Tactical Planning for Medisch Spectrum Twente

Designing a tactical resource capacity planning concept for the outpatient clinics and operating rooms of MST

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Foreword

Before you lies the result of my studies at the University of Twente, the report for my master thesis. Not only does it symbolize the last part of my studies, but it also concludes the last chapter of my life in Enschede. I have had a great time here and I would not have missed it for the world, but I believe I am now ready for the next step. I hope my report will have a similar effect for MST, in that it will provide a stepping stone for the next step in planning for MST. I hope it provides insight in the current situation and the possibilities for tactical planning.

Erwin said that writing my thesis would be the best period of my studies (in hindsight, that is). I am very proud to finally be able to present it to you all. But I am sorry, I cannot say it was the best period... Erwin, thank you for your help and support. I always came out of our meetings way happier than I went in. Thank you for that (and for letting me know that I do not have to worry so much)!

Irma, thank you for providing me with this opportunity. And thanks for the support, even though my subject kept changing, and it took me much longer than expected to finish. I hope you are pleased with the result.

Jasper Quik, thank you for the opportunity to learn about tactical planning in ZGT. Peter Hulshof, thank you for your help and insights into tactical planning. Ingrid, thank you for your comments that helped improve my report. Further, I thank all employees of MST I spoke to, who helped me gain insight in the processes, organization, and planning in MST, and who thereby advanced my study.

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Bram, as you know I have not forgotten about you, even though you left me alone at the Beltstraat and we do not get to drink coffee as often any more. I do not think there is anyone that knows as much about my life during this last year. Thank you for you (and for introducing me to sushi take-away).

Martenique, our dinner dates have not actually served their purpose, but I am very pleased to have gotten to know you better over this last year. Marc, I like to thank you especially for motivating me throughout and the fact that you kept listening. Erik, the same holds for you. Thank you for listening and our occasional HEMA breakfasts and early cups of coffee. Everyone else, thank you for listening to my ideas (and listening in general). Anneloes, I think it is about time for those victory drinks.

Finally I thank my mother and "little" brother for their support and the occasional hug when I needed one. And Nic, I have not known you for that long and I realize I have not been the easiest girlfriend. Thank you for your help, motivation, distraction, and everything you are to me!

Richelle Rijntjes
Enschede, November 30th

Management summary

Background

Better care at less costs has become the main focus point of the health care system in the Netherlands, emphasizing the need for logistic principles that help improve both efficiency and patient care. The health care system is currently under influence of (increased) government cost cutting. In 2010, MST started a return improvement program with the main emphasis on improving efficiency of processes. In 2011, this program is accelerated to deal with additional budget cuts.

Research scope

We focus our research on tactical capacity planning of outpatient clinics (OC) and operating rooms (OR) in MST. The outpatient clinic generally marks the start of the care trajectory of a patient and generates demand for the OR. Both the OC and OR require time from the specialist, their shared resource. The performance of OC and OR capacity planning, defined by access, waiting, and throughput times and production realization, is critical for hospital performance.

Research problem and objective

Tactical capacity planning, of patient processes and related resources of outpatient clinic and operating rooms, is hardly done in MST. Moreover, MST is also lacking the required and reliable information for tactical planning.

The objective of this research is
to design a tactical planning concept for the outpatient clinics and operating rooms of MST and to determine the necessary steps for implementing this concept in the organization.

Method

A context analysis and literature research provide the input for the design of a tactical planning approach and recommendations for MST.

The context analysis includes a description of the patient process, including related logistic indicators, an evaluation of strategic, tactical, and operational level planning and control, and the definition and description of performance indicators and assessment of current MST performance. Interviews and conversations with employees of MST provided the main input for the context analysis.

The literature research consists of scientific literature on tactical capacity planning for outpatient clinics, operating rooms, and integrated planning approaches. Literature references from the bibliography of the CHOIR research unit of the University of Twente, Orchestra, are used as a starting point. Further, tactical planning in a practical setting is described, following an interview with an employee concerned with tactical planning within neighboring hospital ZGT. Also, one specific article is described in more detail as it includes tactical planning for both OC and OR. We obtained additional information on this article from a presentation and conversations with the author.

Conclusions

Current resource capacity planning in MST is supply-oriented. Tactical planning consist for the OR of a quarterly roster for which the exchange of OR blocks is not centrally organized and basically non-

existent. Apart from orthopedics, no tactical planning is made allocating capacity over patient categories.

MST should benefit from increased communication and coordination on the tactical level to improve patient care and enable more efficient use of capacity. Accurate performance information is required to enable tactical planning, but while most data is available from MST systems not all information is accurately used or made available. Logistic indicators could help forecast demand and performance for the near future by using knowledge of the patient process (steps in the process and transition probabilities and times).

Literature on integrated planning for OC and OR is limited. MST requires a workable method. Therefore mathematical methods from literature do not provide a solution on their own as they often provide "one optimal solution" for a certain point in time, which does not include all restricting factors and may differ extensively between periods, which complicates acceptance by specialists. In ZGT, tactical planning is already part of the organization, where tactical planning is organized in meetings in which capacity allocations are discussed and determined based on tactical management information, providing a workable method.

Recommendations

Tactical planning concerns elective patient (category) planning on an intermediate term. We advise MST to organize tactical planning in tactical planning meetings in which decisions about (re)allocations of capacity will be made, based on management information of supply, demand, and past and forecasted performance. Supply and demand should be aligned by reallocating capacity among specialties and patient categories when needed, for which we assume sufficient total capacity (until proven otherwise). Scenarios should be used, in which the effects of different capacity planning decisions/adjustments on performance are evaluated, enabling timely reallocation of capacity. We advise that two meetings are held each month, between specialties on hospital level (allocating OR capacity among specialties) and within specialties on specialty level (allocating capacity among patient categories).

A large part of the tactical planning concept is to know what information is required, which data to gather, how to turn this data into information, and how to use this information to your advantage. MST requires process information, patient categories, and tactical management information for tactical planning. We advise the following projects, considering information building from data already available in MST systems, to ensure the required conditions for tactical planning:

- **Strategic planning** – strategic choices are made, and strategic goals are set. Strategic planning provides focus in the tension field between management, personnel, and patients and determines the flexibility/degrees of freedom for tactical planning.
- **Availability of process information** – information about the patient process (probability of requiring a certain step and time between steps) is made available. This information is required for patient categorization and demand forecasting.
- **Patient categorization** – DBC types are clustered into patient categories per specialty. Patient categories are required for capacity allocation on specialty level and enable more precise demand forecasts to be made.

- **Availability of tactical management information** – several types of information (demand, supply, and performance information) are made available. This enables informed planning decisions to be made; capacity (re)allocation is based on this information.
- **Pilot tactical planning** – a pilot should be started to evaluate the benefits and possible problems with tactical planning for MST. Immediate implementation into the entire organization is too extensive, therefore a small number of larger surgical specialties is included.

A specific employee (or a selection of employees) should be made responsible for information gathering and specifically the availability of tactical management information. Also, a key role in tactical planning is reserved for business and medical managers. The business managers should be the driving force behind tactical planning and are concerned with project management. The medical managers represent their specialty in hospital level tactical planning meetings. Additional training may be required for all involved employees (especially those who deal with tactical management information).

Managementsamenvatting

Achtergrond

Betere zorg voor minder geld is het belangrijkste speerpunt binnen het Nederlandse zorgstelsel geworden. Dit benadrukt de behoefte aan logistieke principes die zowel de efficiëntie als de patiëntzorg kunnen verbeteren. Het huidige zorgstelsel heeft te maken met (toenemende) overheidsbezuinigingen. In 2010 is in het MST gestart met een rendementsprogramma, waarbinnen ook de verbeterde efficiëntie van processen centraal staat. In 2011 is er een versneld programma geïntroduceerd om in te spelen op de verdere bezuinigingen.

Onderzoekskader

We richten ons op de tactische capaciteitsplanning voor de poliklinieken en operatiekamers (OK) van het MST. Het zorgtraject van de patiënt (binnen het ziekenhuis) start vaak op de polikliniek. De polikliniek genereert daarmee vraag voor de operatiekamers. Beide vragen tijd van de specialist, hun gedeelde resource. De prestatie van de poliklinieken en operatiekamers (toegangs-, wacht- en doorlooptijden, en het behalen van productiedoelstellingen) vormen kritieke prestatie-indicatoren voor de prestatie van het ziekenhuis.

