on this day X. A comparison of the planned inventory and the required instruments on day X results in an overview of not available instruments and instrument sets (without interceding of involved employees). This can be input for further future actions. The real time overview of available and not available instruments and instrument sets, however, will reduce the amount of emergency appeals.

> The planned inventory is an overview of the inventory at moment X. This planning is based on the actual inventory plus the instruments and instrument sets that are planned to return from the SPD. This return planning can be based on the agreed decontamination time of 12 hours. After usage in an operation room (this is recorded by scanning) the particular instruments and instrument sets can be blocked for 12 hours. This block can be cancelled when the instruments and instrument sets enter the warehouse again (this is also recorded by scanning).

Besides creating an improved visibility of the instruments and instrument sets, it also is necessary that the planning department reckons with the amount of available reusables when planning the surgeries. Because of the agreed decontamination time of 12 hours it is not possible to use an instrument or instrument set several times a day without emergency appeals. The planning therefore has to be based on the amount of available instruments and instrument sets. When only two laparoscopic sets are available, it will not be possible to plan three laparoscopic surgeries with the current decontamination time. To be able to use instruments and instrument sets several times a day, there are two options:

- The agreed decontamination time has to be lowered. The Martini Hospital for example has an agreed decontamination time of *only 4 hours*. It would be interesting to research the causes of this great difference.
- The specialism or SPD (dependent on the owner) has to buy extra instruments and/or instrument sets. When registering the targets of the emergency appeals (which sets), it can be examined whether it often are the same instruments and instrument sets and whether it thus is necessary to obtain some extra items of these instruments and instrument sets.

The described solution is already in use at the Deventer Hospital. A screenshot of the used information system (also Chipsoft) is presented in *Appendix Book XXIII*. The figure clearly shows the shortage of 4 sets for today and 22 sets for tomorrow. It also specifies the kind of sets that are needed. The information on this screen is an input for the processes at the sterile processing department. The advantage is that the surgical assistants or logistical employees now do not have to start telephoning again that particular necessary instruments are not available. This then is real time visible at a screen at the SPD. Possible changes in the surgical schedule and consequences for required instruments also will automatically be processed on the screen.

5.2.4 Interdependency of the logistical process in the direction of an operation room

Regarding the amount of emergency appeals for stock items, non stock items and reusable items, it can be concluded that the logistical process in the direction of an operation room currently is not of sequential form. Information and products are not sequentially flowing from A to B to C, but "from A to C, back to A and then to B". Although this logistical process on paper would be classified as sequential, it currently functions in a reciprocal way **[**Thompson, 2008**]**. This is a clear indication that the process functions in a suboptimal way and that interventions are necessary.

5.3 How great is the task diversity of a surgical assistant and what are the consequences of placing the transition point at this function?

Figure 54 presented the proposed hard cut between supporting tasks and core CARE tasks. This proposal is the result of different studies that indicated that transferring a maximum amount of tasks and responsibilities to those workers actually adding value would have positive effects on the quality, speed and costs of the core processes [Womack, 2005]. Since patient care has become a sequence of demands and deliveries, the supply function has become too specialized for care related employees to handle by themselves [Lee, 1971]. Besides that, health care professionals have limits on how far their labor flexibility can go. Too much worker responsibility, multi-skilling and job variety does not lead to better performance and employee well-being.
The current organization, whereby the surgical assistant function (walk around) is the transition point from logistical – to care related tasks, requires a high level of flexibility and multi-skilling. A too high level of flexibility and multi-skilling can lead to general health problems and job stress [Moad, 1993]. In a time where demand for surgical assistant resources far exceeds the available supply of surgical assistant time, it therefore is critical that they are set free of as many non-patient care tasks as possible. By freeing the care personnel from logistical tasks, they can spend more time at delivering care [Barlow, 2008].
In this paragraph we will analyze whether the work of surgical assistants comprises too much logistical elements and whether this influences the quality, costs and speed of care.

5.3.1 General Work of Surgical Assistants measured using MDWS

The analysis of the current tasks and activities of a surgical assistant (walk around) with the multi-dimensional work sampling technique supports the idea that the current organization of the surgical assistant function (walk around) consists of a high percentage of non care related tasks. Table 29 showed that only 62% of the tasks is care related and that 30% is non care related (8% is administrative). As already mentioned, because of the presence of a sector assistant at Sector 1 and not at the other 2 sectors, we expect an higher percentage of care related tasks for the inside walk around and a lower percentage of care related tasks for the outside walk around.
A further analysis of the data furthermore showed that in only 59% of the measurements, surgical assistants were working or actively executing tasks. In 41% of the measurements they were waiting for new tasks / observing the surgeries.

An important question to raise at this moment is, whether it is important to analyze the current organization of the surgical assistant function? Different supporting answers can be provided:

- Currently there are great shortages of surgical assistants in Dutch hospitals. A research of the amount of vacancies of surgical assistants in Dutch hospitals on May 14th 2009 supported this picture (figure 57). An analysis of the websites of all the vacancies on the websites of all the Dutch hospitals showed that 72% of the hospitals had a vacancy for a surgical assistant (also look at *Appendix Book XXIV* for the total overview). The consequences of these vacancies are:
    - Extra tasks for the remaining surgical assistants, which can lead to more general health complaints and job stress
    - Postponement of surgeries, which leads to longer waiting lists

This means that freeing the surgical assistants of non care related tasks creates extra time for care related tasks (it is not directly suggested that the waiting lists therefore will decline).

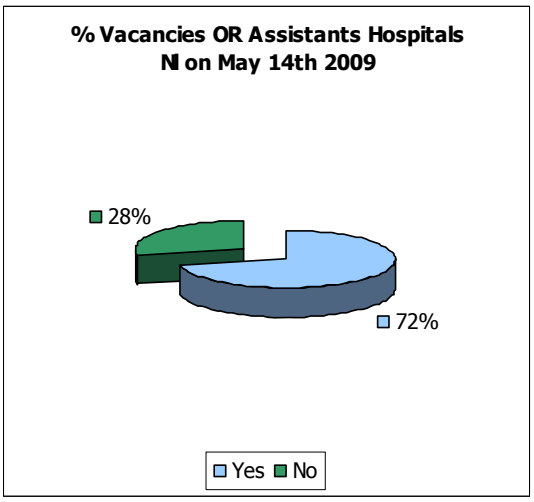


***Figure 57**, Percentage vacancies of surgical assistants in Dutch hospitals*

- Letting the non care related tasks form part of the tasks of a surgical assistant, has a great influence on the quality, speed and costs of the logistical process in the direction of an operation room. This will be explained in the following paragraphs.

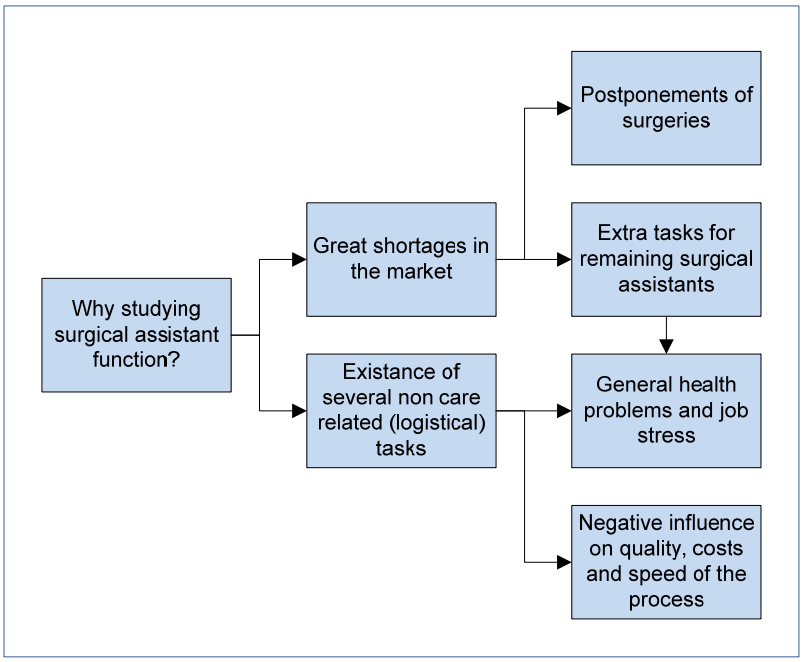


***Figure 58**, Reasons to study the surgical assistant function*

5.3.2 Amount of times out OR and amount of door movements

Surgical assistants with walk around function often need to leave the operation room for logistical related tasks. The study of the amount of OR leaves of surgical assistants showed an average amount of 12.1 OR leaves per day. A surgical assistant leaves the OR for on average 73 seconds (with a standard deviation of 46.6 seconds), which means that a surgical assistant, in all, is out of an operation room for 14.7 minutes per day. The study further showed that 71% of the OR leaves is logistical related.

When regarding the general description of a surgical assistant in *Appendix Book XVII*, it is possible to see that, normally, one surgical assistant with walk around function is present in an

operation room. The core task of this surgical assistant during a surgery is handing required disposables and reusables to the instrumenting surgical assistant. When a surgical assistant with walk around function thus leaves the operation room to collect not present instruments or to fill the surgery cart he or she indirectly endangers the patient. The different case examples showed that during the research it happened several times that we had to hand required materials to the instrumenting surgical assistant because the surgical assistant with walk around function was out of the OR for logistical related reasons.
Besides endangering the surgeries, leaving the OR also influences the speed of the surgical process. When nobody else is in an operation room to hand required materials and instruments to the instrumenting surgical assistant, the surgery will be delayed since the surgeons and assisting surgical assistants have to wait until the surgical assistant with walk around function has returned. With an average cost price of €1000 per hour per operation room, significant delays will rapidly result in significant monetary losses.

Besides the surgical assistants with walk around functions, there also are other employees walking in and out of the operation room. Table 33 and table 34 showed the amount of door movements during Thorax surgeries and Orthopaedic surgeries. The table showed an average amount of 33.1 door movements during Thorax surgeries and an average of only 2.4 door movements during Orthopaedic surgeries. A door movement can be the opening of a door and the closing of a door.

This research towards the amount of door movements generates a striking conclusion. The amount of door movements at the Orthopaedic surgeries is much lower than the amount of door movements at the Thorax surgeries. The explanation for this difference is that at the Orthopaedic surgeries an outside walk around (surgical assistant) is responsible for all the logistical tasks. At the Thorax surgeries, the surgical assistant has to leave the operation room to collect missing instruments. At the Orthopaedic surgeries the outside walk around collects and delivers these missing instruments at the operation room. The result for the Orthopaedic surgeries is:

- Much less door movements
- Much less endangering of the surgeries since there always is a surgical assistant with walk around function present at the operation room
- Less delays of the surgeries since surgeons and assisting surgical assistants do not have to wait until the surgical assistant with walk around function has returned in an operation room (when they need extra materials and/or instruments)

Besides the endangering of the patients and the consequences for the duration of the surgery, the different door movements also are influencing the sterility of the operation room. Based on the detailed background in *Appendix Book XXV* it is possible to conclude that the great amount of door movements are influencing the overpressure of an operation room. Since an operation room needs an overpressure to prevent against the existence of micro organisms in the sterile area around the surgery table, the amount of door movements result in higher opportunities for infections. This is especially the case at prosthesis and implant surgeries.

This also is the reason why the Orthopaedic department decided to implement a "closed doors policy". Only in really essential occasions, employees are allowed to leave an operation room. This clearly is visible in the difference between the amount of door movements at Thorax surgeries and Orthopaedic surgeries. To be able to facilitate this policy, the Orthopaedic department uses distinct outside walk around surgical assistants. This makes it possible that inside walk around surgical assistants stay inside an operation room since all the logistical tasks are executed by the outside walk around. The consequences of this policy on the infection rate of

Orthopaedic surgeries is presented in table 50 and figure 59. The table and figure show a decrease of the post operational wound infection rate from 6.3 and 5.7 until 2000 to 2.9 and 3.2 in 2007.

	Hip prosthesis	Knee prosthesis
01/10/98 - 01/10/00	6.3	5.7
10/09/01 - 01/10/03	8.8	8.4
01/10/03 - 2005	2.9	4.3
2005 - 2007	2.9	3.2

***Table 50**, Percentage post operational wound infections Orthopaedics*

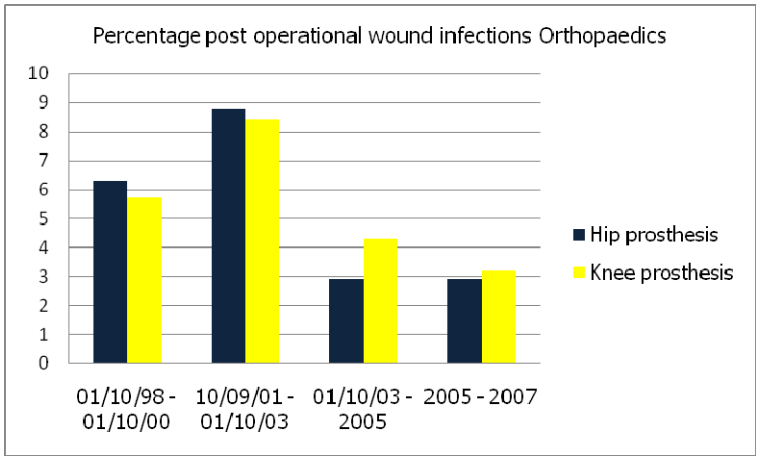


***Figure 59**, Percentage post operational wound infections Orthopaedics*

Figure 60 shows that it obviously looks like the decrease of the post operational wound infections is, among others, related to a decrease of the amount of door movements at Orthopaedic surgeries.

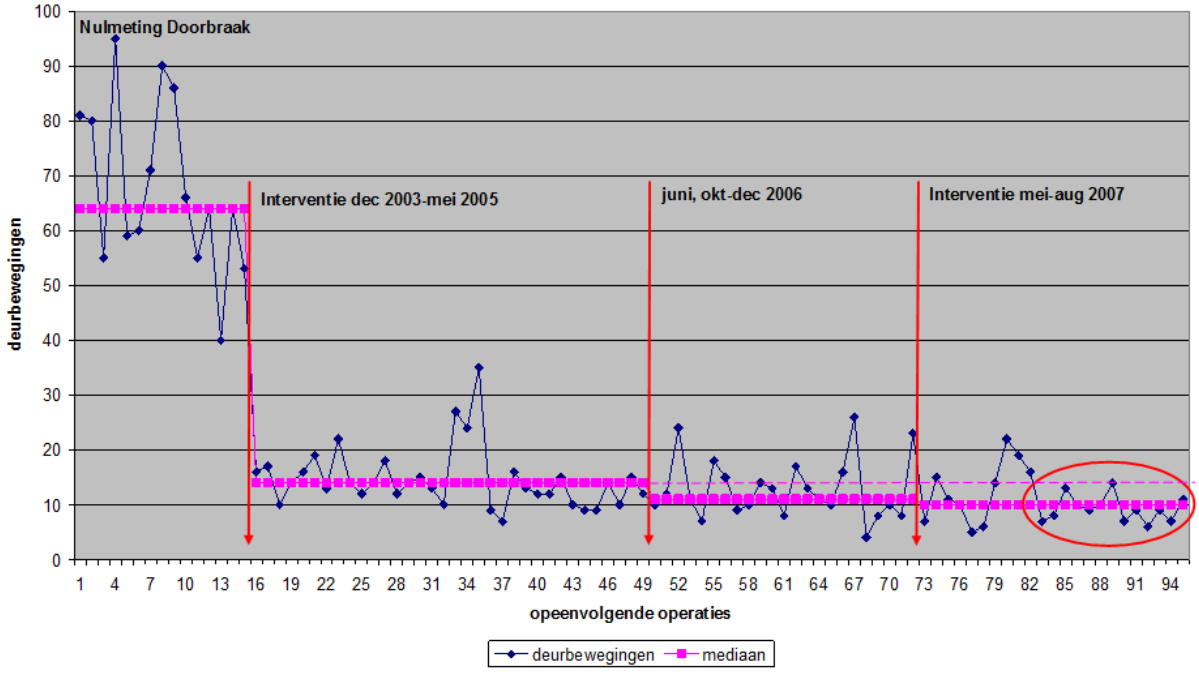


***Figure 60**, Decrease of the amount of door movements at Orthopaedic surgeries*

The data in the table legitimizes the "closed door policy" of the Orthopaedic surgery. Besides less door movements, less endangering of the surgeries and less delays of the surgeries, it thus also may result in a higher sterility of the operation room. Based on the earlier discussion about the hard cut between care related tasks and facilitating tasks, the limits on the flexibility of surgical assistants and freeing care personnel of non-care related tasks it however is important to wonder whether the surgical assistant is the right person for these tasks. We already mentioned the *great shortages of surgical assistants*, but there also is a *monetary aspect* and a *quality aspect*.

Surgical assistants are classified in the 7th or 8th salary scale (*Appendix Book XXVI*). This means that their salary varies from €1986 to €2937 per month. Logistical employees, who in theory could execute the logistical tasks that currently are executed by surgical assistants, are classified in the 3rd or 4th salary scale. This means that their salary varies from €1534 to €2217 per month. This means a difference per employee of €452 to €720 per month.

The final argument that legitimizes the discussion about the execution of logistical tasks at an operations center is based on quality aspects. Different studies stress the quality of logistical employees when compared to care related employees in the execution of logistical tasks. Logistical employees have got more dedication, more effort and more time to execute these tasks. They besides that also have higher interests, higher motivation and better education to do it effectively, efficiently and properly **[**Barlow, 2007**]**. As a result, the dynamics between the OR and a logistical department can change and logistical employees can take over logistical responsibilities of surgical assistants. To align the surgical services with the logistical processes, tightly integrated scanning and inventory management systems (as described in the previous paragraphs) are required **[**Wyatt, 2006**]**.

5.3.3 Average materials preparation time

Besides leaving the operation room for logistical tasks, another important logistical task of the current organization of the surgical assistant function is the preparation of necessary materials for a surgery. Currently this task is executed by a sector assistant (Sector 1) and the (outside walk around) surgical assistants (Sector 2 and Sector 3). The results in paragraph 4.3.4 showed an average materials preparation time for the sector assistant of 9.2 minutes by an average amount of 31 products and an expected average materials preparation time of around 15 minutes for the surgical assistants of Sector 2 and Sector 3.