Het probleem en doel van het onderzoek

Tactische capaciteitsplanning, van patiënt processen en de gerelateerde resources polikliniek en OK, is zeer beperkt in het MST. Daarbij mist het MST de juiste en betrouwbare informatie voor tactisch plannen.

Het doel van dit onderzoek is een tactisch plannen concept te ontwerpen voor de poliklinieken en operatiekamers van het MST en om de voorwaardelijke stappen voor implementatie van het concept in de organisatie te bepalen.

Methode

Een contextanalyse en literatuuronderzoek vormen de input voor het ontwerp van een tactisch plannen concept en de aanbevelingen voor het MST.

De contextanalyse bestaat uit een beschrijving van het patiëntproces, de bijbehorende logistieke indicatoren, een evaluatie van de strategische, tactische, en operationele planning, en de beschrijving van prestatie-indicatoren en de prestatie van het MST. Interviews en gesprekken met medewerkers van het MST vormen de belangrijkste bron voor de contextanalyse.

Het literatuuronderzoek bestaat uit wetenschappelijke literatuur met betrekking tot tactische capaciteitsplanning voor poliklinieken, operatiekamers, en geïntegreerde planning. Als een startpunt zijn referenties gebruikt uit de bibliografie van de CHOIR onderzoekseenheid van de Universiteit Twente, Orchestra. Naast de wetenschappelijke literatuur wordt ook een praktijkbenadering van tactisch plannen beschreven. De informatie volgt uit een gesprek met een medewerker van het nabije ziekenhuis ZGT, die zich bezig houdt met tactisch plannen. Ook wordt een artikel in meer detail beschreven, gezien het tactische capaciteitsplanning voor zowel de polikliniek als de OK behandelt. We hebben aanvullende informatie verkregen uit een presentatie en gesprekken met de schrijver.

Conclusies

De huidige capaciteitsplanning in het MST is aanbodgeoriënteerd. Tactisch plannen bestaat voor de OK uit een kwartaalrooster, waarbij de uitwisseling van OK blokken niet centraal georganiseerd is en zeer beperkt plaatsvindt. Buiten orthopedie bestaat er geen tactische planning waar capaciteit over patiëntcategorieën wordt verdeeld.

Het MST kan profiteren van verbeterde communicatie en coördinatie op tactisch niveau om zo zowel de zorg voor de patiënt als de efficiëntie in het gebruik van capaciteit te verbeteren. Prestatie-informatie is nodig om tactisch plannen mogelijk te maken. Terwijl de meeste data beschikbaar is in de systemen van MST, wordt deze toch niet (op een juiste manier) beschikbaar gemaakt. Logistieke indicatoren kunnen helpen om vraag en prestatie voor de nabije toekomst te voorspellen door de kennis van patiëntprocessen te gebruiken, bestaande uit de stappen in het proces en overgangskansen en -tijden.

Literatuur op het gebied van geïntegreerde planning van poli en OK is zeer beperkt. Het MST heeft behoefte aan een werkbare methode. De mathematische modellen bieden daarom niet direct een oplossing. Zij berekenen vaak "een optimale oplossing" voor een bepaald moment, waarbij niet alle restricties kunnen worden meegenomen en waarbij de planning per periode (na herberekening) sterk kan verschillen, dit bemoeilijkt acceptatie door specialisten. In het ZGT is tactisch plannen al onderdeel van de organisatie. In tactisch plannen bijeenkomsten wordt daar de verdeling van capaciteit besproken en bepaald met behulp van tactische stuurinformatie.

Aanbevelingen

Tactisch plannen behandelt electieve patiënten (-categorieën) planning op middellange termijn. We adviseren het MST om tactisch plannen in bijeenkomsten te organiseren waar beslissingen over (her)verdeling van capaciteit worden gemaakt, gebaseerd op stuurinformatie op het gebied van aanbod, vraag, en prestatie (uit verleden en verwacht). Vraag en aanbod zullen op elkaar afgestemd moeten worden door capaciteit te verdelen over specialismen en patiëntcategorieën wanneer nodig. We gaan hierbij uit van voldoende capaciteit (tot anders blijkt). Scenario's moeten worden gebruikt om het effect van verschillende capaciteitsaanpassingen op de verwachte prestatie te bekijken. Dit maakt tijdige beslissingen over herverdeling mogelijk. We adviseren om iedere maand twee bijeenkomsten te houden, tussen specialismen op ziekenhuisniveau (waar OK capaciteit wordt verdeeld over specialismen) en binnen specialismen op specialismenniveau (waar capaciteit wordt verdeeld over patiëntcategorieën).

Een groot deel van het tactisch plannen concept bestaat uit de kennis omtrent welke informatie benodigd is, welke data hiervoor verzameld dient te worden, hoe deze data wordt omgezet in nuttige informatie, en hoe deze informatie in je voordeel te gebruiken is. Het MST heeft procesinformatie, patiëntcategorieën, en tactische stuurinformatie nodig voor tactisch plannen. We adviseren de volgende projecten, die onder andere het samenstellen van informatie uit reeds beschikbare data behandelen, om te voorwaarden voor tactisch plannen te behalen:

- **Strategisch plannen** – strategische keuzes worden genomen en strategische doelen worden bepaald. Strategisch plannen geeft focus in het spanningsveld tussen management, personeel, en patiënt en bepaalt de flexibiliteit/vrijheidsgraden voor tactisch plannen.

- **Beschikbaarheid van procesinformatie** – informatie over het patiëntproces (kans op een bepaalde stap in het proces en tijd tussen stappen) wordt beschikbaar gemaakt. Deze informatie is benodigd voor patiëntcategorisatie en vraagvoorspelling.
- **Patiëntcategorisatie** – DBC typen worden per specialisme geclusterd in patiëntcategorieën. Patiëntcategorieën zijn benodigd voor capaciteitsverdeling op specialismenniveau en maken nauwkeurigere vraagvoorspelling mogelijk.
- **Beschikbaarheid van tactische stuurinformatie** – verschillende informatietypen (vraag, aanbod, en prestatie-informatie) worden beschikbaar gemaakt. om geïnformeerde tactische planningsbeslissingen te kunnen nemen. Capaciteits(her)verdeling is gebaseerd op deze informatie.
- **Pilot tactisch plannen** – er zal een pilot moeten worden gestart om de voordelen en mogelijke problemen rond tactisch plannen te evalueren. Directe implementatie in de gehele organisatie is te omvangrijk, daarom wordt een klein aantal grotere snijdende specialismen betrokken in de pilot.

Een specifieke medewerker (of aantal medewerkers) zal verantwoordelijk moeten worden gemaakt voor de informatievoorziening en specifiek ook voor de beschikbaarheid van tactische stuurinformatie. Ook is een belangrijke rol weggelegd voor de bedrijfskundig- en medisch managers. De bedrijfskundig managers zullen de drijvende kracht achter tactisch plannen moeten zijn en zullen zich bezig houden met projectmanagement. De medisch managers vertegenwoordigen hun specialisme in de tactisch plannen bijeenkomsten op ziekenhuisniveau. Aanvullende training is mogelijk nodig voor de medewerkers die met tactisch plannen (en met name de tactische stuurinformatie) te maken krijgen.

Contents

1. Introduction

The topic addressed in this research is hospital resource capacity planning, which considers efficient allocation of available resources (Van Houdenhoven, 2007). Capacity planning, when mentioned in this report, concerns the allocation of time (the specialist's time, or time in the outpatient clinic (OC) or operating room (OR) schedule) over different activities.

This chapter starts with a background description of the main changes in the health care environment in the Netherlands in Section 1.1. Section 1.2 gives a characterization of MST. Section 1.3 describes the general problems concerned and gives the problem statement. Section 1.4 describes the research objective. To reach the goal of the research, it is split into several research questions. Section 1.5 gives these research questions and through these questions the outline of the research and report.

1.1. Background

The world of health care is becoming more and more complex. The board of directors of MST also emphasizes this in the introduction of the annual report 2009. While medical innovations become available that can improve the life expectancy of patients, at the same time the pressure to limit the costs of health care increases. In 2007, we spent 8.9% of our GDP on health care, this is a little over the overall European percentage of 8.8. 82% of the total health care expenditure was financed by the government, which is more than the European average of 76% (WHO, 2010).