To be able to examine whether the average materials preparation times are lower when:

- surgeries are prepared by logistical employees
- logistical employees are using picking lists
- all the materials are stocked in one warehouse
- materials are clearly identified
- materials are combined in procedure trays (all these advantages were mentioned in the theoretical framework)

…we also executed the materials preparation study at the Martini Hospital Groningen. At this hospital, the surgeries are prepared by logistical employees (salary scale 3 and 4), the logistical employees are using picking lists (*Appendix Book XXVII and Appendix Book XXVIII*), almost all the reusables and disposables are stocked in one warehouse (*Appendix Book XXIX*), the materials are clearly identified (to correspond with the picking lists) and a great amount of materials is combined in procedure trays (*Appendix Book XXX*).

	N	TimeTOT	X Products	X TIME p/cart	Average TIME p/product**
Sector Assistant UMCG	20	183.2	621	9.2	17,7
Surgical Assistant UMCG		Unknown	Unknown	15*	Unknown
Experienced Log. Empl. Martini	29	81.3	412	2.8	11,8
Inexperienced Log. Empl. Martini	23	116.5	260	5.1	26,9

* Based on interviews
** Measured time is in *seconds*

***Table 51**, Average materials preparation time*

Table 51 clearly shows the difference between the average materials preparation time at the UMCG and the Martini Hospital Groningen. The sector assistant at the UMCG needs 9.2 minutes to prepare a surgical cart for a surgery, an inexperienced logistical employee of the Martini Hospital needs on average 5.1 minutes and an experienced logistical employee of the Martini Hospital finally on average only needs 2.8 minutes to prepare a surgical cart. Based on different interviews with surgical assistants of Sector 2 and Sector 3, we can conclude that a surgical assistant at the UMCG on average needs 15 minutes to prepare a surgical cart.

As is visible in table 52, the Martini Hospital on average uses a great amount of the already mentioned procedure trays. Procedure trays are sterile packets which are compiled based on the requirements of the users. The packets carry as much disposables (that are required during a surgery) as possible. It is possible to create a procedure tray for each specialism. The advantages are optimal when the procedure trays are used by the entire organization, instead of only by a few specialisms. The main advantages of the procedure trays are:

- Preparing surgical carts for a surgery takes less time since it now is possible to take a single tray instead of different loose products from the shelves
- Clearing away replenishment stocks takes less time since it now is possible to place a single tray on the shelves instead of different loose products
- Preparing surgeries takes less time since the preparing employee now only has to open a procedure tray instead of placing different loose products
- The amount of stock is reduced since a great amount of the loose disposables is stocked at the supplier of the procedure trays
- The supplier of the procedure trays purchases greater amounts of individual disposables since he creates procedure trays for several hospitals. This leads to higher quantity discounts and thus to lower prices of the individual disposables
- More standardization of the disposables assortment **[**Werner, 2002; Hesson, 2004**]**.

	N	Total amount of products	Average amount p/cart
Procedure trays Martini Hospital	25	1106	44.2
Procedure trays UMCG	1	46	46

***Table 52**, Average amount of procedure tray products*

Because the Martini Hospital is using more procedure trays than the UMCG (*Appendix Book XXX*), the logistical employees need to collect less materials from the shelves than the sector assistant and surgical assistants at the UMCG. We therefore also looked at the preparation time per product. Table 51 shows that the sector assistant on average needed 17.7 seconds per product, the inexperienced logistical employees of the Martini Hospital 26.9 seconds and the experienced logistical employees 11.8 seconds per product. These results demonstrate that the logistical concept of the Martini Hospital, an integrated logistical service center, among others leads to faster preparations of necessary materials.

5.3.4 General Health and Utrecht Burnout Scale

The different results and discussions that are presented until now show that the current organization of the surgical assistant function comprises different logistical related tasks. This combination of logistical and care related tasks requires a great flexibility of the health care professionals. We also already stated that health care professionals have limits on how far their labor flexibility can go. Too much worker responsibility, multi-skilling and job variety does not lead to better performance and employee well-being and can result in job stress. The results of our research towards job stress, general health and appreciation of the logistics, supported the different theories we found in the different consulted journals.

The results of the general health of the surgical assistant showed that the average health of a surgical assistant is bit worse than usual. This is not a real alarming result and can be explained by the great shortages on the labor market en the resulting extra pressure on the remaining surgical assistants.
The high percentage (31%) of individuals that filled in the questionnaire and need extra attention or intervention, however, does is alarming. Regarding the shortages on the labor market, the UMCG cannot afford the leaving or illness of more surgical assistants. It therefore is important that interventions are implemented as fast as possible.

Besides a research towards the general health of the surgical assistants, we also researched the burnout scale of the surgical assistants. The results of paragraph 4.3 show that the high average score on exhaustion, the high average score on depersonalization and the low average score on personal accomplishment indicate serious burnout signals at questioned surgical assistants of the UMCG. We further showed that 21% of the surgical assistants need extra attention and interventions regarding their high scores on the three researched categories.

The different results of our research towards the general health and burnout scale of surgical assistants show that the current organization of the function leads to great possible health problems of the surgical assistants. Because of the labor shortages and the required flexibility, the questioned surgical assistants show serious signs of health complaints and burnouts. This situation raises the chance of more job switches, discharges and illnesses of surgical assistants. This is something which would endanger the quality of care and the continuing of the delivery of care. It further also will lead to extra expenses (hiring more temporary workers) and lower incomes (empty operation rooms). Every possibility of sparing surgical assistants should thus be considered.

These results of our research towards the general health and burnout rate of surgical assistants legitimize our discussion about a hard cut between care related tasks and supporting tasks. We already mentioned the influence on the quality, speed and costs of the logistical processes, but now we can also show the influence on the health of the surgical assistants. Releasing them from logistical tasks will decrease the required flexibility and will provide extra time for care related tasks. This will positively influence the experienced stress of the surgical assistants since they then have more time for executing care related tasks **[**Langham, 2007**]**.

This conclusion is also supported by our research towards the stressors of the surgical assistants. The results showed that the suboptimal recovery possibilities, vagueness of tasks, high work speed and *quantity*, high emotional strain and (mainly) high *work strain* are leading to stress experience of the surgical assistants.

5.3.5 Job descriptive index

Besides researching the general health and the burnout scale of surgical assistants, we also studied the Job Descriptive Index (JDI) of the surgical assistant function. The JDI is the mostly used instrument to measure work satisfaction **[**Hanisch, 1997**]**.
The results in paragraph 4.3 showed that the average score of the surgical assistants on the JDI was 2.34. This means a score below the average of all the different professions in The Netherlands. This means that surgical assistants in the UMCG are not really satisfied with the current organization of the surgical assistant function. Out of the different studied categories it turned out that the job on average is:

- Not creative
- Not respective
- Tiring
- Bad for the health
- Frustrating

These five categories can be an input to a more detailed research towards the current organization of the surgical assistant function. The five mentioned categories can be a starting point in this research. It further also is advised to also consider the earlier results of the general health and burnout rate of the surgical assistants. We finally also would like to remember the high percentage of "waiting for work" of the surgical assistants with walk around function. It might be sensible to study whether this function, for example in a time of shortages, also can be executed by other employees (for example sterile processing department employees or logistical employees).

5.3.6 General logistical questions

Although the different results show that the current organization of the surgical assistant function has a negative influence on different performance indicators and that interventions are required, it also is important that these interventions are supported by the surgical assistants **[**Rousseau and Tijoriwala, 1999**]**. We therefore also studied the opinion of the surgical assistants concerning the organization of the logistics at the operations center as a motivation of possible future changes.

Based on the different results in paragraph 4.3 we can conclude that the general opinion concerning the current organization of the logistics is really negative. Although the average opinion on the questions whether logistical tasks are part of the surgical assistant function and whether surgical assistants should prepare the necessary materials for a surgery were slightly positive, the high standard deviations indicate a great disharmony under the surgical assistants. Based on the answers on the questions whether they enjoy the logistical tasks and whether they appreciate the current organization of the logistics at the operation center it is possible to conclude that the surgical assistants do not support the current organization. It therefore also is not surprising that they value the question whether the logistical tasks at the operations center should be executed by logistical employees instead of surgical assistants with a 6.24 (on a 10 point scale).

Although we can conclude that the surgical assistants do not support the current organization of the logistics at the operations center, there also is a great disharmony (regarding the high standard deviations). We therefore studied the relation between the age of the surgical assistants and their appreciation of the logistics. The results in paragraph 4.3 indicate the possible existence of a relation. With the exception of the 50-59 years category, it is possible to see that the younger

surgical assistants have a lower appreciation of the logistics than the older employees. The age of an employee is thus influencing the opinion. Based on research by Peeters and van Emmerik **[**2008**]** it is possible to classify the possible moderators in three categories:

- cognitive ability changes
- physical and functional changes
- mental health changes

Since there exists ample evidence that the physical and functional conditions change as one grows older, it is expected that the different opinions result from the other two categories. Two declarations can be applied. We first of all expect that older workers would have greater difficulty performing tasks that require retention of large amounts of information or that require rapid cognitive processing **[**Peeters and van Emmerik, 2008**]**. This of course is the case in the current IT era, and might be a declaration of the high valuation of the current (and historic) organization of the logistics.
The second possible declaration of the higher valuation among older employees is that older employees are likely to be more satisfied with their jobs than younger employees. Younger employees are more willing to invest in improvements and changes, while older employees are more easily satisfied with "how things work nowadays" **[**Oswald and Warr, 1996**]**.
It can thus be advised to approach older employees in a different way, in case of possible changes and interventions, than younger employees. It is necessary to consider their changed cognitive ability and mental health. Besides that it also can be sensible to consider the work history of the employees. A separation of the appreciation of the logistics at the operations center based on work history showed that employees who had worked at a different hospital than the UMCG, appreciated the logistics with a lower mark than employees who had worked their entire life at the UMCG. These employees, who worked as surgical assistant in other hospitals, might have experienced a different (and perhaps better) organization of the logistics and can provide the UMCG valuable improvement possibilities.

We finally also presented several comments of the surgical assistants regarding the current organization and procedures of the logistics at the operations center in *Appendix Book XXXI*. These comments also clearly indicate the opinion of the surgical assistants concerning the current organization of the logistics.

5.4 What is the origin of the demand for reusables and disposables?

As already stated in the previous chapters, the health care industry is characterized by a great variability in demand. In this research, demand can be further defined as demand for surgeries and the resulting demand for medical resources. Different kinds of demand were already mentioned whereby a division can be made between emergency – and elective demand. Emergency cases arrive randomly and must be served immediately on the same day. Elective cases can be delayed and planned for future dates **[**Li et al, 2002**]**.
In health care delivery, the inability to meet demand has more serious consequences than it does in other services such as restaurants, travel providers, beauty salons, retail shops, or hotels. Denying or limiting service to patients can have negative consequences, including patient death. In some other service areas, a limited ability to meet demand can even have a positive impact for the service provider because it creates an image of exclusivity that may enable the organization to raise its fees. The situation is quite different in health care, where hospitals must incur high costs for enough slack resources to provide timely care to all patients **[**Jack and Powers, 2004**]**.
Appropriate demand management decisions through planning and control can positively affect hospital cost performance. Hospitals that put more effort into demand management are better in improving capacity utilization, holding down average patient cost and achieving higher labour productivity as compared to their competitors **[**Li et al, 2002**]**.

5.4.1 Amount of surgeries

The current demand for reusables and disposables (towards suppliers) is not based on the demand for surgeries. Instead of pulling the resources to an operation room, the materials are pushed to the warehouses. Instead of using *the time* as a buffer, the UMCG is using *inventories* as buffer. Switching to a pull based strategy can thus lead to lower inventories. Most health care providers however are hesitant against implementation of a just in time system because of a common feeling of not being able to predict the production capacity and scheduling. An often heard argument is that hospitals are facing a great amount of short term emergency demand and that there just is not enough time to implement a just in time strategy.

When we however analyze the different amount of surgeries over 2008 and the planning horizon of the surgeries, it is possible to dispute this feeling. Figure 61 presents the maximum execution time of the four different sorts of surgeries at the UMCG (elective, urgent, emergency and acute), the required preparation time for surgeries (which in this case consists of the materials preparation time and the transport time from the LCE to the operations center). To clarify our statements we are using an imaginary surgery on 08:00 hr. The transport time from the SPD to the OC is not considered since it always is less than the transport time from the LCE to the OC.

Normally, the planning on this day x is filled with elective surgeries. Based on the waiting lists and the conditions of the patients on the waiting list different surgeries are planned. These elective surgeries are presented as the green bar in figure 61. The normal preparations for a surgery are based on these elective surgeries. These surgeries are always in time known by the preparing employees. During the morning, the surgeries for the subsequent afternoon are prepared. The surgeries for the morning are prepared during the afternoon.
It however happens each day that emergency surgeries need to be planned. As already mentioned, three different emergency surgeries can be distinguished. The urgent surgeries (yellow bar) must be executed within 24 hours. The figure shows that these surgeries are known on the moment that the final planning (14:30 hr.) and real planning (18:00 hr.) become final. This means

that the planning department can incorporate these urgent surgeries in their planning and that the preparing employees can incorporate these surgeries by their normal preparing.

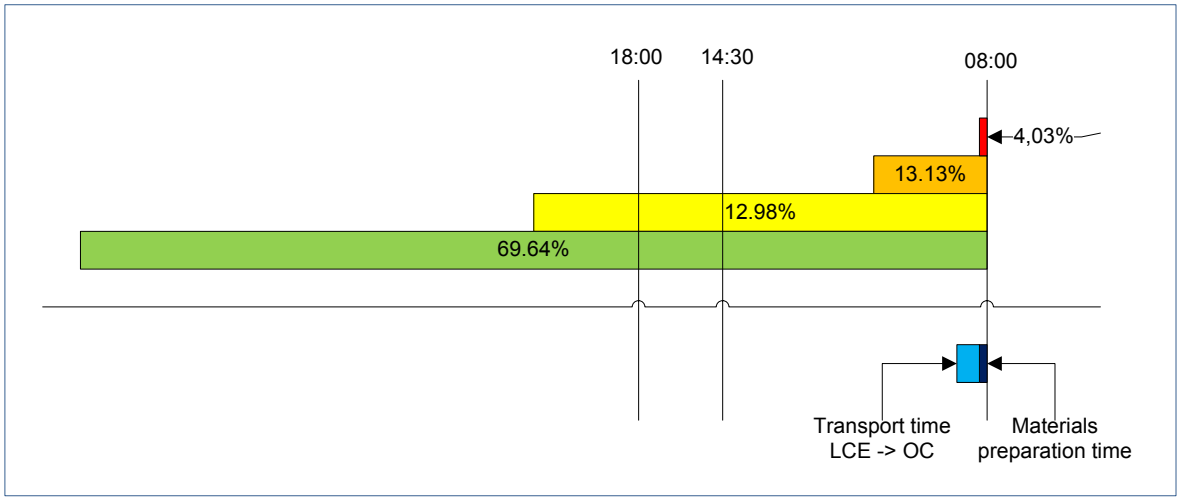


***Figure 61**, Maximum execution time and required preparation time of surgeries*

The emergency surgeries (orange bar) must be executed within 6 hours. As is shown in figure 61, it will not be possible to incorporate these surgeries at the normal planning and preparing. This means that these surgeries are planned in short run instead of an elective or urgent surgery and that the preparing should take place on a later or earlier moment than the standard preparations. Since these surgeries however must be executed within 6 hours, there is enough time to prepare these surgeries. As was presented in the subsequent paragraphs, the materials preparation time (dark blue bar) in the current situation has a maximum of 15 minutes and the transport time from the LCE to the OC (light blue bar) has a maximum of 60 minutes. This means that *4 hours and 45 minutes* are left for possible delays or occupation at the LCE (because for example not present materials need to be collected and prepared for transport to the OC).

The acute surgeries (red bar), finally, must be executed at once. This means that no time is available for materials preparations and transport of necessary materials from the LCE to the operations center. The necessary disposables and reusables should immediately be ready for use.

Based on the above discussion we can state that hospitals indeed are facing a great amount of short term emergency demand (30.36%). Figure 61 however shows that *only 4.03% or 634 surgeries* (2008 data) cannot be buffered with the available time until the moment of surgery. In view of the fact that the UMCG currently is using high inventories as buffer, it thus is possible to significantly reduce the amount of stock and use the available time as buffer.
The 4.03% or 634 acute surgeries per year mean an average of *1.73 acute surgeries per day*. Since it is not possible to buffer these surgeries with time, these surgeries should be buffered with inventory. A solution can be to create a certain amount of emergency carts (divided per specialism). These carts are filled with all possible necessary disposables and reusables for an acute surgery and are stocked in a special part of the warehouse so that they can be transported to the operation room as fast as possible when they are required. These emergency carts are also used at the Martini Hospital Groningen and the Medical Center Leeuwarden. An example of a picking list for an emergency cart of the MCL is presented in *Appendix Book XXVIII*. It is important that after usage, a new emergency cart is created as fast as possible.

We furthermore also would like to regard to figure 40 again. This figure is again presented as figure 62 and discusses the location of the customer order decoupling points.

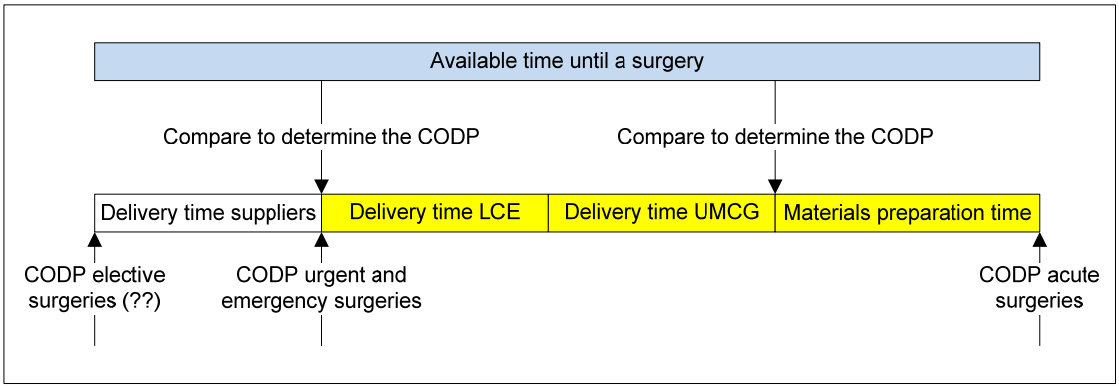


***Figure 62**, A comparison between the available time until a surgery and the total logistical process time (composed out of four different processes) determines the location of the Customer Order Decoupling Point. The yellow coloured process times are studied in this research*

Based on figure 62 we can conclude that there probably are three different customer order decoupling points in the logistical process in the direction of an operation room. Since the acute surgeries should be executed at one, the demand to these researches cannot penetrate in the logistical process. The urgent and emergency surgeries should be executed between 6 – 24 hours. Since this amount of time is greater than the total materials preparation time plus delivery time UMCG plus delivery time LCE, the CODP theoretically can be placed at the LCE. This theoretically means that all the medical resources for these surgeries can be stored and prepared at the LCE. The location of the third CODP, for the elective surgeries, is dependent on the delivery time of suppliers. When the necessary delivery time of suppliers is less than the available time until a surgery, it is possible to place the CODP at the suppliers. This means that the total demand for medical resources can be based on the actual demand for elective surgeries and that materials can be delivered just in time.

To be able to facilitate the just in time preparation of necessary materials for surgeries at the UMCG, a few conditions are of course required:

- The preparing employees (logistical employees are advised) should always be accessible
    - They should be informed when an emergency surgery (executed within 6 hours) is planned and material preparations are required
    - They should be informed when the surgery planning is changed and other preparations are required
    - They should be contacted when extra materials are required in an operation room (the logistical employees should bring these materials instead of surgical assistants leaving the OR to collect them)
        - It is advised to extend each logistical employee a mobile telephone so that they always can be reached. To be able to reach the logistical employees effectively, each operation room should also be equipped with a mobile phone (instead of the current fixed phones on the wall)
- There should be an elaborate insight in the locations of the different reusables and disposables to be able to trace the location of necessary materials. This should be reached with the use the earlier mentioned materials scanning system
- Preparation protocols should be as reliable as possible (can be obtained with information that results from implementing a scanning system)

Based on the above discussion about the maximum execution time and required preparation time it is possible to conclude that, although it on beforehand it is not possible to know the occurrence of an emergency surgery, the demand is not as variable as thought on beforehand.

Because of the minimal materials preparation time and the wide maximum execution time of the greatest percentage of the surgeries, it often is possible to prepare a surgery within the available time buffer. It can be stated that only 4.04% of the demand is unpredictable and variable.

5.4.2 Planning of the surgeries

Because of the importance of high operating theatre efficiency in terms of overtime and throughput time as well as waiting list reduction, a reliable planning of surgery time is required. In the current realization of the planning the surgery times are based on "always used" time slots. This means that no single historical variable is taken into account.
To be able to make the planning of surgery time more reliable it is advised to base the surgery time on:

- Historical cutting time of a surgeon (available in OK plus)
- ASA Code of a patient (patients with a higher ASA code possibly need more time)
- Present surgical assistants (available in OK plus)

This manner of surgery time planning is also applied in the Deventer Hospital. Based on the historical cutting time of a surgeon and the present surgical assistants, a reliable surgery time is obtained. The consequence of this way of planning is different but more reliable time slots for similar surgeries executed by different surgeons. *Appendix Book XXXII* presents an OK Plus screenshot of the "specialist vs. verrichting" application. With this application it is possible to base the time slots on the cutting history and present surgical assistants.

5.4.3 Sorts of surgeries, requirements per surgery and specific wishes of the surgeon

As already mentioned, the most important elements of the preparation procedure are the preparation protocols (*Dutch: klaarzetboeken*). Preparation protocols are standardized lists of the necessary reusables and disposables per different surgery. Currently, the UMCG is not creating individual preparation protocols for specific surgeries. All the preparation protocols are bounded in one preparation book. The preparing employees always use this book. One of the greatest disadvantages of the current preparation protocols is the great choice of the surgeons concerning available disposables and reusables, the limited amount of standardization and the absence of location codes to create a sort of picking list.

Examples of preparation protocols with location codes and barcodes were presented in *Appendix Book XXVIII* and *XXIX*. These preparation protocols can be used as picking list, but are also useful for the management of the inventories since it is possible to scan the bar codes when a product is taken of the shelves (in case of preparations) or is returned to the shelves (in case of remains after a surgery).

Appendix Book XXVIII furthermore also shows the specific preferences of three surgeons for this Hemorrhoid surgery. In every hospital, each surgeon has his or her own preferences **[**Bonvissuto, 2007**]**. These specific demands of surgeons however lead to great costs for the hospital (high inventories of different products). To prevent these extra costs, it is advised to standardize the demand in protocols **[**Barlow, 2007**]** with marginal differences per surgery. This can be obtained by the earlier mentioned procedure trays, or just by an extensive standardization of the available assortment. This standardization should occur in consultation with the surgeons, anesthetics and surgical assistants.

To be able to create a clarified amount of preparation protocols, it is advised to base a preparation protocol on the Dutch CBV codes. A CBV code is the code for a medical or

paramedical surgery. Each surgery has a unique code with an unambiguous meaning and definition. The CBV archive currently consists of 34.000 different surgeries. These CBV codes are used by the hospitals to communicate to the insurance companies, which actions are performed. A complete surgery can be a combination of different CBV codes. The remuneration subsequently is based on these CBV codes.

One of the hospitals that already has based his preparation protocols on the CBV codes is the Deventer Hospital. *Appendix Book XXXIII* presents a screenshot with an overview of different CBV codes. Since not all CBV code based surgeries are the same, the Deventer Hospital has extended the CBV codes with letters (table 53). This makes it possible to create different preparation protocols for different surgeries with the same basis CBV code. This also is presented in *Appendix Book XXXIII*. Besides the overview of the CBV codes we also showed a screenshot of an extended preparation protocol. Based on the basis CBV code 38567, the Deventer Hospital created an extended preparation protocol 38567B with specific information for a Total Hip Zweymuller. Besides presenting information about the necessary disposables and reusables, it also is possible to present other required information (in this case information about the catheter and the positioning).

38534	Femurfractuur operatief
38534**B**	Ongeboorde femurpen
38534**C**	Femurpen 130 gr. Antegrade vergrendeling
38534**D**	Femurpen miss-a-nail vergrendeling
38534**E**	Femurpen spiraalblad vergrendeling
38534**F**	Supracondylaire femurfractuur m.b.v. 95 gr. hoekplaat
38534**G**	Femurcondylfractuur m.b.v. 95 gr. Hoekplaat
38534**H**	Femurcondylfractuur m.b.v. D.C.S
38534**L**	Femurpen Distale Femur Nail (DFN)
38534**M**	Antegrade femur nail/AFN
38534**N**	LCP distale femur

***Table 53**, Extended CBV codes*

5.5 How should the inventory at an operations center be managed?

Inventory management professionals within the supply chain profession are vital to hospital performance and patient care quality. Hospitals need to store a great variety of medical and surgical supplies which often are very critical and therefore required to be of sufficient quantity and availability for the staff to use at all times. Fear of stock outs however has limited the attempts of health care organizations at the development of an effective and efficient inventory management policy: Common practices are ordering at different vendors, ordering done by not qualified persons, unnecessary high inventories, outdating of stocks and not transparent inventory process. It besides that often also is not clear how much and where supplies are stocked **[**Langham, 2007**]**.
To prevent the existence of high inventories, hospitals are advised to base the amount of inventory on the price of the products, the history of use, the delivery costs, the inventory costs and the available inventory space. These variables however often are not available. This restrains the possibility of tailor made inventory strategies and leads to even higher stock levels and costs. **[**Yokl, 2008**]**.

5.5.1 Influence of changing responsibilities at the operations center on organizational learning

As discussed at the results section, each logistical employee at the operations center currently is responsible for one or two warehouses, whereby this responsibility changes every month. This means that the logistical employees are supposed to execute the different mentioned logistical tasks at different warehouses each month. The most important consequence of this policy is a sub optimal execution of the different logistical tasks and sub optimal learning curve of the individual logistical employees. Since continuous learning is important both for organizations and individuals, this is not an optimal situation.
Crossan et al **[**1995**]** assume that learning occurs when there has been an adjustment or change in the way organizations or individuals behave, process information, develop shared meanings and interpret events. Two types of learning can be distinguished based on the observed patterns of organizational behavior. Incremental learning is grounded in small changes in the pattern of behavior, while transformational learning is grounded in radical changes in behavior.
Appelbaum and Reichart **[**1998**]** suggest that organizational learning consists of three overlapping stages. At the first stage, members of learning communities expand their thinking and create new knowledge. The second stage is related to how workers perform their work. Employees begin to internalize their new insights and adjust their work practices. The last stage is improvement in performance, with changes in practices leading to measurably better results, superior quality, an increased market share or other tangible gains.

Slotte et al **[**2004**]** present four important practices that influence individual learning:

- practical on the job learning
- learning from mistakes and other challenging situations
- individual goals and motivation
- personal growth and self development

It is the (partial) absence of these practices that hinder the individual learning of the logistical employees and which keeps them stuck on a sub optimal performance level.

The first concept, practical on the job learning, is only partly present at the operations center for the logistical employees. Largely because of the changing responsibilities, the logistical employees are supposed to execute the same tasks every month, at a different location. They are not

empowered to do things that do not belong to their daily job routine. It always are the same tasks that are executed every day. This makes their work to a sort of routine with almost no challenges. The second concept, learning form mistakes and other challenging situations, is also not present. Since the tasks of the logistical employees have become a sort of routine, the logistical employees are not facing challenging situations that trigger their problem solving and creative skills. Tasks should be executed in almost the same way as they were executed 10 years ago. The logistical employees furthermore also are not confronted with examples of logistical management in other organizations (hospital and non-hospital). They do not receive the possibility to learn from other, external, challenging situations. The interviews show that they do are very interested in these situations, but just do not receive the possibility.
Based on the interviews and working day at the operations center, we have the hunch that the third concept, individual goals and motivation, has already been disappeared by the logistical employees. Because of the absence of training possibilities (also this is wanted by the logistical employees), promotion possibilities and motivation from the management, the employees are not interested in personal (and organizational) development anymore. This also influences the fourth concept, personal growth and development. It looks like the logistical employees are "stuck" at the operations center and currently are not interested in job related activities to include self development.

Because of the (partial) absence of the above described practices, the logistical employees do not reach the first, second and third stage of organizational learning. Things are the same as 10 years ago and expansion of thinking, creation of new knowledge, new insight in work practices and finally improvement of performance are largely missing. This also is shown in figure 63 which presents the learning curve of the logistical employees and the three stages of organizational learning.

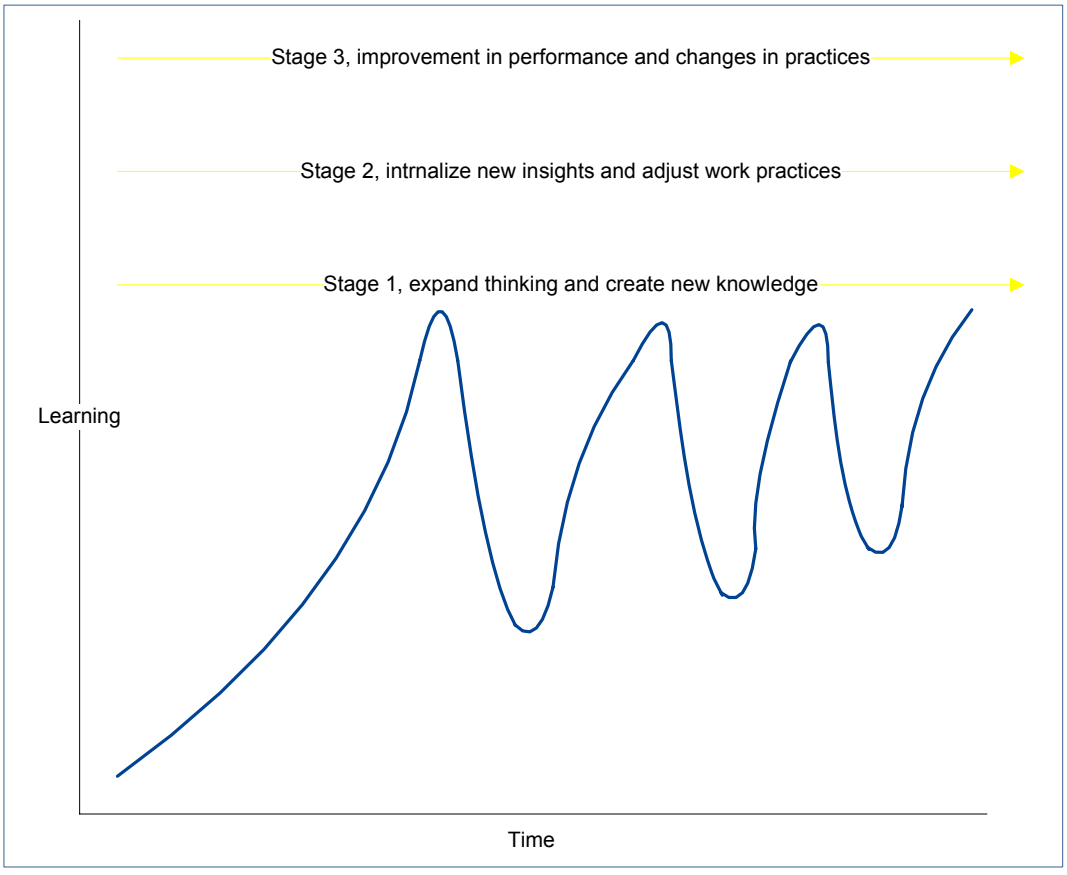


***Figure 63**, Learning curve of logistical employees and three stages of organizational learning*

The figure shows that, partly because of the absence of the described practices, there is a lack of organizational learning. Each time a logistical employee is approaching the first stage, he has to switch from warehouse responsibility. This switch of warehouse results in a decline of the approached level of learning since he has to get used to the practices at the new warehouses. And because it takes a half year before a logistical employee has passed all the warehouses, it is hard to exceed the obtained level of learning again. The result is that the organization of the logistics at the operations center is not developing in line with environmental developments. In other words, the logistics at the operations center of the UMCG is losing ground with regard to other hospitals. Innovations and new thoughts about inventory management are not applied and work practices are based on historical ideas.
To be able to catch up the arrears with regard to other hospitals, the UMCG is advised to break out of the current paradigm. This double-loop learning involves changes in cognition and behavior, outside the existing strategic paradigm **[**Crossan et al, 1995**]**. The UMCG has to facilitate the individual learning of the logistical employees at the operations center and adopt innovative logistical concepts out of the external environment. One of the main modes to reach these changes is stopping with the dispersion of warehouse responsibilities. It can be advised to create one integrated logistical service center (as discussed earlier and discussed in the subsequent paragraph) whereby tasks instead of responsibilities are dispersed. This means that an employee is not responsible for all the tasks in one warehouse anymore, but responsible for a single task (for example clearing away materials, preparing materials, ordering replenishment stocks) in the integrated logistical service center. This practice already is also successfully implemented at the Martini Hospital Groningen.

5.5.2 Clearing away ordered disposables and reusables

The clearing away of ordered disposables and reusables starts when the internal logistical department has placed containers with reusables and disposables at the goods receipt point at the operations center. When analyzing the process of clearing away ordered disposables and reusables different problems can be mentioned:

- Because the warehouses are dispersed over the operations center (away from the rising point) and the logistical employees all are working in and around these warehouses, the logistical employees often do not know that containers with replenishment stocks have entered the operations center. This means that containers sometimes stand untouched at the goods-receipt point for tens of minutes (or hours)
- Because of the dispersed responsibilities, all containers are not simultaneously unpacked and cleared away

To be able to improve the clearing away of ordered disposables and reusables it, as already mentioned, is advised to create an integrated logistical service center whereby employees are responsible for a single task instead of all the tasks in a single warehouse. It then would be possible to immediately execute the entire task, instead of not immediately a part of the task. When these responsibilities also are communicated to the care related employees, there also always is a fixed contact point in case of problems or questions (portable telephones are advised).

The materials that remain unused during a surgery are currently cleared away by the surgical assistants. These not used materials are, after the surgery, placed in a cart. This cart subsequently is placed on the corridor, where it waits until the surgical (or sector -) assistant transports it to the warehouses. Since this is not one of the core tasks of the sector – and surgical assistant, it often takes tens of minutes or hours before the carts are transported to the warehouses and the materials are cleared away. It therefore can be advised to, in line with the earlier mentioned hard cut between care related tasks and supporting tasks, let the logistical employees clear away the not

used disposables and reusables. The surgical assistants of course can transport these carts to the warehouses, but the logistical employees should clear the materials away because it can be regarded as one of their core tasks. Changing the responsible employee for clearing away not used materials will lead to a faster presence of materials in the warehouses which contributes to less stock outs and a more reliable materials management.

To, finally, facilitate the efficient and effective clearing away of disposables and reusables it furthermore can be advised to:

- Place items more orderly in the used containers at the LCE
- Connect letters of content to the products and do not throw them disorderly in the used containers. It besides that also can be advised to add the locations of the materials to the letters of content to speed up the clearing away of materials
- Improve the identification of material locations

5.5.3 Control of stock in hand and ordering replenishment stocks

The result section of paragraph 4.5 describes the current way of ordering replenishment stocks for stock items and non stock items. Analyzing this process shows a few problems:

- Double execution of tasks (things on paper and things in the computer)
- Tardiness of the process because of the double execution of tasks
- Limited amount (only 2 times) of ordering per week
- Vague determination of amount of replenishment stocks (based on experience and possible knowledge about future surgeries) which leads to high costs (high inventories) and quality risks (not available inventories)

As already mentioned and advised in earlier paragraphs, we think it would be wise to implement a digital scanning system in the UMCG. This scanning system should be used for ordering stock items and non stock items. To be able to stop using the current elaborate way of ordering replenishment stocks, it is necessary to implement the replenishment policy of the supermarket industry.

Figure 64 presents the reordering policy of a supermarket. The inventory system digitally adjusts the stock levels of products based on the scanning of these products, which are required by the customer, at the cash desks. To be able to guarantee reliable stock levels, the digital stock levels are manually adjusted by periodical cycle counting. At the end of the day, the stock levels are checked by the responsible manager, who gives the final go for the ordering of the replenishment stocks when the stock level has fallen below the reorder point. At this moment he also has the possibility to consider possible future promotion actions or knowledge about sales patterns of certain products. The ordered products enter the supermarket before the opening hours next day.

Although it of course is not possible to compare the products and environment of a supermarket with a hospital, it does is possible to adopt their inventory management practices. A possible inventory practice is presented in figure 65. The figure shows a great amount of similarities, but also a few specific hospital elements (yellow coloured).