The "Sneller Beter" report of TPG in 2004 provided new insight into the lacking efficiency of health care in the Netherlands. The main conclusion of the report is that the health care sector can benefit both financially and qualitatively from a better organization based on several logistical concepts. One of these is changing from a push to a pull system: provide patient-centered care, organize health care based on demand instead of providing care based on available capacity. This report contributed to the changes in our health care system, which are made to improve the efficiency and quality of health care provided.

The government introduced market forces into our health care system in 2005. The distinction between public and private health insurance was terminated and replaced by an obligatory basic insurance and optional complementary packages. Health insurance companies purchase care from health care providers and are expected to do so not only based on costs, but on quality as well. The competition between health care providers is to keep costs at a minimum and improve the quality of care (Glöckner, et al., 2009).

Currently, hospital's budgets are partly fixed (based on the number of available beds, the potential patient volume, and the presence of a trauma center for instance) but are mostly determined by production numbers through Diagnosis Treatment Combinations (in Dutch: DBC). Cost prices are determined for the steps in a treatment plan of a patient; these are standardized and connected to a diagnosis. Health care providers use the DBCs in the agreements with health care insurers. For DBCs, there are two financing structures: DBCs that are negotiable in number but not in price (the A-segment) and freely negotiable DBCs (the B-segment). Many DBCs are still in the A-segment, but each year more are directed into the B-segment to benefit from the positive effects of market forces. In 2010 34% of annual hospital turnover came from the B-segment (DBC Onderhoud, (2010); Kollenstaart, (2010)).

The Minister of Health, Welfare, and Sport has made several propositions for changes in the health care system from 2012 and onwards. In 2012 the current DBCs, 30.000 in total, are replaced by the DOT structure, which has 4000 health care products. Financing is structured through a free (B-segment), a regulated (A-segment), and a fixed segment. In 2012, the free segment will be expanded to 70% of care, emphasizing the shift from a budget system to performance pay (MinVWS, 2011).

1.2. Medisch Spectrum Twente

The annual report of 2009 gives MST's vision concerning health care: Medisch Spectrum Twente wants to be patient-centered, provide in hospitality and service, and deliver efficient and effective care, in a safely manner. The primary goal of MST is to improve the health of the people in the service area, by providing them with curative health care. The primary care is the basis of care provided. Apart from primary care, MST also provides top clinical and top referent health care (Medisch Spectrum Twente, 2010 [1]).

Medisch Spectrum Twente is one of the largest non-academic hospitals in the Netherlands with two locations in Enschede, one in Oldenzaal, and outpatient clinics in Haaksbergen and Losser. It has 1,070 acknowledged beds and employs around 4000 people plus 220 specialists. In 2010 there were 507,000 recorded visits to the outpatient clinics, of which 174,000 were first outpatient consults. The main service area is the Twente region, with primarily the municipalities Dinkelland, Enschede, Haaksbergen, Losser, and Oldenzaal. The primary service area includes around 264,000 people, in which MST had a total market share of 87% for the outpatient clinics and 85% for clinical and day admissions in 2009 (Medisch Spectrum Twente, 2011 [3]).

Health care in MST is organized in RVEs, Result Responsible Units, since 2008. Appendix A gives an overview. Each RVE has one or more operational managers that are responsible for the operational organization and a medical manager and business manager on the tactical level. The business managers head one or more RVEs. The RVEs are responsible for their own organization and finances (Medisch Spectrum Twente, 2011 [3]).

In 2010, MST has started with the return improvement program (in Dutch: rendementsprogramma) to structurally improve the return for MST with 22 million Euros by 2015. This is realized in the areas personnel, materials, process, and investments, with the emphasis on improving efficiency of processes (Medisch Spectrum Twente, 2011 [3]). MST is required to realize a cost reduction of 9 million Euros in the year 2011 due to government cost cutting. Shortly before the start of 2011 this reduction was increased by the government, from 3 to 9 million Euros. The return improvement program has therefore been accelerated, which is done under the name “Dare to Choose” (in Dutch: Durven Kiezen) (Medisch Spectrum Twente, 2011 [2]).

1.3. Problem description

The outpatient clinic is the starting point in the care trajectory for many patients, after which surgery may be required. Tactical planning provides possibilities for more integral planning. By using knowledge of the patient processes, better OC and OR demand forecasts can be made for the (near) future. Tactical planning in hospitals considers allocation of capacity over specialties and patient categories. Supply is adjusted to demand. By better forecasting and increasing flexibility in capacity allocation, indicators like access and waiting times and realization of production will be better manageable. In order to make (tactical) planning choices accurate information should be available.

In our research we focus on the tactical capacity planning for outpatient clinics and operating rooms of MST. The outpatient clinic generates demand for the OR. OC and OR both require time from the specialist, a shared resource. Furthermore, the OC and OR are considered in critical performance measurement for the hospital, defined by access, waiting, and throughput times and production realization indicators.

In MST, the OC and OR capacity planning are supply driven; OC and OR capacity are not adjusted to demand, but to availability of specialists. Also, the allocation of OR blocks limits the available time for outpatient clinic hours, the relation between the two is not made insightful. Access times to the outpatient clinics are not within norms for all specialties, they are high in many cases, and are reacted to in an ad hoc manner. Control on realization of production is also often reactive, as well as reaction to waiting times. Specialties have different ways of planning and organizing (secretaries, acute care, and more), working as they always have, lacking coordination and communication within and among specialties. This is also indicated by the limited exchange of OR blocks, the late return of blocks, and the fact that OR time is not always used efficiently.

Tactical capacity planning remains underexposed in many hospitals in the Netherlands, as well in MST. Where tactical planning is incorporated, the OR provides the main focus point. BLOKplan, a roster dividing OR blocks over specialties, provides a basic part of tactical planning on the hospital level. On specialty level, where the allocated OR capacity can be divided among patient categories, tactical planning is hardly done.

1.3.1. Problem statement

Tactical capacity planning, of patient processes and related resources of outpatient clinic and operating rooms, is hardly done in MST. Moreover, MST is also lacking the required and reliable information for tactical planning.

1.4. Research objective

The objective of this research is
to design a tactical planning concept for the outpatient clinics and operating rooms of MST and to determine the necessary steps for implementing this concept in the organization.

1.5. Research questions

To reach the research objective, various steps are taken in the research. These steps are described through research questions. This section gives the outline of the report through these research questions. Figure 1 gives a schematic overview of the structure of the research (report).

Chapter 2 gives the context analysis, in which the current organization of planning is discussed. Information from interviews and conversations with employees of MST are the main input for the content of this chapter. Chapter 3 includes the findings from the literature research. We used literature references from the bibliography of the CHOIR research unit of the University of Twente, Orchestra (CHOIR, 2011), as a starting point. Appendix B gives more information on the search process. Section 3.1 is composed with the information from scientific articles, Section 3.2 is based on interview, and Section 3.3 is based on one specific article, information from a presentation, and conversations with the writer. Chapter 4 combines the information from literature with the current planning in MST to compose a plan on how to organize and implement tactical planning in MST. We presented this plan to several employees* for feedback.

Chapter 2: Context analysis

How is planning currently organized and how can this process be described?

2.1 What steps are involved in the patient process and which indicators can be used to describe this process?

2.2 How is planning organized on a strategic, tactical, and operational level?

2.3 Which indicators can be used to examine the performance of the capacity planning and what is the current performance?

Chapter 3: Literature research

Which tactical capacity planning concepts from literature may be applied in MST?

3.1 Which concepts can we find in literature used in tactical capacity planning related to…
- o Outpatient clinics?
- o Operating rooms?
- o Integrated planning for outpatient clinics and OR?

3.2 How would tactical planning be organized in a practical setting?

3.3 How would tactical planning be organized built from theory?

Chapter 4: Design of a tactical planning approach for MST

How to organize tactical planning in MST?

4.1 What is an appropriate tactical planning concept for MST?

4.2 Which projects to undertake to enable tactical planning?

4.3 – 4.6 What is the content of these projects?
- o What, why, how, who, and when?

4.7 How to organize tactical planning, starting with a pilot project?
- o On hospital level
- o On specialty level
- o Evaluation of process and information

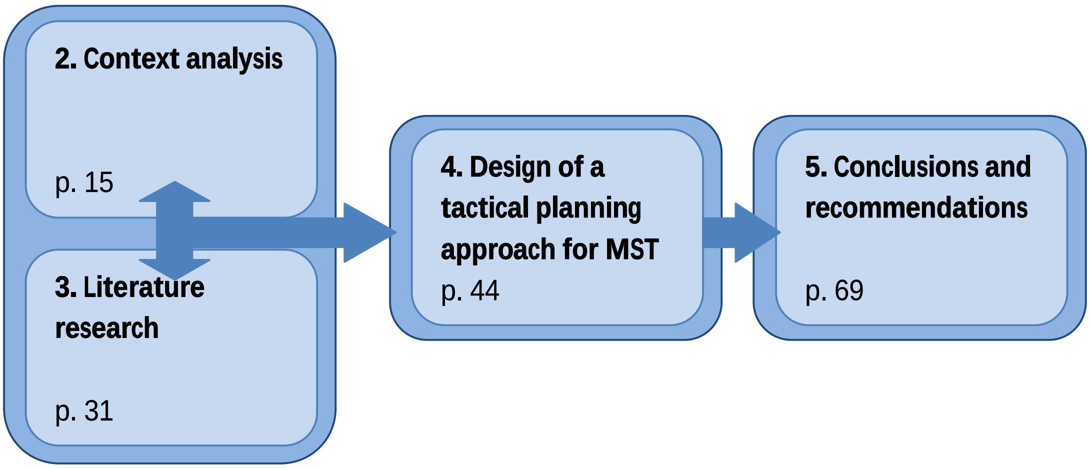


Figure 1: Research report structure (including page numbers)

*Gerwen Apenhorst (project officer OR), Maurice Erkens (business systems analyst), Ilona Grooters-Oosterholt (operational manager Orthopeadics), Thijs Schopman (operational manager OR), Irma de Vries-Blanken (program leader BPR, manager patient planning)

2. Context analysis

The context analysis in this chapter provides more insight into the process of planning, logistic indicators considered in this process, and the possibilities for performance measurement. Section 2.1 gives a description of the typical patient process and the logistic indicators used to describe this process. Section 2.2 describes the current organization of planning and control of the outpatient clinics and operating rooms. Section 2.3 gives the indicators that can be used to measure the performance of the planning. Section 2.4 consists of the conclusions from the context analysis and better defines the research scope.

2.1. The patient process

The first visit of patients to the outpatient clinic generally marks the start of a care trajectory, which may consist of e.g. surgery, further diagnostics, a stay at a ward, and revisits of the outpatient clinic. Figure 2 gives a simple representation of the typical patient process. Section 2.1.1 considers different aspects of demand and supply in this process and gives indicators through which the patient process can be described.

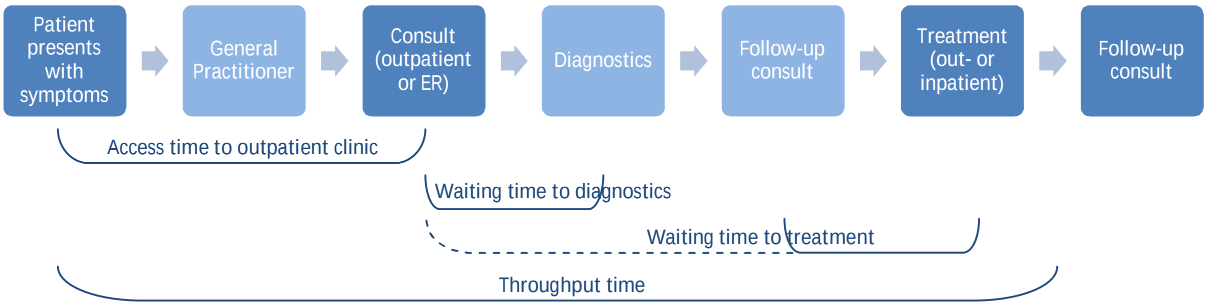


Figure 2: **The typical patient process, including access, waiting, and throughput times**

Consultation and diagnosis

A patient presents with symptoms and goes to the hospital for a specialist's consult. The patient is usually referred by his/her general practitioner (GP), but may also go straight to the emergency room (ER). After the first consult, further diagnostic tests, like lab tests or an MRI, may be required to determine a diagnosis. A follow-up consult may be required to discuss the outcomes, for instance in case of possible cancer diagnosis.

Treatment and follow-up

After the diagnosis is made, during the consult or through further tests, treatments can be scheduled. Treatment can either be inpatient (in the OR and ward) or outpatient (in the outpatient clinic or outpatient OR). Admission to the ward can be a day admission at the day of surgery or for a longer period of days, before and/or after surgery. Usually, a follow-up consult is scheduled after treatment, but other possibilities are a telephone consult or the patient is asked to contact the hospital if problems occur. For patients with a diagnosed chronic condition the follow-up consults will continue.

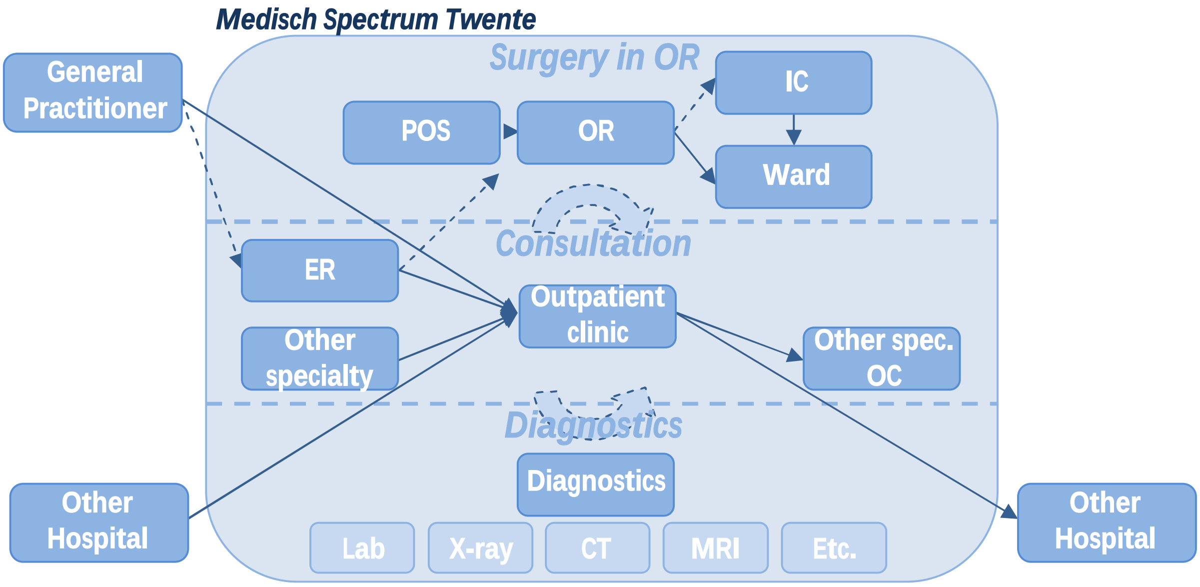


Figure 3: Schematic representation of the various disciplines/departments in the patient process

Figure 3 is a schematic representation combining the different disciplines, GP, ER, diagnostics etc. that are associated with the patient process. This figure also includes the possibility of a patient being referred from another hospital or outpatient clinic specialty, for care or an inter collegial consult (ICC), and the referral to another hospital or specialty. It is also shown that before surgery in the OR a patient goes through the post operative screening (POS) and that surgery results in an admission to a ward. It is also possible that a patient needs to stay in the intensive care.

2.1.1. Logistic indicators

Logistic indicators can be used to describe the patient process with planning in mind. We distinguish supply and demand-related indicators and indicators that can be used to model the patient process and forecast demand in the foreseeable future. All logistic indicators can be evaluated per diagnosis, per period, and possibly per specialist.

The following indicators are related to the demand side of planning:

- Expected volume
  - Elective or acute?
  - Production agreements
  - New patient consults
  - Follow-up consults and follow-up factor
  - Surgery indications
  - No shows
  - Variance in volume requirements (per period)
- Consult and surgery duration

The following indicators are related to the supply side of planning:

- Available time
  - For outpatient clinic hours (per period)
  - For surgery (per period)
  - Of the specialist

- Other activities during the week (study hours, administration time)

- Variance in availability
  - Holidays
  - Absence through illness

Appendix C further discusses these indicators for supply and demand.

Figure 27 in Appendix D also shows the patient process, of which Figure 2 gave a simple representation. The indicators that are required to model the patient process are included in this figure:

- % of patients requiring a certain step in the process (surgery, further diagnostics, follow-up consult)
- Time between process steps

Appendix D also gives a more detailed description of these process indicators.