Based on the scanning of the necessary materials for a surgery (it is for example possible to use the preparation protocol of *Appendix Book XXVIII* which already consists necessary bar codes) the stock level of the concerned products is adjusted. Since not all products are used during a surgery, these stock levels can be raised again by the returning of these products. It besides that also is necessary to incorporate frequent cycle counting to be absolutely sure of the digital

overview of the amount of stock. When a stock level falls below the reorder point, the system provides information to the manager that replenishment stocks are necessary.

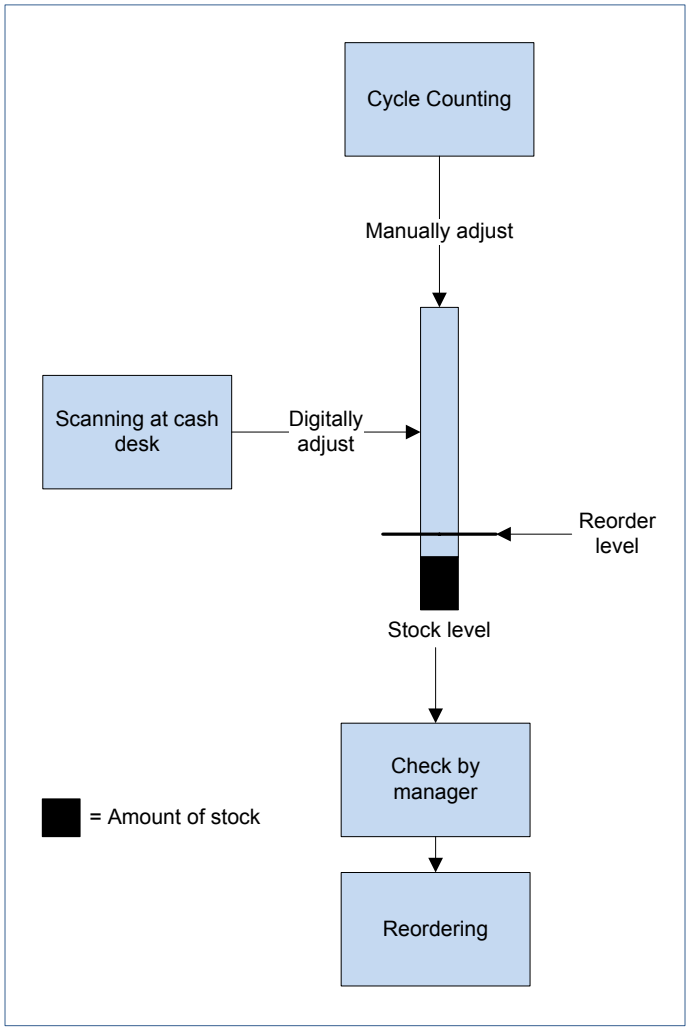


***Figure 64**, Reordering policy of a supermarket*

Because a stock-out in a hospital is much worse than a stock-out in a supermarket, it also is important to incorporate required materials for the planned surgeries of the coming days. As was already discussed in the previous paragraphs, a comparison between the necessary materials and planned inventory can also provide information of necessary replenishment stocks (while the stock level maybe not even has fallen below the reorder point). It however then is important to consider the average delivery time of the suppliers (which can be calculated or agreed in contracts).
It finally is the manager of the logistical department who gives the final go for replenishment stocks of stock items and non stock items. To be able to make this process work as in the supermarket industry, it is required that the necessary items (in any case the stock items) are collected and delivered during the evening or night. This then means that they will be available again before the first surgeries of the subsequent day begin.

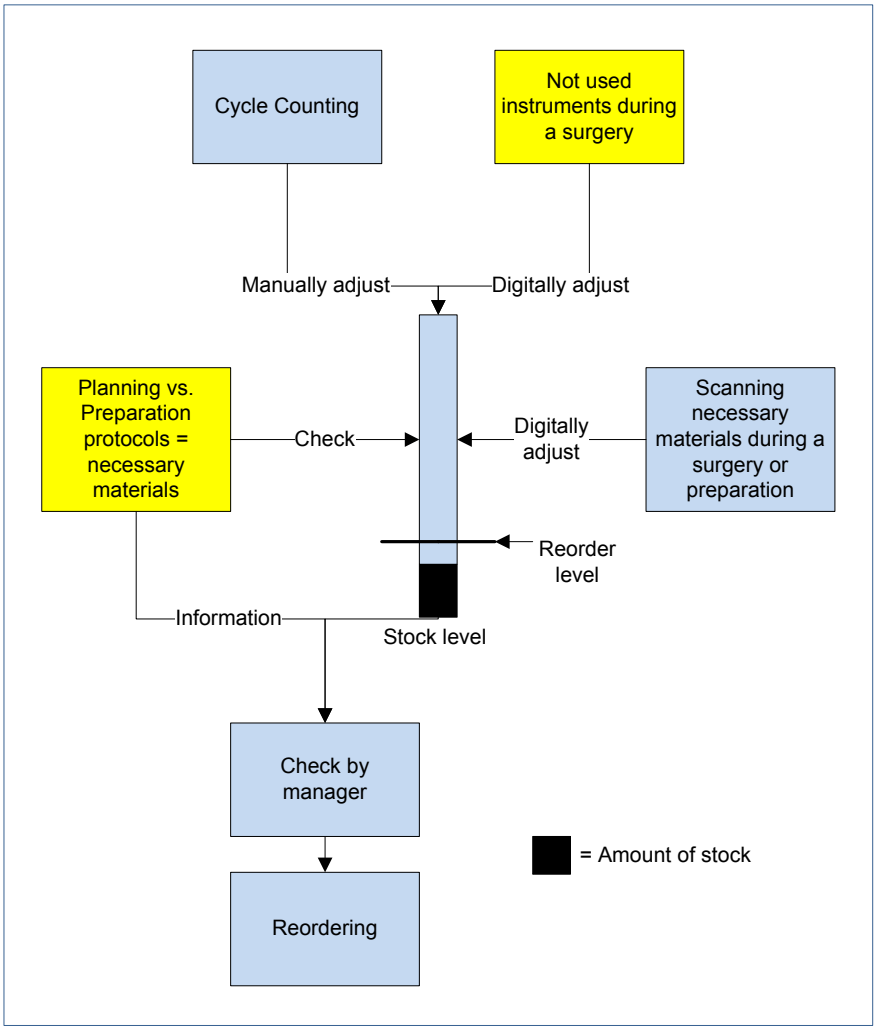


***Figure 65**, Possible reordering policy of a hospital*

Since the assortment of the UMCG consists of thousands of different products, it is not wise to apply this system to all the different products. The Deventer Hospital, for example, has drawn a line by €50. This means that all the products with a purchase price above €50 are scanned. Products with a lower purchase price can be reordered with the use of the earlier mentioned two bin or topping up system. They also have chosen to base the stock levels on the scanned products in an operation room instead of the packed products during the preparation of a surgery. A screenshot of an overview of scanned products, to illustrate this process, is presented in *Appendix Book XXXIV*. The first page shows the standard screen of OK Plus and the possibility to scan a product. It also nicely shows the scanned disposables under the heading *Artikelen*, the prices of the disposables under the heading *Artikelprijs* (protected with a red bar) and the total price of the used disposables under the heading *Totaalprijs* (also protected with a red bar). The figure also shows a little extent of the scanned instruments (besides the heading *NetID*).

Implementing the above mentioned system would solve the first three of the four mentioned problems. The system makes the double execution of the job redundant, limits the tardiness of the process and provides the possibility to order every day instead of only 2 times per week.

To be able to reduce the high costs of too high inventories and to improve the quality of the process by guaranteeing the availability of materials, it also is necessary that a more reliable determination of the amount of replenishment stocks and the amount of safety stock is implemented. Different formulas are available for the determination of the order quantity and the

amount of safety stock (EOQ, Order Point technique). Since the demand for disposables and reusables shows statistical fluctuations it, however, is advised to incorporate fluctuation inventory or fluctuation stock [Schönsleben, 2007]. We furthermore also advise to base the order quantity and the amount of safety stock on the historical data which can be provided by the implemented inventory management system. The scanning of the products namely provides a great amount of management information which for example can show possible trends or changes in the usage rate. This will solve the last of the four mentioned problems, the vague determination of the amount of replenishment stocks. This now can be calculated by the used information system and based on the historical usage. By also incorporating the planning of the surgeries, the problem of short-outs during unique surgeries that are planned in a sequence can also be solved.

The consequences of the advised implementation of a supermarket based inventory system are less inventory (because of more reliable amounts of stock and more frequent ordering) and higher quality (less stock-outs because of more reliable replenishments amounts and connection with planning of the surgeries).

5.5.4 Ordering of special, high cost non stock items (heart valves, prostheses, etc.)

The results of paragraph 4.5.3 also present the current ordering process of special high cost non stock items like heart valves (€2000 - €4000), vessels (€1000 – €5500) and knee prostheses (€1000 - €3000). An analysis of the presented replenishment cycle of these items already showed 7 points of postponement and reasonable quality risks because of forced leaving of an operation room (to place the registration forms in boxes at the welcoming of the operations center) and the high error prone of the used system. The consequence of the current ordering policy is a too high amount of stock since the variability of the delivery time (because of the postponement points) is very high. Since it is required that a used special high cost non stock item is reordered as fast as possible and that the amount of stock is as low as possible (because of the high costs of these items), the used system should be changed.

To be able to improve the speed of the reordering process and avoid the mentioned quality risks, it can be advised to reorder the special high cost non stock items with the use of the (already used) scanning system. Figure 30 shows that the products currently are already scanned for internal registration. Connecting this scanning system to an automatic reordering system (which for example is possible with the use of GHX), would remove 6 steps of current replenishment cycle. Since 4 of these steps currently are postponing the process, the process will be significantly speeded up. The amount of process steps will be reduced from 17 to 11 steps. Since it now also is not necessary anymore to leave the operation room and the error sensitivity of the process is also significantly reduced, the quality of delivered care can be improved.

5.5.5 Management of the warehouses

In the current organization of the logistics at the operations center, the logistical department operations center is responsible for the management of the warehouses. Analyzing the current organization of the warehouses shows 3 main problems:

- Frequent changing locations of materials
- Poor identification of the reusables and disposables in the warehouses
- Shortage of space

These problems are the result of several connected problems. We first of all already described the continuous addition of new materials to the assortment. This is the result of the preference of medical specialists of working with the newest products and applications. This is not a problem

as long as the "old" products are consumed first or can be returned to the supplier. Because of the poor communication, lack of an inventory management system to notice the unused instruments and old fashioned medical specialists who keep on using the "old" products, the new products are added to the assortment and warehouses without removing the "old" products. This leads to high stocks and consequently to frequent changing locations of products and shortage of space. The solutions to these problems are already mentioned:

- Better communication between logistics and care related employees. A solution can be to implement frequent meetings between the two parties to communicate possible changes, wishes and problems
- Implementing an inventory management system which has the functionality to indicate that certain products are not used anymore for a certain amount of time. These indications can be an input to the frequent meetings where the participating groups can consider the removal of these products out of the assortment
- More standardization of preferences among surgeons. The specific preferences of surgeons lead to high costs and high inventories **[**Bonvissuto, 2007**]**. This especially applies to the products with a high purchase price. More standardization can thus lead to lower costs, lower inventories and less necessity of changing locations since there is less shortage of space

The frequent changing of locations, furthermore, also is the result of the current logistical strategy of the UMCG. As already mentioned, the care related employees currently are leading and the logistical related employees are supporting. With regard to the frequent changing locations, this is clearly visible in *Appendix Book XXI*. The "appeal of a medical resource form" shows that the care related employees are not only determining the amount of stock, but also the location in the warehouse. This of course leads to frequent changes since each new medical resource receives a new location.

To prevent these frequent changes of locations, we once again want to introduce the hard cut between core CARE and supporting tasks. Since the organization of the logistics is not a core care tasks of the care related employees, this should be managed by the logistical employees and not by the surgical assistants. Because we also already proposed to let the logistical employees prepare the materials for a surgery, deliver missing materials and clear away not used materials, it is not relevant anymore that surgical assistants determine the location of materials. Since location management is a fundamental element of logistical management, this should be determined by the logistical employees. And when the locations of the materials also are present in the information system and connected to the preparation protocols, changing locations will automatically be carried through. To prevent long searching times during the night (when no logistical employee is present) it, however, does is important that the surgical assistants keep visiting the warehouse and that it always is possible to find the location of a material with the use of the information system.

The second problem of the current management of the warehouses is the poor identification of the reusables and disposables in the warehouses. Different products and shelves do not contain an identification card and the used identification cards are not clear and clarifying. It besides that also often happens that placed identification cards (by surgical assistants) are removed by the logistical employees.

To improve the identification of the products it is necessary that each product/location receives a standardized identification card. It is important that these cards are designed in such a way that they can be connected to the inventory warehouse system and the track and trace system of reusables and disposables. These identification cards should therefore at least contain:

- Location code
- Product name
- Minimum amount of stock

- Replenishment order amount
- Price of the product (to make the employees cost-conscious)
- Bar code

Since it is possible, to support an effective and efficient inventory management system, that locations and amounts of stock of products change, we also advise the consideration of digital information tags instead of paper information tags. Digital information tags are energy-efficient, all-in-one LED screens that can display anything from prices to bar codes. These kind of information tags are already frequently used in, for example, French supermarkets. Certainly in case of frequent information changes, these tags can save a great amount of money. Two examples of the digital information tags are presented in *Appendix Book XXXV*.

The third problem, the shortage of space in the warehouses, is already discussed several times. Different causes (frequent changes of – and additions to the product assortment and the lack of an inventory control system which leads to high stocks to guarantee a service level of 100%) are already mentioned and discussed. The two other causes (amount of stock is determined by care related employees and the high duplication rate of materials) are discussed in the subsequent chapters.

5.5.6 Ordering new products (not yet in the assortment)

As already mentioned in the previous paragraph, the care related employees are currently responsible for determining the amount of stock of new catalogue items (*Appendix Book XXI*). Since there is no inventory management system to analyze whether the determined amount of stock is too high (which probably often is the case), the inventory is growing and the free space is decreasing. These high stocks furthermore also lead to a higher amount of forced location changes and a higher perishability of materials. It thus is necessary that the current organization of ordering new products is changed.
The solution to this problem actually already is described in the previous chapter. We would advise the UMCG to implement an inventory management system to be able to be informed by the system when the amount of stock is too high regarding the historical usage. It besides that it also is important that the demanded amount of stock by the care related employees is properly grounded. It should not just be an estimation, but a well argumented calculation.

5.5.7 Control of sterility dates of disposables and reusables

The control of sterility dates of disposables and reusables, finally, also is an important element of the different tasks of the logistical employees. When analyzing the current control of sterility dates, two connected problems can be mentioned:

- The sterility dates are not frequently controlled
- Controlling sterility dates takes a lot of time because of the great amount of stock

Since the surgical assistants often do not check the sterility dates of the products when using a product in an operation room, there is a reasonable chance of using a product with a passed sterility date. This of course brings great risks for the patient and should be prevented.
A solution to this problem would be the already mentioned introduction of a complete scanning system. This means that reusables and disposables should be scanned at all the different mentioned locations in figure 30. Since the bar code of a product also can contain the sterility date of a product, it then would be possible to check the sterility dates with the help of the information system. Because the locations of all the products are present in the system, the system easily can present an overview of the (locations of) the products that should be thrown

away (disposables) or decontaminated (reusables). This system already is successfully implemented at the Martini Hospital Groningen, the Deventer Hospital and the University Medical Center Utrecht. An example of the output of the information system of the Martini Hospital Groningen is presented in figure 65.

NetID	Naam	Locatie	SterielTot	Afdeling
N000000538	MALLORY 1 4	BERGING STERIEL (RETOUR)	7-5-2009	OK
N000000930	NAVIGATIE RUG SET 1	BERGING STERIEL (RETOUR)	6-5-2009	OK
N000000964	KNO BOOR XOMED 1	BERGING STERIEL (RETOUR)	8-5-2009	OK
N000000732	ENUCLEATIE	BERGING STERIEL CSA	6-5-2009	OK

***Figure 65**, Overview of products with a passed sterility date (reusables)*

Implementing the system makes it possible to frequently (daily is possible) check the sterility dates of products. A further extension of this system would be the allocation of materials to a certain surgery. This means that the system can allocate a reusable and/or disposable to a certain surgery based on the duration of the sterility of the product.

5.6 At which locations (in the researched part of the) hospital supply chain should resources be stored and warehouses be placed?

A fear for stock outs has limited the attempts of health care organizations at the development of effective and efficient hospital locations, resources and facilities. It therefore often is not clear how much and where supplies are stocked. Hospitals furthermore often have a too great amount of storage locations [Rivard-Rover et al, 2002] leading to high inventory costs, waste of materials, waste of time and emergency orders. A classic hospital furthermore keeps these warehouses full of all the different materials and instruments that could be required during a surgery, which leads to even higher inventory costs.
On the road to a lean supply chain it, however, is important that also the structure of the last part of the supply chain is reconsidered [Liyanage and Egby, 2008]. Hospitals should also consider the declining amount of available square meters, determine the most efficient and effective lay-out of the operations center and the connection with previous and subsequent processes and departments. Historically, hospitals then often decide to choose for rebuilding and extending. These days the focus should be shifted to reengineering and restructuring. Unnecessary warehouses, for example, should be removed to create space for care related activities [Kreeft and Dewaet, 2008]. Hospitals need a new logistical structure and lay-out to match possible new strategies and processes.

5.6.1 Current strategy behind the structure and lay-out of the operations center and warehouses

Where we concluded the results section with the strategy behind the structure and lay-out of the operations center, we would like to start with this element at the beginning of this last paragraph of the analysis section. We namely already analyzed and discussed the greater part of the current strategy and also mentioned some valuable recommendations. As was mentioned at the results section, in the current organization of the logistics at the operations center, the surgical assistants are responsible for a great amount of the logistical tasks (preparing, collecting, ordering, etc.). To be able to keep this strategy working properly, the operations center currently needs the following conditions:

- Great amount of warehouses spread over the entire operations center
- Warehouses close to the operation rooms
- High percentage of duplication of materials

These conditions are visible in the current structure of the operations center. The results showed a total amount of 12 warehouses located close to the operation rooms and with a high duplication percentage of materials. This strategy however leads to a great amount of disadvantages in terms of the performance indicators quality, speed and costs. We already showed a great amount of disadvantages, but also would like to mention the disadvantages that directly are the result of the structure and lay-out of the operations center.