2.2. Planning and control

Figure 4 shows the framework for hospital planning and control by Hans, Van Houdenhoven, & Hulshof (2011). The framework subdivides planning hierarchically on four levels: strategic, tactical, operational offline, and operational online planning, and discerns four managerial areas. As displayed, the framework gives the application to a general hospital. Sections 2.2.1-2.2.3 describe the planning and control activities in MST, for outpatient clinic and OR, using the hierarchical levels from the framework.

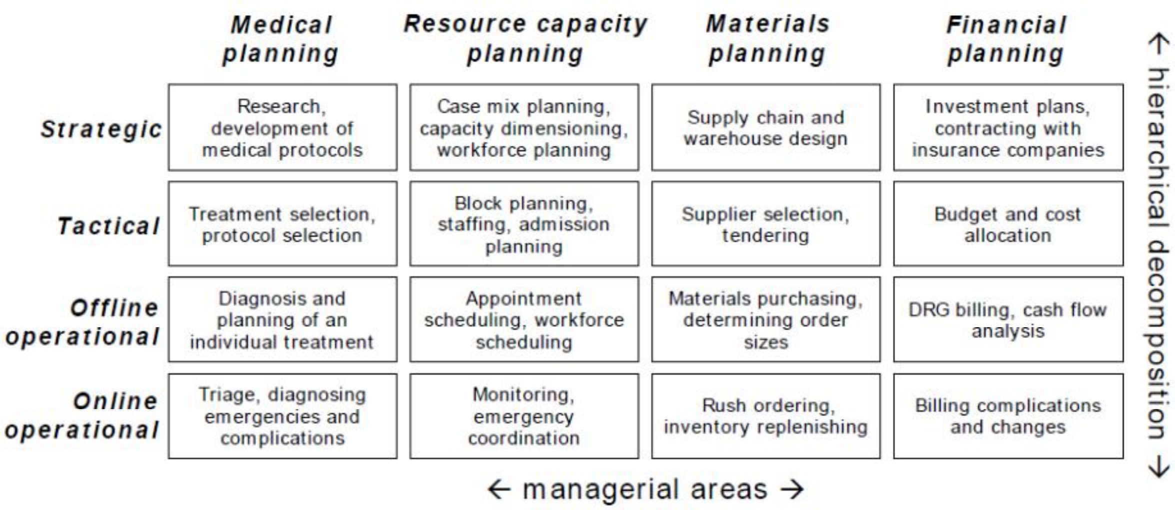
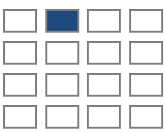


Figure 4: **Framework for Health Care Planning and Control, applied to a general hospital (Hans, Van Houdenhoven, & Hulshof, 2011)**

2.2.1. Strategic



Strategic planning considers long term choices and objectives: case mix planning, capacity dimensioning, workforce planning, production numbers in agreement with health care insurers, and time targets (e.g. access time to OC, waiting time for surgery) (Glöckner, et al., (2009); Hans, Van Houdenhoven, & Hulshof, (2011); Van Houdenhoven, (2007)). For the OR this translates to: capacity dimensioning, basic assignment of OR capacity over specialties (based on case mix), and long term staffing (Hans, Nieberg, & van Oostrum, 2007).

Case mix planning

MST is currently debating the case mix. With all the ongoing changes in the health care system, where insurers may expect high quality for low prices, decisions need to be made on specialty level on which types of patients to treat (De Vries-Blanken, 2010 [2]).

Capacity dimensioning

Capacity dimensioning concerns the determination of required renewable resource capacities, e.g. available (dedicated or generic) rooms and involves determining the working hours. The decision on how to deal with acute care (e.g. use of carve-out/dedicated capacity) has an impact on the flexibility in organization of elective patient planning and is therefore also of importance.

Capacity dimensioning - Outpatient clinics

Specialties have their own consultation rooms in their outpatient clinic. Consults are performed in Enschede, but for some specialties also at the locations in Oldenzaal, Haaksbergen, and/or Losser. Working hours for the outpatient clinic lie between 8:30 and 17:00 hours on week days, divided in a morning and an afternoon, with breaks planned in between. Planning of these consult hours differs per specialty and per specialist (see Section 2.2.2. – Block planning). The calculation from production targets to available outpatient clinic hours is hardly made. In pediatrics, the operational manager has started to calculate the required room capacity for each specialty, based on production numbers from previous years, including a safety margin (Koster, 2010).

Most specialties have interchangeable consultation rooms, in which the basics are available. There may be specific requirements for equipment for instance, that is installed in only one, or a limited number of rooms. In pediatrics, one room has the facilities and provides enough space for FUN (Follow-up Neonatology), neurology, and physiotherapy consults. Also one room has an entrance from outside the building, which can be used if contagiousness is expected (Pediatrics, 2010).

The handling of acute patients is organized differently for each outpatient clinic specialty. In pediatrics, one specialist each day is responsible for the same-day acute patients and one room is kept available to deal with this group. The access time of pediatrics usually lies within two weeks, which means that semi-acute patients can often be scheduled within a few days. In ophthalmology and neurology, time in the planning is reserved for semi-acute patients, but same-day acute patients come through the ER.

Capacity dimensioning - Operating rooms

There are 11 ORs in Enschede, plus one dedicated outpatient OR. Location Oldenzaal has 2 ORs, and one outpatient OR. Working hours are between 8:00 and 16:00 hours on week days. During holidays the number of available ORs is reduced, following a decrease in demand and the limited availability of (OR) personnel. Production targets should match the availability of OR capacity, but this calculation is not made (Straalman, 2011).

Specialties are usually assigned to the same ORs. In some cases this is due to certain characteristics, for instance one OR has a baby room, used by gynecology, and neurosurgery requires a larger room. Also ENT, Orthopedics, and General surgery have one or more dedicated ORs (Straalman, 2011).

The OR schedule (including scheduled patients) is only determined one week in advance. This means that only acute or urgent (within a few hours or a day) and semi-acute (within a week) surgical cases require changes in the schedule. These cases are included as they occur, or require capacity outside the standard working hours (in the evening, or on weekends). Some specialties regularly deal with acute cases and organized it differently. Gynecology requires an emergency section almost each day, which they deal with in planning by scheduling until 15:00 instead of 16:00 hours. General surgery fills one OR until 12:00 hours, notifying the scheduled patients of possible cancellation when acute surgical cases occur (Straalman, 2011).

Workforce planning

The workforce consists of the specialists, secretaries in the OC, and OR personnel. In the outpatient clinic also specialist's assistants are available for consults, who need supervision for a new patient consult and therefore require specialist capacity (Neurology, (2010); Ophthalmology, (2010)). Ophthalmology has TOAs, technical support assistants, available that can do some preparation for the specialists which creates extra capacity.

A certain number of specialist FTEs is present, which can be increased following an increase in production. As access times to the outpatient clinic increase, a decrease (e.g. due to illness or job changes) in available FTEs is usually mentioned as a reason why "we cannot do any better right now", which may limit the will to try and improve (Tackenkamp, 2010). The available FTEs (subtracting study time, administration time, visitation in mornings, night- and weekend shifts, supervision hours etc.) are used as a starting point for OC and OR capacity planning. The number of FTEs is not determined based on the expected demand or agreed production targets, but evaluated the other way around (Ophthalmology, (2010); Pediatrics,(2010)).

There are different ways of organization for secretaries. In neurology for instance, each specialist has one secretary, while in ophthalmology all secretaries work in shifts and not for one specific specialist.

Strategic goals

A dashboard (a Business Objects program) is available with performance indicators for the strategic level, based on data from the Data Warehouse. It includes scores on government indicators concerning quality of care (including access time to the OC and waiting time to treatment), personnel characteristics, production targets, and financial indicators.

Strategic goals - Quality of care

Indicators nationally used to measure quality of care, by for instance the IGZ (Healthcare Inspectorate), are naturally of a physical nature. This are, for instance, indicators on decubitus ulcers and malnutrition (IGZ, 2009). A complete overview of MST performance on government indicators is available through kiesbeter.nl.

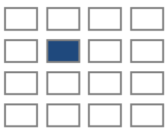
Access and waiting times are connected to the quality of care. These numbers are available on the website. For the outpatient clinic these values are not the actual access times, but are based on the third available slot in the planning, determined by the secretaries.