5.6.2 The locations of the warehouses

The consequence of the current organization of the logistics at the operations center is the existence of several different warehouses dispersed over the operations center. These warehouses use a great amount of space which actually is very scarce at a great amount of hospital operations centers. Hospital operations center square meters should be filled with care related activities, but currently often are filled with logistics related activities [Shields, 2001]. Since the UMCG

currently has a shortage of space at the operations center, it thus can be advised to change the logistical strategy to free logistical space for care related space as operation rooms.
We furthermore also would like to advise to reconsider the necessity of separate bulk store rooms at the operations center while the UMCG has a logistical center at its disposal. Since the space at the operations center is more valuable than the space at the logistical center Eemspoort, it is desired that frequently used products which currently are not accepted at the LCE and products that are purchased in large quantities, also are accepted by the LCE. Since test products simply can be stocked at regular warehouses, it then is not necessary anymore to use bulk storerooms at the operations center. This will free space for care related activities and also will reduce the inventory costs since products that are stored in the bulk storeroom, also are stored at the sterile – and non sterile warehouses.

5.6.3 The lay-out of the operations center and warehouses

Paragraph 4.6.2 presented the current lay-out of the operations center and the lay-out of the different warehouses. When analyzing these lay-outs we can mention the following disadvantages:

- Long transport times of logistical employees when clearing away replenishment stocks
- High complexity of clearing away replenishment stocks because of a great amount – and similar warehouses
- "Contamination" of the clean corridor with prepared – and used surgical carts
- Absence of material preparation rooms (*Dutch: opdekruimtes*)
- High duplication percentage of stored materials

Because of the dispersion of the warehouses over the operations center, the transport times of logistical employees, from the rising point and their office next to the rising point to the warehouses, is very long. Since logistical employees have to go to a warehouse for, among others, clearing away replenishment stocks, controlling stock levels, ordering replenishment stocks and answering logistical related questions of care related employees, they loose a significant amount of time. The great distance from the office to the warehouses furthermore also results in a lack of overview of what is happening in the distinct warehouses.

The dispersion of the warehouses over the operations center furthermore also leads to a high complexity of clearing away replenishment stocks. It first of all requires extra time to find the correct container with replenishment stocks for the concerning warehouse. Since replenishment stocks for different warehouses however often are placed in the same container, it secondly requires again extra time to connect certain replenishment stocks to certain warehouses and to disperse the materials in the proper quantities.

A third disadvantage of the chosen lay-out is the contamination of the clean corridor with prepared and used surgical carts. In the current lay-out of the operations center, there is no distinct space for the storage of prepared and used surgical carts. This leads to blockades of walking routes and doorways. There furthermore also is a risk of collisions with the carts which can influence the sterility of the prepared materials.

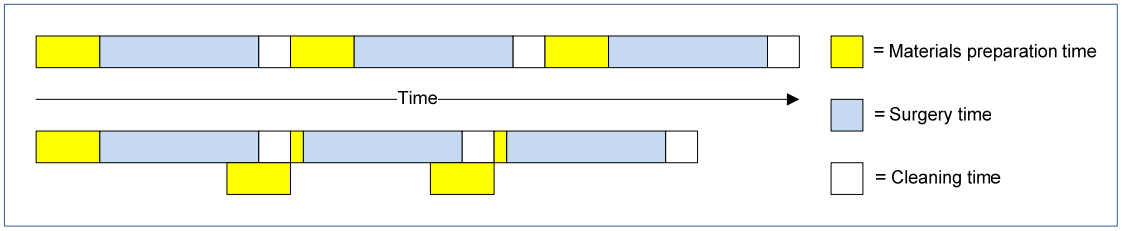


***Figure 66**, Savings of surgery time when using materials preparation rooms*

The fourth disadvantage of the chosen lay-out at the operations center is the absence of material preparation rooms. Currently, the necessary materials for an operation are laid out on special sterile tables in the operation room. This means that the complete OR team has to wait with the start of the surgery until all the materials are prepared and laid out.
Especially in case of high turnover rates of operation rooms, the usage of materials preparation rooms can result in great savings of valuable surgery time (figure 66). Time is saved (yellow bars) because the materials for a subsequent surgery are already laid out in an adjacent sterile room and directly after the cleaning of the operation room can be transported inside. When the anaesthetist then also has finished al his necessary tasks, the surgery directly can begin. Figure 67 presents the possible lay-out of an operations center with materials preparation room. The figure shows that the materials preparation rooms are located between two operation rooms.

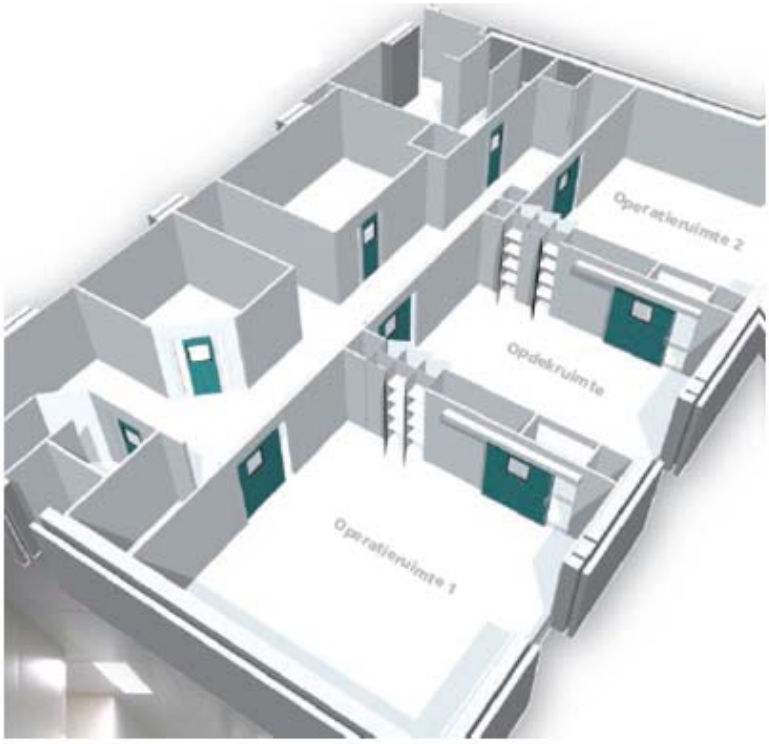


***Figure 67**, Possible lay-out of an operations center with materials preparation rooms*

The fifth and final disadvantage of the current lay-out of the operations center and warehouses is the high duplication rate of stored materials. The different presented floor-plans in the results section already showed that the sterile warehouses, the non sterile warehouses and the anaesthetic warehouses all comprise a great amount of identical materials. Only a limited amount of products is stored at one warehouse. The greater part is stored at several locations.
The results of the high duplication percentage of materials are usage of valuable and scarce space and the already mentioned high inventory costs. These are compiled of:

- Ordering costs
- Carrying costs
  - The costs of financing (capital costs)
  - Storage infrastructure costs (buildings, installations, warehouse employees, insurance, etc.)
  - The risk of depreciation
    - Technical obsolescence
    - Perishability
    - Damage, spoilage or destruction

5.6.4 Integrated logistical service center

The mentioned disadvantages of the current logistical strategy at the operations center and the disadvantages due to the current locations and lay-out of the warehouses all are an argument to change the current organization of the logistics at the operations center. They actually show that it is not only necessary to create a hard cut between care related – and supporting tasks, but also to apply this to the chosen structures and lay-out. To be able to integrate and standardize the logistics at the operations center whereby the best efforts and practices can be combined and concentrated, it is necessary to create a centrally led operation model; an integrated logistical service center **[**Mulani, 2009**]**.

We, because of different reasons, already advised to create a hard cut between the supporting tasks and the care related tasks. But to implement this hard cut successfully and make it work properly, it is necessary to also separate the care related space and supporting space. In other words, it also is necessary to separate the operation rooms and the warehouses to:

- Facilitate an efficient and effective execution of the different logistical tasks (clearing away, preparing, reordering)
- Create a better overview of the present disposables and reusables
- Improve the quality and speed of the communication
- Reduce transport times
- Reduce decontamination of the corridors
- Reduce the duplication percentage of materials

As was stated by Mulani **[**2009**]**, centrally led operating models can be catalysts for improved visibility and business intelligence whereby inventory levels can be better ascertained and thus reduced. The net effect is better and more integrated materials planning and increased supply chain responsiveness. With supporting functions concentrated in a central unit, most companies also find it easier to formulate or adjust effective strategies and deploy them consistently across the organization. Functions ultimately can be introduced or outsourced more easily.
With so many supporting functions centralized, rewards such as better control, greater synchronization, increased availability and improved service frequently follow. Inventory levels furthermore often fall by 25 - 40 percent and overall logistics costs can drop by 10 - 15 percent.

Appendix Book XXII and *Appendix Book XXXVI* show how an integrated logistical service center could look like. Here we have presented the floor-plan of the Medical Center Leeuwarden. The floor-plan shows that the most important supporting departments for an operations center, the sterile processing department and the warehouses, are located next to the operation rooms in one centralized facility.

A simplified example of an integrated logistical service center for the UMCG is presented in figure 68. The figure shows that, because of the continuous flows of materials, information and persons between the warehouses, sterile processing department and operation rooms, it is required that these facilities are located nearby each other. The figure furthermore also shows the hard cut between supporting (logistical and decontamination) tasks and care related tasks.

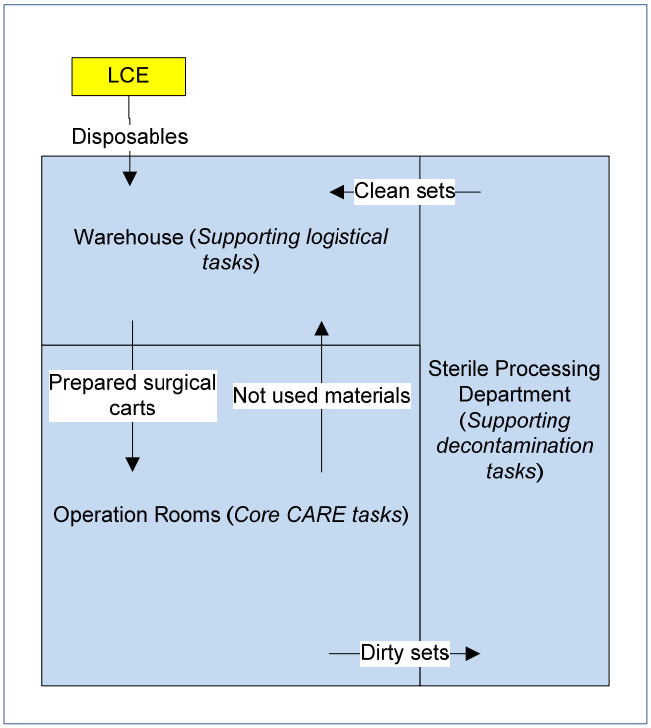


***Figure 68**, Material flows and processes at a simplified integrated logistical service center*

In case of the UMCG, three different opportunities for the generation of an integrated logistical service center are possible:

- A sub optimal integrated logistical service center whereby the warehouses at the operations center are restructured in a central facility around the rising points (at only one floor, or two centers at both floors)
- The creation of a new integrated logistical service center whereby the operations center and the sterile processing department (they both are depreciated) are rebuild on a new location on the UMCG area
- The creation of a shared logistical service center on the Eemspoort. From here it then is possible to transport prepared surgical carts to different hospitals in the environment of Groningen. This shared logistical service center is an extension of the shared sterile center **[**Goudswaard, 2006**]**.


4/0.1
100

6.

- Conclusions and recommendations -

The objective of this research was to improve the organization of the logistical processes in the direction of an operation room to be able to meet the changed demands of the market and thereby taking into account the specific internal situation of the UMCG. We first of all have studied the current organization of the logistical processes. From the analysis of the current organization and in combination with the developed theoretical framework, we have developed several interventions to improve the performance. With the use of different calculations, tables and figures we have demonstrated the possible performance improvements of these interventions. In this chapter we will discuss the final conclusions of this research and present the different recommendations. These recommendations, which can be implemented to be able to increase the quality and the speed of the logistical processes in the direction of an operation room and decrease the costs, were for the greater part already mentioned during the analysis section. Implementing these recommendations would make it possible to make up the arrears on other hospitals and organizations in the environment.
To be able to make a distinction between the different sorts of recommendations, we have classified the different recommendations as incremental changes or quantum changes. Incremental changes tend to involve limited dimensions and levels of the organization. They occur within the context of the organization's existing business strategy, structure, and culture and are aimed at improving the status quo. Quantum changes are directing at significantly altering how the organization operates. They tend to involve several organizational dimensions, including structure, culture, reward systems, information processes and work design **[**Meyer et al, 1990**]**.
After presenting the most important conclusions and recommendations, this chapter also will present some important directions for future research and will highlight the scientific value of this research. As addition to the mentioned recommendations, we have presented the advantages of implementing:

- Procedure trays
- Hard cut between supporting functions and core care functions
- A digital scanning system
- An inventory management system

… and the advised expansion of Chipsoft in *Appendix Book XXXVIII*.

6.1 Conclusions and recommendations

The main reason for this research was the changed market – and internal situation of the UMCG. Because of the need for lower costs, higher quality and a better understanding of the origin of quality and costs, the UMCG is forced to change the structure of the logistical processes in the direction of an operation room. Our study shows that different elements of the current organization of these logistical processes are negatively influencing the performance indicators quality, speed and costs. We will present these elements with the help of the stated sub-questions.

1. How are the logistical and care related processes in the direction of an operation room currently organized and what is the quality of the current insight into the different steps of the process?

Based on our analysis of the current organization of the logistical and care related processes in the direction of an operation room, we can conclude that the organization is on different point not in accordance with the different theories as mentioned in the theoretical framework.
During the results section we first of all have showed that the total process can be characterized as a sequential process with frequent interactions. Such a process has three important conditions for effective and efficient functioning: locating the different processes nearby each other, high communication between involved persons and departments and horizontal mechanisms such as integrators or task forces. It is the absence of all these three important characteristics that leads to higher costs, lower speed and lower quality of the logistical process in the direction of an operation room at the UMCG.
When first of all regarding the locations of the different sub processes, we can conclude that the different elements of the process are dispersed over the UMCG site, different floors and are even located on a different part of Groningen. Employees, products and information therefore have to bridge greater distances (which leads to longer process times, higher possibilities of mistakes and higher inventories). The fact that the processes are not located nearby each other also has a great influence on the execution of the different tasks. The limited amount of supply rounds, suboptimal loading of containers, not attaching opening hours, lack of signals and lack of transfer of information all are indications that the different persons and departments are operating in functional silos with mainly an internal focus. This lack of an external focus results in a suboptimal organization of the logistical processes and a suboptimal division of tasks.
Sequential interdependencies between persons and departments, furthermore, creates a greater need for horizontal mechanisms as integrators and task forces and high communication between departments. Both the high communication and the horizontal mechanisms are currently missing in the organization of especially the supporting logistical processes. The lack of communication is mainly due to the great distances between the departments and the different position in the organization chart of the UMCG. The most striking example was the existence of two identical departments that are responsible for the logistical function. Besides that, there also is a clear link with the absence of horizontal mechanisms. There currently is no person with a multiform view of the total process. This leads to a lack of communication, but also to a lack to developments of the total process since each sub process is developing without taking into account the total process. This leads to adjustment problems and, as was shown in the second research question, a great amount of emergency appeals.

An important consequence of the current organization of the logistical process is that this process currently does not meets all the stated conditions for a lean supply chain (as is desired by the UMCG). The frequency of deliveries is too low (which leads to higher inventories and higher

inventory costs), the lot sizes are too high (which also leads to higher inventories and higher inventory costs) and the deliveries are not synchronized with the work schedule of the logistical employees (which leads to longer process times, not clearing away of materials and extra searching time for surgical assistants or possible stock outs. This last point again leads to higher inventories).

An extra fourth condition for an important sequential process in a hospital is to have a high quality of insight in the different steps of the process. This insight has a location and monetary factor. The quality of both factors of the logistical process in the direction of an operation room in the UMCG is currently too low.
There first of all almost is no insight in the available amount – and the location of the different medical resources. The total process actually is a "black box" and care related employees can only hope that the required medical resources are present or come in on time (which leads to a great amount of uncertainty). Since this not always happens there first of all are great possible risks for the patient, the speed of the process is slowed down and the costs will rise since the uncertainty is reduced with extra inventories.
There secondly also is no insight in the origin and total amount of costs. As was stated in the introduction of this research, the Dutch government imposes hospitals to raise the insight in the origin of the costs of surgeries to be able to create individual and reliable prices of surgeries (and consequently DBCs). This currently is not possible at the UMCG which forces the UMCG to still use the standard costs prices of surgeries. This leads to unreliable compensations of surgeries and a lack of insight in which medical resources actually are used during a surgery. This also has a great influence on other parts of the logistical process (creation of preparation protocols, creation of procedure trays and inventory management).

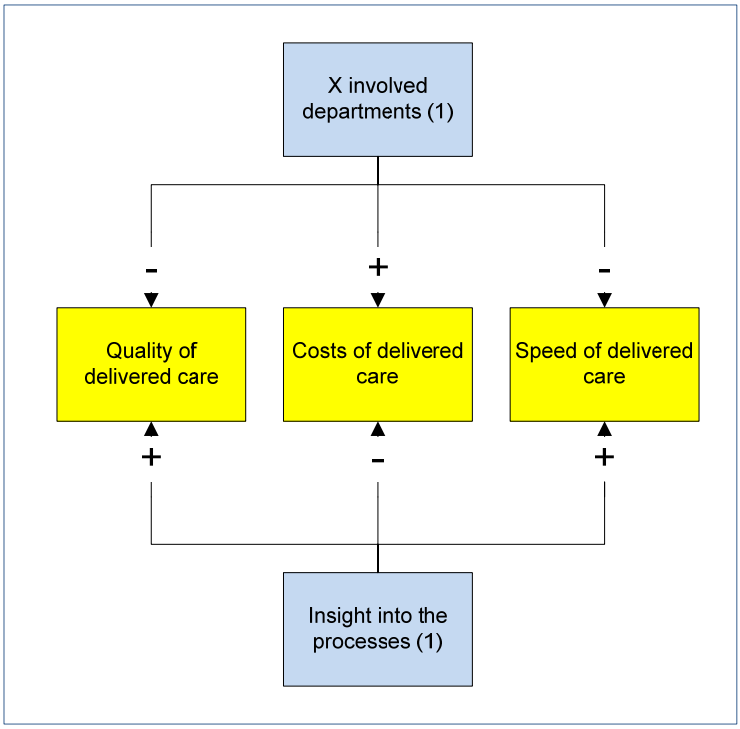


***Figure 69**, Revert to the conceptual model*

Based on the different studies, the different results and our analysis we can thus conclude that the amount of involved persons and departments, the organization of the process of which these persons and departments form part of and the amount of insight in the processes has a great influence on the quality, costs and speed of the delivered care (figure 69).