Strategic goals - Production targets

Each year new production numbers are decided upon. This is done based on the figures of last year. The realization is calculated and adjusted for expected (fluctuations in) demand and availability (for instance a decrease in number of FTE). When more than sufficient capacity was available the specialists together may decide to increase the production on a certain diagnosis (Penterman, 2010).

A central negotiation team, representing the board of directors of MST, conducts the negotiations with the health care insurers about the production numbers for A-segment and prices for B-segment DBCs. If production for A-segment is lower than agreed, the hospital will have to refund the rest to the insurer, while for a higher realization usually no additional funding is provided to the hospital (Kollenstaart, 2010). The team “speed-dates” with the RVEs about the agreements on production numbers, every two months (Medisch Spectrum Twente, 2011 [3]).

2.2.2. Tactical



Tactical planning considers medium term objectives from strategic planning and medium term choices: block planning, staffing, and admission planning (Hans, Van Houdenhoven, & Hulshof, (2011); Van Houdenhoven, (2007)). For the OR this translates to the assignment of OR time to specialties using block planning and planning of surgical staff (Hans, Nieberg, & van Oostrum, 2007). Tactical planning is elaborated further in Section 3.1 of Chapter 3, on page 31.

Block planning

Block planning - Outpatient clinic

The outpatient clinic capacity is divided over new patients, follow-up consults, and telephone consults, and a distinction is made between elective and acute patients. The outpatient clinics use preset slots in their planning. For instance 30 minutes for a new patient and 15 minutes for a follow-up consult (Neurology, 2010). These planned durations differ per specialty and can differ per diagnosis and specialist, which makes determination of required capacity more complicated (Penterman, 2010). The division over the different types, in most cases, followed from a “working without waiting”-project a few years back. Ophthalmology additionally uses a division over different types of diagnostics and treatment (like laser treatment), with slots at certain times of the week. For neurology the fit with the production agreements (new patient slots) of the tactical planning is monitored by the medical manager.

The block planning of outpatient clinic capacity is organized differently per specialty. In a basic schedule, the hours are divided in entire mornings or afternoons with a certain number of patient slots available. For instance, from 9 o’clock in the morning until ten past twelve, leaving room for 2 new patients and 10 follow-up consults (Pediatrics, 2010). In neurology the specialists decide themselves when they do their consults, which means the basic schedule for some consists of several clusters of only a few hours (Neurology, 2010).

The available outpatient clinic capacity is not calculated based on requirement, but is primarily based on the availability of the specialists, considering predetermined OR time, study time, part time days, etc. Also, few outpatient clinics predetermine a capacity-division over different patient types.

Specialties use different planning horizons for their tactical block planning. The actual available capacity is normally known on short term, due to discarded hours following other affairs of specialists like conferences. A shorter planning horizon is used to decrease the need for rescheduling patients when changes are made, but this requires more flexibility in workforce planning. With a longer horizon a long term basic schedule is used for planning.

Block planning - Operating rooms

BLOKplan includes (part of) the tactical capacity planning. The schedule gives the OR capacity division over specialties. It has a four-week rotating roster, which has not changed much over time. New specialties and expansion of specialty FTE put pressure on the existing roster.

The planning in BLOKplan is secured per quarter, six weeks in advance. Once it has officially been determined, it will only change on the operational level (short term exchange of OR blocks between specialties). Pressure on the roster comes from the specialties requesting more OR time (requesting less time is very uncommon), from the hospital to realize the production targets, and from within the OR department in case of a shortage in personnel. The capacity reduction during holiday periods is allocated as fair as possible to specialties using a reduction percentage.

Only orthopedics uses a Master Surgical Schedule (MSS) in which the tactical planning consists of predetermined slots for certain patient categories. Considering surgery duration, length of stay at the ward, and IC requirements an MSS can result in a more robust OR planning and bed utilization.

An OR dashboard combines the capacity planning over specialties with the actual patients scheduled (operational planning). It includes capacity information (incl. allocated, reduced, and extra capacity) and information about the use of this capacity (incl. utilization and overtime). Control based on utilization (possible exchange of capacity between specialties) is limited. The appointed blocks from tactical planning are not always used as efficient, still blocks are almost never returned. In the future, sanctions will be put in place for non-efficient use (low utilization) of the allocated OR capacity, this becomes possible due to better registration and the information from the dashboard (Straalman, 2011).

Staffing

Due to part time jobs and preferences from the specialist it proves hard to construct a basic schedule in which the availability is evenly distributed over the week. This is preferred to level the workload for secretaries, to have a more equal occupancy of the available room capacity, and to be able to deal with acute patients. The OR time together with part time days and requirements set by the specialists on night shifts and administration days, provide the basis for shift scheduling. This schedule is usually constructed by the team head, possibly together with a few secretaries, but in neurology specialists decide on their own schedule.

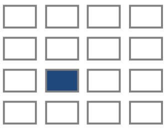
Each specialty allocates OR time from BLOKplan to its specialists. The division can be based on the specialist's waiting list, but is limited by the specialist's availability. More often, patients are asked whether they give permission to be operated upon by another surgeon than the one that diagnosed them, which increases the flexibility of capacity allocation (Straalman, 2011).

OR staff is a bottleneck capacity in tactical planning for the OR. Due to staffing shortages not all 12 ORs in Enschede are used each week. The basic capacity is 11 for each day, with an increase to 12 one day every fortnight (Straalman, 2011).

2.2.3. Operational

Operational planning considers short term planning, capacity allocation to patients (Glöckner, et al., 2009), to achieve higher level objectives. It is split into operational offline and operational online planning.

Operational offline



Operational offline planning considers in-advance elective patient scheduling (or: appointment scheduling) and workforce planning (Hans, Van Houdenhoven, & Hulshof, (2011); Van Houdenhoven, (2007)). For the OR this translates to the in-advance scheduling of patients to the available blocks from tactical planning and staff assignment (Hans, Nieberg, & van Oostrum, 2007).

Appointment scheduling

Appointment scheduling – Outpatient clinics

The scheduling requests for patients come via the front desk, over the phone, and for some specialties by e-mail via the website mst.nl. The program X/Care is used in planning and scheduling for the outpatient clinics in MST. Secretaries at the front desk and telephone have access to this system and can add a patient to the schedule. This is done using the predetermined slots in the tactical planning. Known patients are usually scheduled with their own specialist, but new patients are scheduled in the first available slot in planning (specialist's assistant or specialist). If patients cannot be scheduled, due to long waiting lists and a short planning horizon, they can be put on a waiting list in X/Care and are added to the schedule when the next week becomes available (Ophthalmology, 2010).

A subdivision used is between new patient consults and follow-up consults. In operational planning a new patient consult is any consult for a patient that has never visited the specialty before, a consult for known patients that visit the specialty for a new problem, and a consult for patients for whom the previous consult took place (almost) over a year ago. For all of these patient types more time needs to be scheduled for a consult. Considering the financial structure only the first type is a certain first outpatient consult (EPB). This may also be the case for the third type if the last declared consult took place over a year ago (Kollenstaart, 2010). This principle is used when scheduling a patient for a long term follow-up consult (Ophthalmology, 2010).

Even if no specified slots are provided for certain patient types, patients may be scheduled to a certain specialist based on their expected diagnosis (Neurology, 2010).

Appointment scheduling – Operating rooms

If a patient requires surgery he/she is put on a waiting list and registered from X/Care in the ORsuite system, which handles the operational planning for the OR. The OR time appointed to a specialist is filled with patients waiting for surgery. The admission bureau, or secretaries (this differs per specialty), schedules the patient in a block reserved for that specialty and specialist. Based on a set historic time frame the average duration, based on the type of surgery and the specialist performing the surgery, is calculated and connected to the new patient.

Operational planning in ORsuite is possible once the BLOKplan is available, but the actual patient schedule is only secured one week in advance. Each Tuesday the next schedules are reviewed and the specialty program is approved or disapproved (by e.g. disapproving of certain patients, the effect on expected bed use, or low OR time utilization). If changes are required, these can be made until Thursday 16:00 hours, after which the schedule becomes definite. The schedules are evaluated by the admission bureau. Patients are contacted after the schedules are approved by the OR as well. The use of an MSS, as in orthopedics, makes it possible to appoint an actual surgery date longer in advance as the number of slots for a certain patient type is known, as well as the number of patients on the waiting list for that type.