To be able to increase the quality, costs and speed we have mentioned different recommendations for the UMCG:

Quantum changes

- Locate the sterile processing department and the operations center (including the central warehouse) nearby each other to be able to create an integrated logistical service center
- Extent the current visibility of the logistical processes by increasing the amount of scanning moments and places (introduce a digital scanning system). It is advises to first of all extent the scanning of instruments and instrument sets (inclusive weighing). When this is working properly, it is possible to start scanning at all process steps for the used disposables. It then also is necessary to inventorise at which process steps materials must be scanned and until which purchasing price disposables are scanned
- Create *integrator functions* and *task forces* to improve the communication between different persons and departments to be able to improve the total logistical process in the direction of an operation room (instead of departmental sub optimizing)
- Change the organizational structure of the logistical departments. Create one responsible manager for the total logistical process in the direction of an operation room. Add the responsibility of the logistics at the operations center to the responsibility of the logistical manager UMCG
- Deliver and clear materials away during the nights (or after the surgeries) / adjust the working times of the LCE employees and logistical employees to the surgical production schedule
- Create a better and more obvious ownership of the different sorts of medical resources

Incremental changes

- Increase frequency of deliveries from the LCE to the operations center
- Adjust the delivery times to the working hours of logistical employees (and vice versa) and standardize the direct clearing away of new deliveries
- Improve the logic of the packaging of containers at the LCE to facilitate the efficient and effective unpacking of materials by logistical employees of the operations center
- Let other employees (instead of SPD employees) transport dirty sets from an operation room to the rising point at the operations center (advised: logistical employees)
- Don't let the logistical manager of the operations center execute contracts with suppliers of stock items

2. How great are the interdependencies between the different involved persons and departments?

After the analysis of the results of the first and second paragraph, we can conclude that the current interdependency is not of sequential (as it was *on paper*) but of reciprocal form. The great amount of emergency appeals for stock items, non stock items and reusable items indicate that the current organization of the logistical process, as was already concluded, is of suboptimal form. The great amount of involved persons and departments, the great distances, great amount of transfers (of information and materials) and the low quality of the insight are, among others, responsible for this great amount of emergency appeals. With the great amount of emergency appeals we further showed that the amount of interdependency is influencing the quality, speed and costs of the logistical – and care related processes.

Especially the existence of emergency appeals for stock items indicates the suboptimal organization of the logistics. These C items should always be available and should under no circumstances delay the very costly surgical process. The great amount of emergency appeals for reusable items further indicate the current problems with the insight in the different process steps (which leads to uncertainty and emergency orders to prevent against uncertainty) and the absence of a scanning system and inventory management system (with a connection to the preparation protocols).
Based on the different studies, the different results and our analysis we can thus conclude that the amount of interdependence between the involved persons and departments has a great influence on the quality, costs and speed of the delivered care (figure 70). This influence turns negative when the interdependence has grown greater than actually should be, based on the *paper* situation. Since the interdependency of involved persons and departments also determines the optimal lay-out, structure and organization of the process, which currently is of suboptimal form, we are able to mention the required interventions that should lead to an improved functioning of the process. The greater part of these interventions was already presented after the first sub question. We however want to present a view additions based on the specific results and analysis of this research question.

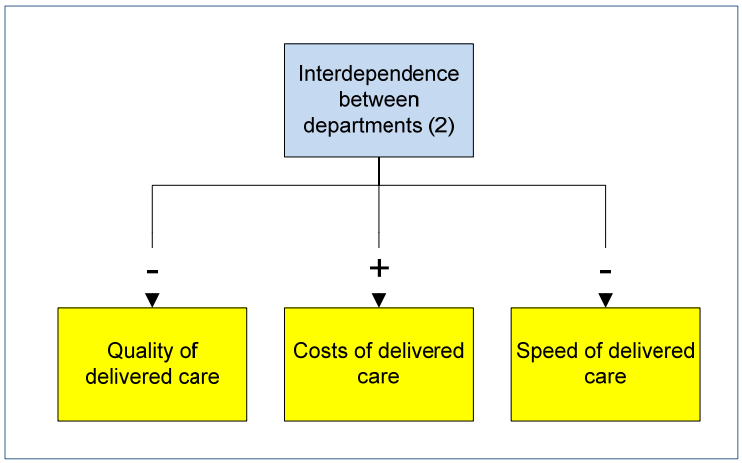


***Figure 70**, Revert to the conceptual model*

Quantum changes

- Create a connection between the planning of the surgeries, preparation protocols and the inventory management system
- Decrease the agreed decontamination time of 12 hours

Incremental changes

- Implement a two bin or topping up inventory management system for C items

3. How great is the task diversity of a surgical assistant and what are the consequences of placing the transition point at this function?

Because of different external and internal reasons, we have concluded that it is legitimized to study the current organization of the surgical assistant function and the location of the transition point. Based on the discussion in this paragraph about the current content of the surgical assistant function, we can conclude that this function currently contains a great amount of logistical related tasks that interfere with their core care related tasks. As is evidenced by the different logistical studies in this research, the preparation of necessary materials, collection of

missing materials, administrative tasks, laying out of materials and stock management takes a lot of time from the surgical assistants. The consequence first of all is that there is less time remaining for their core care tasks and that complete surgical assistant fulltime equivalents (*fte's*) are released for logistical related tasks (this while there are great shortages of surgical assistants in The Netherlands). A second consequence is that the logistical tasks are executed with less speed and quality. This has a negative influence on the costs, quality and speed of the delivered care process. Freeing the surgical assistants of non care related tasks can thus create extra time for care related tasks. Transferring these logistical tasks to logistical employees can be a valuable, economizing and qualitative solution. Logistical employees namely have got more dedication, more effort and more time to execute these tasks. They besides that also have a lower income, higher interests, higher motivation and better education to do it effectively, efficiently and properly.

In line with the previous conclusion about the current suboptimal organization of the logistical processes, we furthermore can conclude that also the transition point from logistical – to care related tasks is placed at the wrong function. Placing the transition point at the surgical assistant function leads to a suboptimal execution of the logistical tasks, but also negatively influences the core care tasks of the surgical assistants because of (among others) the required flexibility. An even worse effect is visible on the health and stress experience of surgical assistants. The survey showed that high percentages of questioned surgical assistants show serious health complaints and show clear signals of a burnout. This situation raises the chance of more job switches, discharges and illnesses of surgical assistants. This is something which would endanger the quality of care and the continuing of the delivery of care. It further also will lead to extra expenses (hiring more temporary workers) and lower incomes (empty operation rooms). Every possibility of sparing surgical assistants should thus be considered.

These effects are also personally supported by the surgical assistants. They first of all appreciate the surgical assistant with a grade which is lower than the average appreciation of professions in The Netherlands. They secondly also appreciate the current organization of the logistics with a serious low grade. They not only dislike the current organization of the logistics, but also do not enjoy executing logistical tasks and think that logistical tasks should be executed by logistical employees instead of surgical assistants. The current organization of the surgical assistant function and the location of the transition point thus demands for rapid changes.

Based on the different studies, the different results and our analysis we can thus conclude that the amount of different tasks of surgical assistants and the location of the transition point have a great influence on the quality, costs and speed of the delivered care (figure 71).

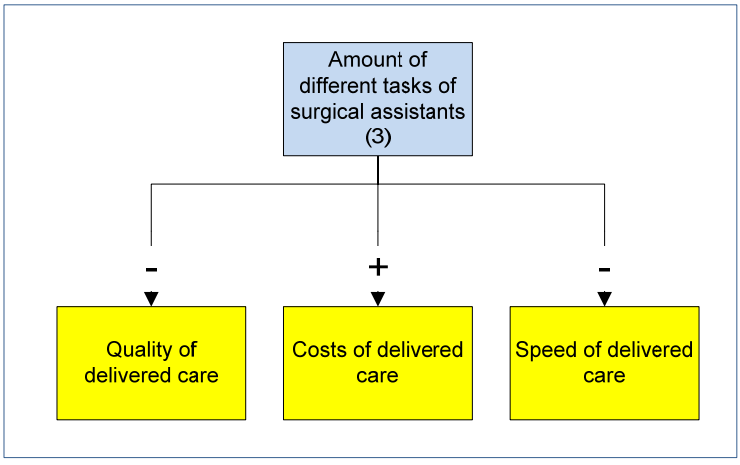


***Figure 71**, Revert to the conceptual model*

These results of our research towards the general health and burnout rate of surgical assistants legitimize our discussion about a hard cut between care related tasks and supporting tasks. We already mentioned the influence on the quality, speed and costs of the logistical processes, but now we can also show the influence on the health of the surgical assistants. Releasing them from logistical tasks will decrease the required flexibility and will provide extra time for care related tasks. We then also would like to present the following recommendations based on this research questions:

Quantum changes

- Create a hard cut between supporting functions (including logistics) and the core care functions (including surgical assistants).
- Extent the usage of procedure trays
- Place the transition point on the logistical employee function

Incremental changes

- Let surgeries be prepared by logistical employees
- Logistical employees should transport missing materials to an operation room
- Let logistical employees clear away not used disposables and reusables after a surgery (also with a signal or surgical assistants can transport the carts to the warehouses)
- Let logistical employees execute the replenishment tasks in and around an operation room
- Let logistical employees lay out the necessary materials for a surgery (when possible)
- Implement a closed door policy for operation rooms (for all concerned specialisms)
- Usage of mobile phones by all logistical employees and walk around surgical assistants

4. How is the demand for surgeries influencing the organization of the logistical and care related processes?

As already stated, the research towards the characteristics of the demand for surgeries and the resulting demand for medical resources was necessary to be able to provide recommendations for a reengineering of the total process. The characteristics of this demand namely influence the possible organization, structure and lay-out of the improved logistical – and care related process.

We already indicated that the surgical process is characterized by a great variability in demand. The current demand for reusables and disposables (towards suppliers) therefore is not based on the demand for surgeries. Instead of pulling the resources to an operation room, the materials are currently pushed to the warehouses. Instead of using *time* as a buffer, the UMCG is using *inventories* (close to the operations center) as buffer. Switching to a pull based strategy can however lead to lower inventories (on different locations). Most health care providers however are hesitant against implementation of a just in time system because of a common feeling of not being able to predict the production capacity and scheduling. An often heard argument is that hospitals are facing a great amount of short term emergency demand and that there just is not enough time to implement a just in time strategy.

Based on our research and analysis we however can conclude that the current demand indeed is variable, but that the excessive usage of inventories on locations close to the operations center is unnecessary. We have shown that only 4.03% of the surgeries cannot be buffered with the available time until the moment of surgery. In view of the fact that the UMCG currently is using

high inventories as buffer, it thus is possible to significantly reduce the amount of stock and use the available extra time until a surgery as buffer.
The above conclusion is further supported when regarding the customer order decoupling point. Based on the available time until a surgery and the duration of the total logistical process it is possible to determine how far actual customer demand penetrates into the production or service process. For the organization of the logistical processes in the direction of an operation room this means that when the available time until a surgery is equal to – or greater than the total logistical process time, the total logistical process can be organized on the base of actual individual surgery demand. When the available time until a surgery is lower than the total logistical process time, a part of the logistical process should be based on forecasts and predictions. Based on a comparison of these two components we can conclude that only in case of acute surgeries there is no penetration of actual demand in the organization of the logistical process. In case of the elective, urgent and emergency surgeries, the available time until a surgery is greater than a part of the total logistical process. This means that actual demand can penetrate into a reasonable part of the logistical process. This influences the organization, structure and lay-out of the logistical – and care related processes and provides an opportunity for more lean, pull or just in time based inventory strategies. The main conclusion can be that it is possible to transfer a part of the warehouses to the LCE to create extra valuable space for care related processes at the operations center. Important conditions that should be met before this is possible are the continuous availability of preparing employees, elaborate insight in the locations of reusables and disposables, reliable and detailed preparation protocols and frequent deliveries from the LCE to the operations center.

Based on the different studies, the different results and our analysis we can thus conclude that the variability of demand and standardization of requirements for surgeries have a great influence on the quality, costs and speed of the delivered care (figure 72).

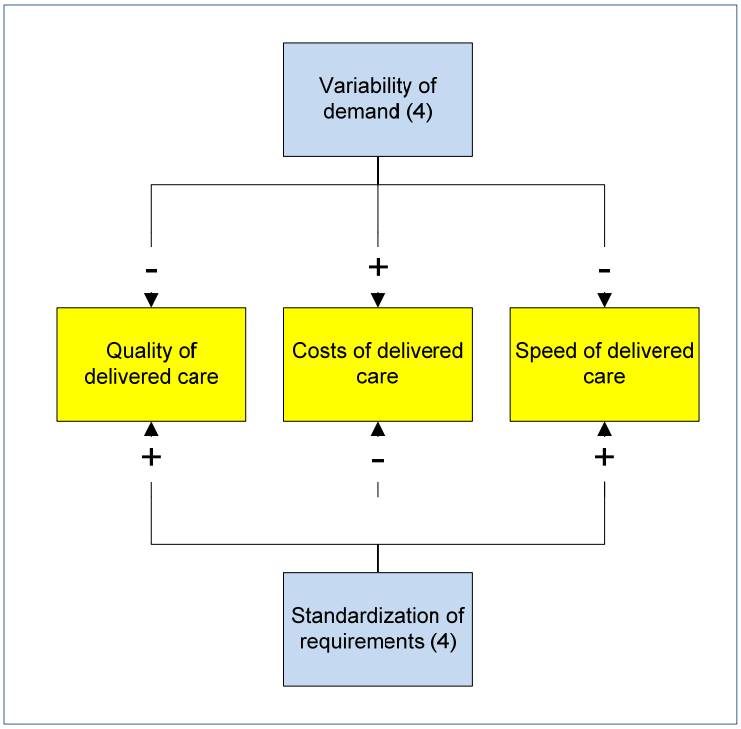


***Figure 72**, Revert to the conceptual model*

To be able to increase the quality, costs and speed of the delivered care we have mentioned different recommendations for the UMCG:

Quantum changes

- Use more time buffers instead of the frequent usage of inventory buffers

Incremental changes

- Fine tune the preparation protocols
- Use CBV codes (and extensions) for the preparation of preparation protocols
- Take into account the available amount of necessary materials when planning surgeries (and also take into account the agreed decontamination time)
- Consider the usage of ASA codes when planning time slots of surgeries
- Direct input of emergency operations, when they occur, into the planning system (OK plus) in combination with a phone call to the preparing employees (also when implementing other program changes)
- Extent the standardization of surgical requirements for surgeries

5. How should the inventory at an operations center be managed?

When regarding the current management of the inventory at the operations center, we can conclude that there currently is no effective and efficient inventory management strategy formulated. Based on the already described characteristics of the total logistical – and care related process, the involved persons and departments, the absence of a digital scanning system, the absence of support of an information management system, the current location of the transition point and the current division of logistical tasks, the logistical employees just are trying to make the best of the current situation (which clearly is not optimal). In combination with the lack of proper logistical education of the right (HBO or academic) level, this has resulted in an outdated inventory management system which leads to higher costs, lower quality and lower speed of the total surgical process. This mainly is the result of using inefficient, paper based and not digitally supported inventory management practices.

Besides the above described organizational causes, we think there also are social and emotional causes of the lack of development of inventory management at the UMCG. Because of the absence of practices that support the learning of employees (practical on the job learning, learning from mistakes and other challenging situations, individual goals and motivation and personal growth and self development) it looks like the logistical employees are "stuck" at the operations center and currently are not interested in – and motivated for personal and work related developments. Besides that, we also think that this is caused by the bureaucracy in the UMCG (many persons have influence on the decisions which leads to slow decision making processes about possible developments) and the absence of an innovative climate that stimulates the development of the logistical function at the operations center. This last point of course also is related to the current strategy at the operations center whereby the care related employees are leading and the logistical related employees are supporting. All the inventory related practices are adjusted to – or determined by the care related employees. They actually are the most important party in the management and organization of the inventory.

The result of the above described situation is that the organization of the logistics at the operations center is not developing in line with environmental developments. In other words, the logistics at the operations center of the UMCG is losing ground with regard to other hospitals. Innovations and new thoughts about inventory management are not applied and work practices are based on historical ideas. We therefore can advise the UMCG once again to introduce the

hard cut between core CARE and supporting tasks. Since the organization of the logistics is not a core care tasks of the care related employees, this should be managed by the logistical employees and not by the surgical assistants. To be able to catch up the arrears with regard to other hospitals, the UMCG is advised to break out of the current paradigm. This double-loop learning involves changes in cognition and behavior, outside the existing strategic paradigm. The UMCG has to facilitate the individual learning of the logistical employees at the operations center and adopt innovative logistical concepts out of the external environment. Together with all involved persons and departments the UMCG should strive for an optimal fulfillment of the logistical function (clearing away new replenishment stocks, clearing away remains of a surgery, ordering new replenishment stocks, digital support, ordering special high cost non stock items, management of the warehouses, ordering new products (not yet in the assortment) and the control of sterility dates). It thereby is important that a new logistical strategy is not an isolated case, but is related and adjusted to the organization of the total surgical process, the involved persons and departments, the location of the transition point, the characteristics of demand and the standardization of the requirements.

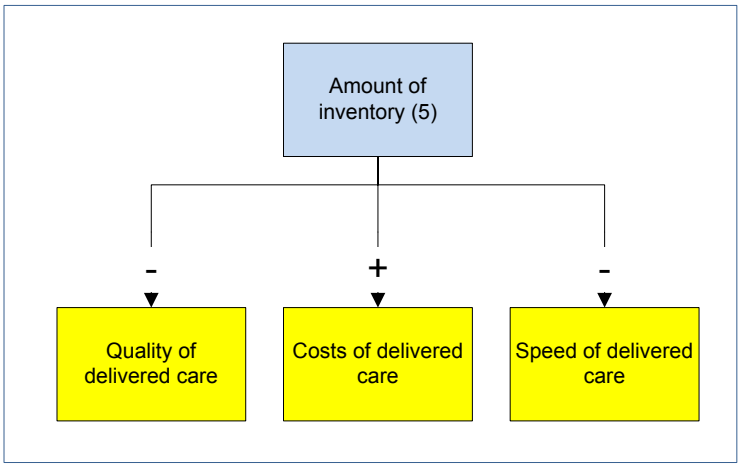


***Figure 73**, Revert to the conceptual model*

To be able to increase the quality, costs and speed of the delivered care we have mentioned different recommendations for the UMCG:

Quantum changes

- Stop with the dispersed responsibilities of logistical employees at the operations center
- Implement an inventory management system
- Extent the usage of Chipsoft (the program has many extra functionalities)
- Expand the tasks of logistical employees and create an *integrated logistical service center* whereby tasks instead of responsibilities are dispersed and different warehouses are integrated

Incremental changes

- Confront logistical employees with logistical processes in other hospitals and organizations
- Increase the amount of (logistical) training of logistical employees
- Increase the amount of benchmarking with other hospitals
- Create frequent meetings between involved parties and persons to improve the communication and create a possibility to mention and discuss possible problems

- Adopt innovative logistical concepts from the external environment (other organizations and hospitals)
- Create innovative and creative sessions with logistical employees, surgical assistants, surgeons and anesthetists (all together) to be able to develop new logistical concepts and increase the amount of involvement
- Create an inventory management policy (for the future)
- Create once per week controlling lists of sterility dates of inventories (with the help of the scanning system)
- Base picking lists on the sterility dates of inventories
- Create a signal when new replenishment supplies have arrived at the goods-receipt point of the operations center
- Direct scanning of materials when taking them out of the warehouse (with regular cycle counting for control)
- Make use of detailed picking lists (and establish them to the used carts)
- Improve the identification of materials in the warehouses (change the identification tags)
- Placement of flat screens in the warehouses and at the sterile processing department (and possible at the corridors)
- Increase the amount of information in Chipsoft about specific surgeries (which also is available and visible in an operation room; for example experience of different surgeons with certain complex surgeries)
- Fast and easy search function in the information system to find necessary materials during the night (for surgical employees)
- Reorder special high cost non stock items with the scanning system at the operation room to be able to directly order by the supplier at the moment the item is used
- Obliged communication when new materials will be introduced (what happens with the old, etc.)

6. At which locations in the (researched part of the) hospital supply chain should resources be stored and warehouses be placed?

The formulated inventory management – and logistical strategy is, in combination with the characteristics of the demand, the organization of the logistical – and care related processes and the insight into the different process steps, determining the amount of locations of resources and warehouses in the total hospital supply chain. The chosen amounts are significantly influencing the costs, speed and quality of the total process. Based on the discussion in around this last sub question we can conclude that the current layout is totally adjusted to the used logistical strategy at the operations center. Since the surgical assistant function currently is the transition point from logistical tasks to care related tasks, the layout is totally adjusted to the different work places of the surgical assistant. This means a great amount of warehouses at different locations in the supply chain, close to the operation rooms with a high percentage of duplicated materials.

When considering the conclusions of all the sub questions, we have to conclude that the current structure and layout of the warehouses at the operations center is ineffective and inefficient. Since we already showed that the current organization of the total logistical – and care related processes, the insight in the total process, the organization based on the interdependency between the involved persons and departments and the location of the transition point are of suboptimal form and that the UMCG is not taking into account the characteristics of the demand for individual surgeries and has not stated a qualitative inventory management strategy we further

have to conclude that it is not wise to adapt the locations and layout to these suboptimal concepts, strategies and realizations. Since the UMCG currently has a shortage of space at the operations center, it thus can be advised to change the logistical strategy to free logistical space for care related space as operation rooms.

The current lay-out at the UMCG is a confirmation of the statement that a fear for stock outs has limited the attempts of the UMCG at the development of effective and efficient hospital locations, resources and facilities. It therefore often is not clear how much and where supplies are stocked. The UMCG furthermore has a too great amount of storage locations leading to high inventory costs, waste of materials, waste of time and emergency orders. These warehouses are also filled with all the different materials and instruments that could be required during a surgery, which leads to even higher inventory costs.
On the road to a lean supply chain it, however, is important that also the structure of the last part of the supply chain is reconsidered. The UMCG should also consider the declining amount of available square meters, determine the most efficient and effective lay-out of the operations center and the connection with previous and subsequent processes and departments. Historically, hospitals then often decide to choose for rebuilding and extending. These days the focus should however be shifted to ***reengineering***. Unnecessary warehouses should be removed to create space for care related activities. Hospitals need a new logistical structure and lay-out to match possible new strategies and processes. It is necessary to create a hard cut between care related – and supporting tasks, but also to apply this to the chosen structures and lay-out. To be able to integrate and standardize the logistics at the operations center, whereby the best efforts and practices can be combined and concentrated, it is necessary to create a centrally led operation model; an *integrated logistical service center*.

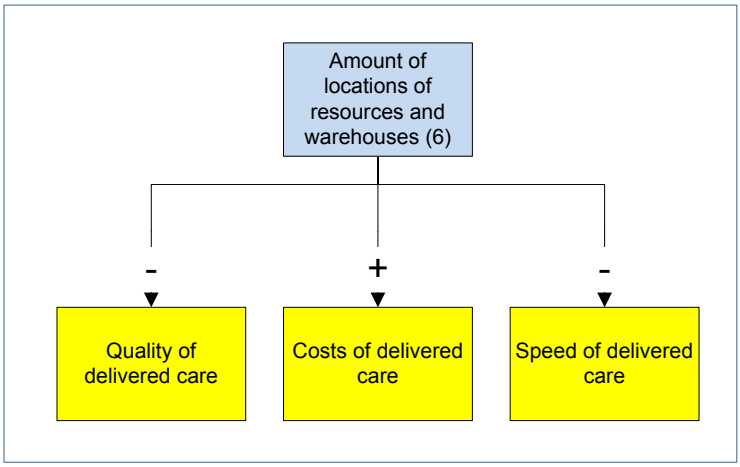


***Figure 74**, Revert to the conceptual model*

In case of the UMCG, three (actually four) different opportunities for the generation of an integrated logistical service center were possible:

- A sub optimal integrated logistical service center whereby the warehouses at the operations center are restructured in a central facility around the rising points (at only one floor, or two centers at both floors)
- The creation of a new integrated logistical service center whereby the operations center and the sterile processing department (they both are depreciated) are rebuild on a new location on the UMCG area
- The creation of a shared logistical service center on the Eemspoort. From here it then is possible to transport prepared surgical carts to different hospitals in the environment of

Groningen. This shared logistical service center is an extension of the shared sterile center

Besides the above mentioned possibilities, it of course also is possible that the UMCG chooses for a fourth "suboptimal optimum" of the current organization whereby the lay-out is not changed and only the recommendations (that can be implemented in the actual lay-out of the total logistical process) are implemented. When we however finally look at our main research question...

> How should the logistical processes, which are facilitating the execution of the surgical process, be reengineered and where should the functional separation between logistical - and care related tasks be placed to be able to increase the speed and quality and decrease the costs of the total surgical process in the University Medical Center Groningen?

… we have to conclude that to be able to increase the speed and quality and decrease the costs of the total surgical process in the UMCG, it is advised to create the recommended new integrated logistical service center. We think that the current situation (depreciated infrastructure of the sterile processing department and operations center) is the perfect opportunity. This also is supported by the expected main negative consequences (which will be present for several years) of choosing for a reconstruction of the current operations center:

- Stress for surgical assistants
- Extra costs of temporary operation rooms and warehouses
- Dirt and dust because of the reconstruction
- An even more suboptimal organization of the surgical process (with negative consequences for the costs, quality and speed of the process)

A choice for a suboptimal optimum furthermore will mean that the UMCG is dependent on this suboptimal optimum for the coming years. To be able to prevent this situation, ***radical decisions are required and necessary!***

The title of this master thesis not for nothing used the term *process reengineering*. Approaches such as process reengineering recognise that business performance is ultimately dependent on the optimisation of core and support business processes. (Surgical) Processes are comprised of sequences of linked activities which cross the vertical and functional boundaries existing in most organisations. Hence the reengineered organization transforms itself from a structure based on departmental roles to one based on directly servicing processes. It then also has been defined as the *fundamental rethinking* and *radical redesign of business processes* to achieve *dramatic improvements* in critical, contemporary measures of performance, such as *cost, quality, service and speed.*

We therefore only can make the conclusion that to be able to significantly increase the speed and quality and significantly reduce the costs of the surgical process in the UMCG, fundamental and radical reengineering is required on the following 6 core areas:

- Division of tasks
- Lay-out of the operations center
- Responsibilities
- Communication
- Digitalization
- Usage of information systems

6.2 Future Research

Further research concerning the logistics at the operations should be focused on the fine tuning of the different mentioned recommendations. Further research is necessary before the different recommendations successfully can be implemented.

1. Further standardization of used/required materials by surgeons
2. Classification of inventory (ABC)
3. Optimizing the planning of surgeries (instead of using fixed time slots and fixed operation rooms, it might be useful to use a different method (much literature available))
4. Possibility to create an earlier concept planning to be able to make an early planning of the necessary materials
5. Allocation of low cost disposables on the base of the duration of a surgery
    - Also look at the subsequent article: Toyabe, S., Cao, P., Kurashima, S., Nakayama, Y., Ishii, Y., Hosoyama, N. and Akazawa, K., Actual and estimated costs of disposable materials used during surgical procedures, *Health Policy*, **73**(1), (2005), p.52 – 57
6. Inventorise delivery times of suppliers
7. Determine the level of scanning (only A and B items or maybe a price level)
8. Which instruments and instrument sets often need an emergency appeal
9. Possibility to change the agreed decontamination time of 12 hours
10. Extent the usage of procedure trays (possible in an UMC?)
11. General health and burnout rates of surgical assistants (and probably other health care functions) as a consequence of their forced flexibility
12. Possibility for a different fulfilment of the surgical assistant function (especially the walk around function)
13. Increase of the amount of temporary workers in health care because of the labour shortages / Are surgical assistants more willing to switch to a employment agency
14. Why surgical assistants with lower ages and history of working in other hospitals appreciate the current organization of the logistics with lower marks
15. Added value when using ASA codes in the planning of surgeries
16. Comparison between actual operation times and planned operation times
17. Current utilization percentage of operation rooms
18. More in dept study of replenishment policy of a supermarket (or other retail company)
19. Usage of digital identification tags in the hospital warehouses

6.3 Scientific value of this research

Because of the extent of this research, it was difficult to focus on only one important and valuable scientific subject. On our opinion we therefore have stressed several subjects with scientific value. These subjects can be an input for further scientific research and/or possible publications.

1. General work of surgical assistants and the great share of logistical tasks
2. Consequences for surgical assistants (in terms of health and burn out) of the great task diversity and resulting forced flexibility (location of the transition point)
3. Possible lay-out of an integrated logistical service center in a hospital
4. Advantages of the creation of an integrated logistical service center in a hospital
5. Necessity of insight in different processes in an hospital (also logistical processes) and the advantages of implementing a digital scanning system in a hospital
6. Advantages of using procedure trays in a hospital
7. Necessity of communication (also in logistics) in a hospital
8. Consequences for the development (of in this case in logistics) when employees have sub optimal learning curves
9. The experienced variability in surgeries which actually is not really variable and can be buffered with time instead of inventory
10. Possible advantages of applying logistical concepts of other industries in a health care environment
11. Necessity of standardized requirements of surgeons for surgeries
12. Application of the Customer Order Decoupling Point to surgical – and logistical processes in a health care environment

- References -

Ansari, A. and Modarress, B., Just in time purchasing: problems and solutions, *Journal of Purchasing and Materials Management*, **22**(2), (1986), p.11 – 15

Ansari. A. And Modarres, B., JIT purchasing as a quality and productivity centre, *International Journal of Production Research*, **26**(1), (1988), p.19 – 26

Appelbaum, S.H. and Reichart, W.R., How to measure an organization's learning ability: the facilitating factors – part II, *Journal of Workplace Learning*, **10**(1), (1998), p.15 - 28

Asoh, D.A. and Rivers, P.A., A research model for health care competition and customer satisfaction, *Health Services Management Research*, **20**(4), (2007), p.244 – 252

Atkinson, A.A., Kaplan, R.S. and Young, S.M., *Management Accounting*, 4th edition, New Jersey: Pearson Education, 2004

Baltacioglu, T., Ada, E., Kaplan, M.D., Yurt, O. and Kaplan, Y.C., A new framework for service supply chains, *Service Industries Journal*, **27**(2), (2007), p.105 – 124

Barlow, R.D., A world without materials management fades to red, *Healthcare Purchasing News*, **31**(7), (2007), p.4

Barlow, R.D., Docs in a box, *Healthcare Purchasing News*, **31**(2), (2007), p.10 - 12

Barlow, R.D., Stocking up on stock out prevention strategies, *Healthcare Purchasing News*, **32**(6), (2008), p.64 - 69

Barney, J., Strategic factor markets: expectations, luck and business strategy, *Management science*, **32**(10), (1986), p.1231 – 1241

Belkoski, D.A., Stop the supply chain insanity: retail as a model for hospitals, *Healthcare Financial Management*, **62**(4), (2008), p.60 – 64

Biao, Y, Ying, Y. and Wijngaard, J., Impact of postponement on transport: an environmental perspective, *International Journal of Logistics Management*, **16**(2), (2005), p.192 - 204

Blackwell, R.D. and Blackwell, K., The century of the customer: converting supply chains into demand chains, *Supply Chain Management Review*, **3**(3), (1999), p.22 – 32

Bonvissuto, N., Experts sleuth out surgeon demands for specialty instruments, *Healthcare Purchasing News*, **31**(3), (2007), p.64 - 65

Borhuis, T.L., Happé, M., Dijkmans van Gunst, G.J. and Hoepel, J.K., De spelregels rond DBC's: Nieuwe ronde nieuwe kansen, *ZM Magazine*, **19**(10), (2003), p.36 – 40

Bourne, M., Mills, J. and Faull, N., Operations strategy and performance: a resource-based perspective, *International Journal of Operations and Production Management*, **23**(9), (2003), p.944 – 946

Boyd, B.B., An analysis of communication between departments – roadblocks and bypasses, *Journal of Business Communication*, **3**(2), (1966), p.27 – 35

Brenninkmeijer, V., *A drug called comparison: the pains and gains of social comparison among individuals suffering from burnout*, Almere: PlantijnCasparie, 2002

Brown, S.W., Fisk, R.P. and Bitner, M.J., The development and emergence of services marketing thought, *International journal of Service Industry Management*, **5**(1), (1994), p.21 – 48

Butler, T.W., Keong Leong, G. and Everett, L.N., The operations Management role in hospital strategic planning, *Journal of Operations Management*, **14**(2), (1996), p.137 – 156

Cachon, G.P., The allocation of inventory risk in a supply chain: push, pull and advance-purchase discount contracts, *Management Science*, **50**(2), (2004), p.222 – 238

Chakravarthy, B.S., Flexible commitments, *Strategy and Leadership*, **24**(3), (1996), p.14 – 20

Chakravarthy, B.S. and Henderson, J., From a hierarchy to a heterarchy of strategies: adapting to a changing context, *Management Decision*, **45**(3), (2007), p.642 – 652

Chase, R.B., The mall is my factory: reflections of a service junkie, *Production and Operations Management*, **5**(4), (1996), p.298 – 308

Chen, J., Achieving maximum supply chain efficiency, *IIE Solutions*, **29**(6), (1997), p.30 – 35

Childe, S.J., Maull, R.S. and Bennet, J., Frameworks for understanding Business Process Reengineering, *International Journal of Operations and Production Management*, **14**(12), (1994), p.22 – 34

Cooper, D.R. and Schindler, P.S., *Business Research Methods*, 8th edition, Singapore: McGraw Hill, 2003

Crossan, M.M., Lane, H.W., White, R.E. and Djurfeldt, L., Organizational learning: dimensions for a theory, *International Journal of Organizational Analysis*, **3**(4), (1995), p.337 – 360

Daft, R.L., *Organizational Theory and Design,* 8th edition, Mason: Thomson South-Western, 2004

Das, C. and Goyal, S.K., A Vendors view of the JIT manufacturing system, *International Journal of Operations and Production Management*, **9**(8), (1989), p.106 - 111

De Leeuw, A.C.J., *Bedrijfskundig Management, primair proces, strategie en organisatie*, 2nd edition, Assen: Koninklijke van Gorcum BV, 2002

D'Netto, B. and Sohal, A.S., Changes in the production manager's job: past, present and future trends, *International Journal of Operations and Production Management*, **19**(2), (1999), p.157 - 181

Enthoven, A.C., Theory and practice of Managed Competition in Health Care Finance, Amsterdam: North Holland, 1988

Evans, G.N., Towill, D.R. and Naim, M.M., Business process re-engineering the supply chain, *Production Planning and Control*, **6**(3), (1995), p.227 – 237

Farrel, D., Henke, N.P. and Mango, P.D., Universal principles for health care reform, *McKinsey Quarterly*, **16**(1), (2007), p.86 – 97

Fitzsimmons, J.A. and Maurer, G.B., A walk-through audit to improve restaurant performance, *The Cornell Hotel and Restaurant Administration Quarterly*, **31**(4), (1991) p. 95 – 103

Fottler, M.D., Schermerhorn jr., J.R., Wong, J. and Money, W.H., Multi-institutional arrangements in Health Care: Review, Analysis and a proposal for future research, *Academy of Management Review*, 7(1), (1982), p.67 – 79

Fowler, A., Operations management and systemic modelling as frameworks for BPR, *International Journal of Operations and Production Management*, **18**(9/10), (1998), p.1028 – 1056

Freeman, J.M., Process Based Management Research Available, *Management Accounting*, **78**(6), (1996), p.63

Freudenheim, M., Removing the warehouse from cost conscience hospitals, *The New York Times*, 3 march, (1991), p.B1

Galbreath, J. and Galvin, P., Which resources matter? A fine-grained test of the resource-based view of the firm, *Academy of Management Proceedings*, (2004), 6 p.