Workforce scheduling

The availability of secretaries in the outpatient clinic is not always coordinated with the consultation hours. In ophthalmology the secretaries work in shifts, which means that over the week about the same amount of secretaries are present (Ophthalmology, 2010). In neurology, even though secretaries work for a specific specialist, their schedules are not synchronized with the schedules of the specialists (Tackenkamp, 2010). In pediatrics the schedule of the secretaries is adjusted to the planning, for three specialists running consults at least two secretaries are required (Pediatrics, 2010).

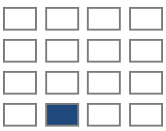
If the OR capacity is decreased due to OR personnel shortage, there is a protocol on how to proceed (where to decrease), including the tradeoff between patient care and hospital costs (Straalman, 2011).

Short term capacity changes

Specialties that request an exchange of OR blocks are often driven by (un)availability of a specialist. These requests are handled by specialties amongst themselves and only registered, not directed, by the OR planner (Straalman, 2011).

If an OR block is returned (either voluntarily or involuntarily) there is a priority ruling in place as to which specialty this time is offered first. Orthopedics and then neurosurgery head this list as they deal with large surgical patient categories and bring in revenue for the hospital. After that gynecology and urology are considered, mainly because of the priority of oncology cases. The OR location is taken into account, as most specialties do not operate at both locations.

Operational online



Operational offline planning considers on-the-day patient scheduling (resulting from disturbances): monitoring and emergency coordination (scheduling of emergency cases and possible rescheduling of elective patients) (Hans, Nieberg, & van Oostrum, (2007); Hans, Van Houdenhoven, & Hulshof, (2011); Van Houdenhoven, (2007)).

Emergency coordination

The handling of acute patients as a strategic choice is described in Section 2.2.1.

Acute patients in the outpatient clinic may have come through the ER, but may still require a short-term follow-up consult in the outpatient clinic. If there is no slot available on the short term in which it is required, an overbooking needs to be made. In practice, overbooking means that the consult durations of patients that are scheduled overlap. Not all specialties use the option for overbooking, which is for instance never done in neurology, while in ophthalmology it is often necessary.

The day coordinator of the OR is responsible for the monitoring and control of that day. This includes for instance the handling of acute patients (in Enschede). As is described under strategic planning, this is organized differently per specialty.

Monitoring

Outpatient consults may be cancelled on a very short term, for instance due to illness, as they cannot always be deferred to another specialist. These patients usually require rescheduling of the cancelled consults. If scheduling is done on longer term, or access times are low, patients can be rescheduled to available slots in the planning. Also, patients can cancel their appointment for a consult, which results in no shows if this is done too short in advance or if no notification is given.

If the secretaries in pediatrics detect an increase in access time, they examine the possibilities of scheduling additional capacity (Pediatrics, 2010). If there is much time left in the planning between consults (for instance over an hour), sometimes patients are asked to come at another time. In neurology, a list is used to record patients that would like to be scheduled at an earlier time, one of these patients is contacted if a slot becomes available.

2.3. Performance of outpatient clinics and operating rooms

Section 2.3.1 considers the performance indicators. Section 2.3.2 gives the key performance indicators (KPIs). Both sections also describe the current performance of MST on the indicators. Key performance indicators represent performance critical to the core business activities and success of the organization; performance indicators complement the KPIs (Parmenter, 2010).

2.3.1. Performance indicators

Three main stakeholders and their goals are considered: *Management* requires cost minimization and provision in good care, *patient* satisfaction, and *employee* satisfaction. These goals can be translated into the following (non-key) performance indicators to measure the performance of (tactical) planning of outpatient clinics and operating rooms:

- Occupancy and utilization rates (management)
  - Experienced workload (employees)
- Work in progress (management, patients, and employees)
- Cancellation rate (patients)
- Overtime (management and employees)
- Outpatient waiting time (patients)

Appendix E gives a further explanation of the indicators. The next section describes the performance of MST on these indicators.

MST performance

Occupancy and utilization rates

Outpatient clinics have their own consult rooms and have sufficient capacity considering the entire week (on specific week days problems may still occur due to a large number of specialists in the outpatient clinic, for instance the Tuesday morning in neurology (Neurology, 2010)). The occupancy rates do not provide very useful information on efficient use of capacity. In future, if consult rooms are shared, the occupancy and utilization rates can be used for allocation of rooms to specialties.

From the Data Warehouse Excel sheets can be generated including utilization information for the outpatient clinic. For each day, also per specialist on a weekly level, the consult hours in planning are compared to the scheduled consult time. Figure 5 gives an overview of the daily outpatient clinic utilization rates for a selection of specialties, for the first week of 2010. Sometimes planned consult hours are (partly) blocked, due to for instance absence of a specialist. For the utilization rate calculations these blocked hours are still included in the total available capacity. This could explain the (overall) low utilization rates displayed in Figure 5.

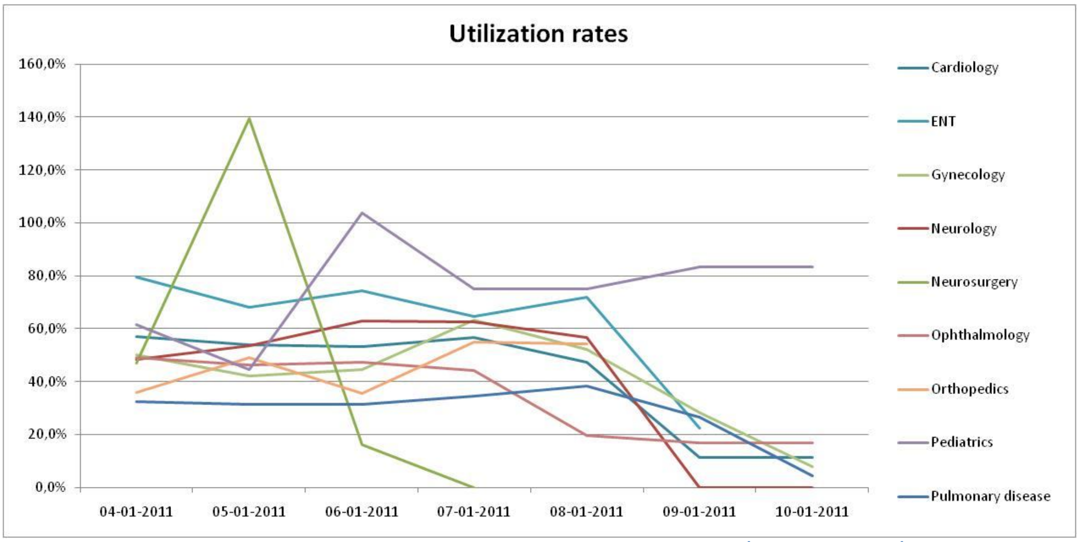


***Figure 5*: Utilization rates of OC hours from the Data Warehouse, for January 4th to January 10th 2010, for a selection of specialties**

The information from the Data Warehouse is based on data from the X/Care system for outpatient clinic planning. Also overviews per specialist of the planned consult blocks can be obtained from X/Care including the number of patients scheduled and the characteristic of total or partial blocking. The size of the blockage is not given and also the patient characteristics (at least the planned consult duration) cannot be easily connected. This makes the calculation of accurate and useful utilization rates complex.

Utilization rates for the OR are displayed in the OR dashboard. Different approaches are calculated: including/excluding set-up times, in/outside own OR blocks.

Experienced workload

The OC capacity (in hours) differs per day of the week. This means that the planned workload, especially considering secretaries, differs as well. In pediatrics for instance, the afternoons are the busiest times, as wards are visited in the morning. Also, the starting times of consults are the same for each specialist's consult, incurring extensive differences in experienced workload within an hour even (Pediatrics, 2010). For the specialty pulmonary disease the outpatient clinic capacity is spread more evenly over the week than before, to decrease the differences in workload over days (Medisch Spectrum Twente, 2011 [1]).

Work in progress

The WIP is measured for financial purposes. The dashboard for managers presents the number of opened and closed DBCs, which provides the WIP for the entire patient process. The WIP for the outpatient clinic can be considered by this overall WIP as most patients will return for a follow-up consult within their process. For the OR the WIP consists of the patients on the waiting list and can be determined per patient category.

Cancellation rate

The cancellation rate serves as an indicator for patient satisfaction. It results from both tactical (how well was the initial planning constructed) and operational planning (short term capacity changes, scheduling). Most cancellations result from operational changes, but when scheduling is done too far in advance also changes on the tactical level can result in consult or surgery cancellations. Rescheduling should usually take place, but patients may also divert to another hospital. The required data is not easily obtained from MST systems and the cancellation rate is not available as a performance indicator in MST.