Ginn, G., Strategic Change in hospitals: An examination of the response of the acute care hospital to the turbulent environment of the 1980's, *Health Services Research*, **25**(4), (1990), p. 565 – 592

Goldstein, S.M., Ward, P.T., Leong, G.K. and Butler, T.W., The effect of location, strategy, and operations technology on hospital performance, *Journal of Operations Management*, **20**(1), (2002), p.63 – 75

Goudswaard, A.P., Sterilisatie buiten het Medisch Centrum, *White paper*, (2006), p.1 – 13

Grey, C. and Mitev, N., Reengineering Organizations: a critical appraisal, *Personnel Review*, **24**(1), (1995), p.6 – 18

Gupta, D., Surgical Suites' Operations Management, *Production and Operations Management*, **16**(6), (2006), p.689 – 700

Haeuser, J.L. and Preston, P., Communication strategies for getting the results you want, *Healthcare Executive*, **20**(1), (2005), p.16 - 20

Hammer, M., and Stanton, S.A., Beating the risks of reengineering, *Fortune*, **131**(p), (1995), p.105 – 114

Hanisch K.A., The Job Descriptive Index revisited: Questions about the question mark, *Journal of Applied Psychology,* **77**(3), (1992), p.377 – 382

Harkey, J. and Vraciu, R., Quality of Health Care and Financial Performance: Is there a link, *Health Care Management Review*, **17**(4), (1992), p.55 – 63

Harris, J.E., The internal organization of hospitals: some economic implications, *Bell Journal of Economics,* **8**(2), (1977), p. 467 – 482

Hedlund, G., The hypermodern MNC – a heterarchy, *Human Resource Management*, **25**(1), (1986), p.9 – 36

Hesson, D., Achieving supply chain savings when you least expect it, *Healthcare Purchasing News*, **28**(8), (2004), p.64 – 65

Hill, T., *Manufacturing Strategy: Text and cases*, Homewood: Irwin, 1989

Hopp, W. and Spearman, M.L., To pull or not to pull: what is the question, *Manufacturing and Service Operations Management*, **6**(2), (2004), p.133 - 148

Horn, C.A., Scientific Management The pioneers 1870 – 1920, *Management Services,* **22**(7), (1978), p.16 - 21

Hornsby, J.A. and Schmidt, R.E., *The modern hospital: its inspiration, its architecture, its equipment, its operation*, 1st edition, Philadelphia: W.B. Saunders Company, 1913

Jack, E.P. and Powers, T.L., Volume flexible strategies in health services: a research framework, *Production & Operations Management*, **13**(3), (2004), p.230 - 244

Jarret, P.G., Logistics in the health care industry, *International Journal of Physical Distribution and Logistics Management*, **28**(9/10), (1998), p.741 - 772

Jelovac, I. and Macho-Stadler, I, Comparing organized structures in health services, *Journal of Economic Behaviour and Organization*, **49**(4), (2002), p.501 – 522

Jiang, B., Frazier, G.V. and Prater, E.L., Outsourcing effects on firms' operational performance, *International Journal of Operations and Production Management*, **26**(12), (2006), p.1280 – 1300

Jiang, H.J., Friedman, B. and Begun, J.W., Factors associated with High-Quality/Low-Cost Hospital Performance, *Journal of Health Care Finance*, **32**(3), (2006), p.39 – 52

Johnston, R., Service Operations Management: return to roots, *International Journal of Operations Management,* **25**(12), (2005), p.1278 – 1297

Johnston, R., Service Operations Management, from the roots up, *International Journal of Operations Management*, **25**(12), (2005), p.1298 – 1308

Johnston, R.A, Newell, W.T. and Vergin, R.C., *Operations Management*, 1st edition, Boston: Houghton Mifflin, 1972

Jones, C., Supply Chain Management: the key issues, *BPICS Control*, **15**(3), (1989), p.23 – 27

Jones, S., OR increases workflow efficiency, charge capture, *Healthcare Purchasing News*, **32**(11), (2008), p.60 – 61

Jurow, S., Core competencies: Strategic thinking about the work we choose to do, *Journal of Academic Librarianship*, **22**(4), (1996), p.300 – 302

Kaczmarek, D.S., Justifying limited storage locations, *Healthcare Purchasing News*, **33**(3), (2009), p.66

Keehan, S., Sisko, A., Truffer, C., Smith, S., Cowan, C., Poisal, J. and Clemens, M.K., Health Spending Projects Through 2017: The baby boom generation is coming to medicare, *Health Affairs*, **27**(1/2), (2008), p.145 – 155

Kocakulah, M.C., McGuire, B.L. and Kueh, M.J., Responding to the demands of cost containment and competitive pressures in health care: A for-profit psychiatric hospital case study, *Research in Health Care Financial Management*, **6**(1), (2001), p.51 – 62

Koeter, M. W. J. and Ormel, J. ,*General Health Questionnaire: Nederlandse bewerking*, Lisse: Swets and Zeitinger, 1991

Kreeft, J. and Dewaet, E., ISS Hospital Services and Hospital Logistics als ideale partner, *De Ziekenhuiskrant*, (2008)

Kumar, S., De Groot, R.A. and Daewon, C., Rx for smart hospital purchasing decisions, *International Journal of Physical Distribution and Logistics Management*, **38**(8), (2008), p.601 – 615

Kumar, A., Ozdamar, L. and Zhang, C.N., Supply chain redesign in the healthcare industry in Singapore, *Supply Chain Management*, **13**(2), (2008), p.95 – 103

Lamming, R. and Hampson, J., The environment as a supply chain management issue, *British Journal of Management*, **7**(1), (1996), p.45 - 62

Langham, M., OR Department uses LEAN to cut unneeded inventory and saves money, *Health Care Purchasing News*, **31**(11), (2007), p.68 – 69

Lee, M.L., Conspicuous Production Theory of Hospital Behavior, *Southern Economic Journal*, **38**(1), (1971), p.48-58

Leedal, J.M. and Smith, A.F., Can techniques from business and management be used to improve the running of operating theatres? *Clinician in Management*, **14**(2), (2006), p.79 - 88

Leonard-Barton, D., Core capabilities and core rigidities: A paradox in managing new product development, *Strategic Management Journal,* **13**(3), (1992), p.111 – 125

Leverment, Y, Ackers P. and Preston, D., Professionals in the NHS: a case study of business process reengineering, *New Technology, Work and Employment*, **13**(2), (1998), p.129 – 140

Li, L.X., Benton, W.C. and Leong, G.K., The impact of strategic operations management decisions on community hospital performance, *Journal of Operations Management*, **20**(4), (2002), p.389 – 408

Lin, B. and Vassar, J.A., Implications of reengineering in health care, *Health Care Supervisor*, **15**(2), (1996), p.63 – 68

Little, J. and Coughlan, B., Optimal inventory policy within hospital space constraints, *Healthcare Management Science*, **11**(2), (2008), p.177 – 183

Liyanage, C. and Egbu, C., A performance management framework for healthcare facilities management, *Journal of facilities management*, **6**(1), (2008), p.23 – 36

Lytle, R.S., and Mokwa, M.P., Evaluating health care quality: the moderating role of outcomes, *Journal of Health Care Marketing*, **12**(1), (1992), p.4 – 14

Majchrzak, A. and Qianwei, W., Breaking the functional mind-set in Process Organizations, *Harvard Business Review,* **74**(5), (1996), p.93 - 99

Mango, P.D. and Shapiro, L.A., Hospitals get serious about operations, *McKinsey Quarterly,* **10**(1), (2001), p.74 – 85

Manoochehri, G.H., Suppliers and the just in time concept, *Journal of Purchasing and Materials Management*, **20**(4), (1984), p.16 - 21

McConnel, C.R., Larger, smaller, and flatter, *Health Care Manager,* **24**(2), (2005), p. 177 – 188

McFarlane, D. and Sheffi, Y., The impact of automatic identification on supply chains, *International Journal of Logistics Management*, **14**(1), (2003), p.1 – 17

Meyer, A.D., Brooks, G.D. and Goes, J.B., Environmental jolts and industry revolutions: organizational responses to discontinuous change, *Strategic Management Journal*, **11**(4), (1990), p.93 - 110

Mintzberg, H., *Structures in fives, Designing effective organizations*, 1st edition, Edinburgh: Pearson Education, 1985

Moad, J., Does reengineering really work, *Datamation,* **39**(5), (1993), p.22 – 29

Mobach, M.P., The general pharmacy work explored in The Netherlands, *Pharmacy World & Science*, **30**(1), (2008), p.353 – 359

Moinzadeh, K. and Nahmias, S., Adjustment strategies for a fixed delivery contract, *Operations Research*, **48**(3), (2000), p.408 - 423

Monczka, R.M. and Morgan, J., What will happen and what you should know, *Purchasing*, **124**(1), (1998), p.78 – 82

Mulani, N., Maximizing worldwide effectiveness with a centrally led operation, *Logistics Management*, **48**(1), (2009), p.25 - 26

Nash, R.K. and Bryce, D.J., Core competencies create value, *Healthcare Financial Management*, **50**(10), (1996), p.35 – 37

Nicholson, L., Vakharia, A.J. and Selcuk, E.S., Outsourcing inventory management decisions in healthcare: models and application, *European Journal of Operational Research*, **154**(1), (2004), p.271 - 290

Nutt, P.C. and Hogan, M.F., Downsizing guidelines found in a success story, *Public Performance and Management Review*, **32**(1), (2008), p.103 – 131

Onwubolu, G.C. and Dube, B.C., Implementing an improved inventory control system in a small company: a case study, *Production Planning & Control,* **17**(1), (2006), p.67 – 76

Oostenbrink, J.B. and Rutten, F.F.H., Cost assessment and price setting of inpatient care in the Netherlands: the DBC case-mix system, *Health Care Management Science*, **9**(3), (2006), p.287 – 294

Oswald, A. and Warr, P., Is job satisfaction U-shaped in age, *Journal of Occupational & Organizational Psychology*, **69**(1), (1996), p.57 - 81

Palmer, R.H., Using clinical performance measures to drive quality, *Total quality management*, **8**(5), (1997), p.305 - 312

Parker, A.J., Production and Operations Management, *Interfaces*, **4**(1), (1973), p.51 – 53

Peeters, M.C.W. and van Emmerik, H., An introduction to the work and well-being of older workers, *Journal of Managerial Psychology*, **23**(4), (2008), p.353 - 363

Perrot, D., The Dutch Health Care System: Possible model for America, *Physician Executive*, **34**(6), (2008), p.16 – 23

Perrow, C., A framework for the comparative analysis of organizations, *American Sociological Review*, **32**(2), (1967), p.194 - 208

Pierskalla W. and en Wilson D., *Review of Operations Research Improvements in Patient Care Delivery Systems*, University of Pennsylvania, 1989

Pool, J.A., Herontwerp van de Centrale Sterilisatie Afdeling in het Universitair Medisch Centrum Groningen, Doctoraalscriptie Technische Bedrijfswetenschappen, January 2007

Porter, M.E., What is Strategy, *Harvard Business Review*, **74**(6), (1996), p.61 – 78

Prahalad, C.K. and Hamel, G., The core competence of the corporation, *Harvard Business Review,* **68**(3), (1990), p.79 – 91

Riege, A.M., Validity and reliability tests in case study research: a literature review with "hands-on" applications for each research phase, *Qualitative Market Research: An International Journal*, **6**(2), (2003), p.75 - 86

Riezebos, J., Syllabus Inrichting van Transformatie Processen, 2004

Rivard-Rover, H., Landry, S. and Beaulieu, M., Hybrid stockless: a case study lessons for health care supply chain integration, *International Journal of Operations and Production Management*, **22**(4), (2002), p.412 – 424

Rousseau, D.M. and Tijoriwala, S.A., What's a good reason to change? Motivated reasoning and social accounts in promoting organizational change, *Journal of applied psychology*, **84**(4), (1999), p.514 - 528

Sasser, W.E., Match supply and demand in service industries, *Harvard Business Review*, **54**(6), (1976), p.133 – 140

Schaepkens, F.F.J.M., Ziekenhuisbekostiging in Nederland, van FB naar DBC, *MCA Tijdschrift voor organisaties in Control*, **6**(5), (2002), p.13 – 25

Schaufeli, W. B. and Van Dierendonck, D. ,*Handleiding van de Utrechtse Burnout Schaal (UBOS)*, Lisse: Swets Test Services, 2000

Schönsleben, P, *Integral Logistics Management: Operations and Supply Chain Management in Comprehensive Value Added Networks*, 3rd Edition, Boca Raton: Auerbach Publications, 2007

Schut, F.T. and Hassink, W.H.J., Managed competition and consumer price sensitivity in social health care, *Journal of Health Economics*, **21**(6), (2002), p.1009 – 1021

Shah, R., Goldstein, S.M., Unger, B.T. and Henry, T.D., Explaining anomalous high performance in a health care supply chain, *Decision Sciences*, **39**(4), (2008), p.759 – 789

Shields, T., Surgery center struggling with storage and purchasing personnel issues, *Healthcare Purchasing News*, **25**(6), (2001), p.16

Shiver, J.M., ED Performance improvement: process changes hospitals can make now, *Healthcare Financial Management*, **61**(12), (2007), p.70 - 73

Silvestro, R., Fitzgerald, L., Johnston, R. and Voss, C., Towards a classification of service processes, *International Journal of Service Industry Management*, **3**(3), (1992), p.62 – 75

Skjoett-Larsen, T., European Logistics beyond 2000, *International Journal of Physical Distribution and Logistics Management*, **30**(5), (2000), p.377 – 387

Slack, N. and Lewis, M., *Operations Strategy*, 1st edition, Edinburgh: Pearson Education Limited, 2002

Slack, N., Chambers, S. and Johnston, R., *Operations Management*, 4th edition, Essex: Pearson Education Limited, 2004

Slotte, V., Tynjälä, P. and Hytönen, T., How do HRD practitioners describe learning at work, *Human Resource Development International*, **7**(4), (2004), p.481 - 499

Smith, P. C., Kendall, L. M. and Hulin, C. L., *The measurement of satisfaction in work and retirement: A strategy for the study of attitudes*, Chicago: Rand McNally and Company, 1969

Smith, H.L., Fottler, M.D. and Saxbert, B.O., Cost Containment in Health Care: A Model for Management Research, *Academy of Management Review*, **6**(3), (1981), p.397 – 407

Stalk, G. and Hout, T.M., Competing against time: How time-based competition is reshaping global markets, *Human Resource Management*, **28**(3), (1989), p.428

Stark, E. and Mangione, T., Top issues facing the hospital supply chain today, *Healthcare Purchasing News*, **28**(11), (2004), p.74 – 75

Stebbins, M.W., Shani, A.B., Moon, W. and Bowles, D., Business process reengineering at Blue Shield of California: the intergration of multiple change initiatives, *Journal of Organizational Change Management*, **11**(3), (1998), p.216 – 232

Svensson, G., The multiple facets of the bullwhip effect: refined and redefined, *International Journal of Physical Distribution and Logistics Management*, **35**(10), (2005), p.762 – 777

Tae-Moon, K., Just in time manufacturing system: a periodic pull system, *International Journal of Production Research*, **23**(3), (1985), p.553 – 562

Thompson, J.D., *Organizations in Action: Social Science Bases of Administrative Theory*, 6th edition, New Brunswick: Transaction Publishers, 2008

Van Bokhoven, P., Engelaar, R., van Merrienboer, S. and Takken, J., Ketenlogistiek medische middelen: één zorg minder, *white paper*, (2000), p.1 - 59

Van der Meer, E.T. and School, M.A.A., De logistiek van het ziekenhuis, *Medisch Contact*, **63**(49), (2008), p.2058 – 2060

Van Yperen, N.W. and De Jong, I.J.A., Is een tevreden werknemer ook een productieve werknemer, *Gedrag en Organisatie*, **10**(2), (1997), p. 69 – 77

Van Yperen, N. W., *Vragenlijst Arbeid & Gezondheid*, Groningen: Rijksuniversiteit Groningen, 2006

Vos, L., Dückers, M., De Bruijn, M., Wagner, C., Groenewegen, P. and Van Merode, F., Naar een procesgestuurd ziekenhuis: beoogde effecten van een logistiek verbeterprogramma, *Tijdschrift voor Gezondheidswetenschappen,* **86**(4), (2008), p.207 – 215

Voss, C., Tsikriktsis, N. and Frohlich, M., Case research in Operations Management, *International Journal of Operations & Production Management*, **22**(2), (2002), p. 195 - 219

Walston, S.L., Lazes, P.M. and Sullivan, P.G., Improving hospital restructuring: Lessons learned, *Health Care Management Review*, **29**(4), (2004), p.309 – 319

Wansink, W., Zorgstelsels: Een groot ziekenfonds*, Elsevier*, (2005), www.elsevier.nl/web/Artikel/Zorgstelsel-En-groot-ziekenfonds.htm

Werner, C., Cost savings in the O.R. is a difficult but rewarding business, *Healthcare Purchasing News*, **26**(5), (2002), p.22 - 23

Whitson, D., Applying just in time systems in health care, *IIE Solutions*, **29**(8), (1997), p.32 – 37

Williamson, J.E., Instrument management systems move beyond tracking level, *Healthcare Purchasing news*, **28**(1), (2004), p.46 - 48

Williamson, J.E., Advanced automated device tracing helps hospitals log more savings, *Healthcare Purchasing News,* **30**(2), (2006), p.44 - 46

Winter, D., Get health care suppliers lean, *Ward's Auto World*, **40**(7), (2004), p.5

Womack, J., Take the lead in lean, *Manufacturing Engineer*, **84**(2), (2005), p.3

Wyatt, J., Aligned schedules make OR and materials more efficient, *Materials Management in Health Care*, **15**(2), (2006), p.32 - 36

Wysocki jr., B., Hospitals adopt Toyota production techniques to cut costs, improve services, in intensive care, *Quality Progress*, **37**(6), (2004), p.15-18

Yin, R.K. and Campbell, D.T., *Case Study Research: Design and methods*, 3rd edition, Beverly Hills: Sage Publications Inc, 2003

Yokl, R.T., Zero waste must be your goal, *Healthcare Purchasing News*, **32**(4), (2008), p.68

Websites

Dossier zorgstelsel, www.nos.nl/nosjournaal/nosdossiers, last visit on the 17th of February 2009

Jaarverslag Universitair Medisch Centrum Groningen 2007, www.azg.nl/azg/store/pdf/Jaarverslag2007.pdf, last visit on the 20th of February 2009

Logistiek Centrum voor Groninger ziekenhuizen, www.logistiek.nl/nieuws, last visit on the 4th of June 2009

The UMCG, www.umcg.nl/Umcg, last visit on the 3rd of June 2009

Universitair Medisch Centrum Groningen, Bouwen aan de toekomst van gezondheid: visie 2007 – 2011, www.azg.nl/azg/store/pdf/Visiemissie, last view on the 13th of March 2009

Amount of words

77.598