Overtime

Specialist overtime usually requires overtime from other personnel as well, secretaries in the OC and OR personnel for surgery. Overtime is incurred on the operational level, the handling is determined on the strategic level (use of planned slack, cancellation of surgeries and consults if in overtime?). Overtime may result from poor tactical planning (planned consult/surgery durations). Overtime data is available from the ORsuite system in which the operational data (starting and end times) is registered. For the outpatient clinic this is not as easily obtained as the end times are not scheduled as such. MST does not use overtime as a control measurement.

Outpatient waiting time

Like the performance indicator *overtime* also the outpatient waiting time is noticed on the operational level, though it may result from poor tactical planning. The outpatient waiting time is, like the cancellation rate, an indicator for patient satisfaction. This waiting time (waiting before a consult) is not easily obtained from the systems of MST. In X/Care the arrival of the patient is documented, but this is not necessarily done at the correct time. Also the start of the consult is not documented as such.

To measure the outpatient waiting time, data must be gathered by empirical research, like for instance a stopwatch study. Occasionally, projects are undertaken for the outpatient clinics to measure waiting times, usually to determine the causes of problems.

2.3.2. Key performance indicators

The following indicators are key to MST's performance and, even though they are measured on the operational level, are related to the performance of tactical planning:

- Realization (management)
- Access, waiting, and throughput times (management and patients)
    - Service level

Appendix F gives a further explanation of these KPIs. The next section describes the performance of MST on the key performance indicators.

MST performance

Realization

The realization of production of A- and B-segment is presented in the dashboard that is accessible to tactical and operational management. The realization is discussed in the speed-dates with Finance and Information. The realization could be monitored weekly (or even daily), by accessing the financial registration from the Data Warehouse. This allows each specialty to keep track of their realization. Still, planning is often adjusted to realization deficiencies in a reactive manner.

Table 1 gives the production agreements and realization over 2010 for the admissions and EPBs in A-segment for MST. The total admission number and ward-day targets were met, the day admission targets for 2010 were not realized.

	Production agreement	Realized production	Realization	
Admissions	22,920	23,617	1.03	103%
Ward-days	148,314	152,814	1.03	103%
EPBs	133,796	128,460*	0.96*	96%*
Day admissions (light)	21,188	20,952	0.99	99%
Day admissions (heavy)	1,334	966	0.72	72%

Table 1**: A-segment production agreements and realization per type for 2010 (Medisch Spectrum Twente, 2011 [2])**

*** This is an extrapolated number from the first three quarters of 2010 (Medisch Spectrum Twente, 2010 [3])**

Table 2 gives the financial production targets for B-segment, per specialty. Most specialties met their production targets, apart from general surgery, neurosurgery, dermatology, and plastic surgery. The total financial target for B-segment was met, with a realization of 106%.

Specialty	Production agreement	Realized production	Realization	
Cardiology	9.8	10.8	1,10	110%
General surgery	9.1	8.3	0,91	91%
Orthopedics	7.2	8.3	1,15	115%
Gynecology	7.4	7.7	1,04	104%
Neurosurgery	5.0	4.6	0,92	92%
Neurology	4.7	5.0	1,06	106%
Internal medicine	3.2	3.3	1,03	103%
ENT	2.9	3.0	1,03	103%
Urology	2.6	2.7	1,04	104%
Ophthalmology	2.3	2.6	1,13	113%
Gastroenterology and Hepatology	1.0	1.8	1,80	180%
Rheumatology	1.2	1.3	1,08	108%
Anesthesiology	1.4	1.6	1,14	114%
Dermatology	0.9	0.8	0,89	89%
Pulmonary disease	0.5	0.9	1,80	180%
Plastic surgery	0.8	0.7	0,88	88%
Pediatrics	0.1	0.1	1,00	100%
Total	**60.1**	**63.9**	**1,06**	**106%**

Table 2**: B-segment production agreements and realization per specialty for 2010 in million Euros (Medisch Spectrum Twente, 2011 [2])**

Access, waiting, and throughput time

The access time to the outpatient clinic is determined by the secretaries based on the third available time slot in the planning and is displayed on the website of MST each month. The waiting times for certain treatment types are also displayed. These numbers are part of government indicators and are displayed on the kiesbeter.nl website as well. Table 27 in Appendix G shows the recorded numbers of the access and waiting times for each specialty.

The norm for access time to the outpatient clinic is 4 weeks (RIVM, 2011). Table 3 lists the specialties meeting the requirement on the left and not meeting the requirement on the right. The norm for waiting time for treatment is split for outpatient and inpatient treatment, set at 6 and 7 weeks respectively (RIVM, 2011). Table 4 gives the listed treatments and specialties not meeting the waiting time norm of 7 weeks. Most of the listed specialties and treatments meet this requirement.

Specialties meeting access time requirements	Access time	Specialties NOT meeting access time requirements	Access time
Cardiology	1	**Anesthesiology**	6
Dermatology (Haaksbergen)	4	**Dermatology (excl. Haaksbergen)**	6
ENT	1-3	**Exceptional dentistry**	
		Anxious and disabled pat.	22
		Maxillo facial prosthetics	8
General surgery	1-2	**Gastroenterology and Hepatology**	7
Gynecology (general)	1-4	**Gynecology**	
Oncology	1	Infertility	6
		Incontinence	8
Internal medicine		**Internal medicine**	
General (Enschede)	4	General (/= Enschede)	8-10
Nephrology	4	Endocrinology	6
Oncology	3	Infectious diseases	6
		Diabetes	6
Neurology		**Neurosurgery**	5
All specialist OCs	<1-<2		
Ophthalmology		**Neurology (general)**	5-10
Cataract surgery	2		
Oral surgery	3	**Ophthalmology (general)**	9
Orthopedics		**Orthopedics**	
General (Haaksbergen)	4	General (/= Haaksbergen)	6
Total hip surgery	2		
Knee arthroscopy	2		
Total knee surgery	2		
Pediatrics	0	**Rehabilitation**	5-7
Plastic surgery	<1-3	**Rheumatology (Oldenzaal)**	5
Psychiatry	4	**Urology (Oldenzaal)**	5
Pulmonary disease	0		
Radiotherapy	1		
Rheumatology (/= Oldenzaal)	<1-1		
Thoracic surgery	0		
Urology	1-3		
Oncology	<1		
Haematuria	<1		

Table 3: Specialties (not) meeting the access time requirement of 4 weeks (Medisch Spectrum Twente, 2011 [6])

Specialties NOT meeting waiting time requirements	Waiting time
Cardiology	
Ablation	6-8
Ablation (narcosis)	14-16
Exceptional dentistry	
Anxious and disabled patients	11
Gynecology	
Hysterectomy	5-12
Incontinence (woman)	8

Table 4: Specialties not meeting the waiting time requirement of 7 weeks (Medisch Spectrum Twente, 2011 [5])

We compared access and waiting times of MST with the national figures (over 2009). We see that specialties that nationally dealt with longer access times (dermatology, gastroenterology and hepatology, ophthalmology, orthopedics, and rheumatology (Nederlandse Zorgautoriteit (2010 [2]); RIVM (2010)) have long access times in MST as well. The waiting times for treatment of breast reconstruction, hip prosthesis, and knee prosthesis (which have long waiting times on the national level), are within norms.

The Menzis "top care" program imposes stricter (compared to government) norms for access and waiting times to ensure timely care for certain diagnoses/treatments in a selection of hospitals. MST is included in the "top care" program for five of them: Hernia, hip arthritis, knee arthritis, sleep apnea, and varicose veins (Menzis, 2011 [2]). Table 5 shows that only orthopedics (for hip and knee arthritis), meets its "top care" requirements.

Treatment	Specialty	Access time		Waiting time	
		Target	MST	Target	MST
Hernia[1]	Neurology/neurosurgery	2	<1/5	4	5
Hip arthritis[2]	Orthopedics	3	2	7	6
Knee arthritis[3]	Orthopedics	3	2	7	6
Sleep apnea[4]	Multidisciplinary including: pulmonary disease/ENT	2	-	8	-
Varicose veins[5]	Dermatology/general surgery	2	6/2	3	<6

***Table 5*: Menzis "top care" access and waiting time requirements, including MST performance (missing sleep apnea data) (Medisch Spectrum Twente (2011 [6]); Medisch Spectrum Twente (2011 [5]))**
[1] (Menzis, 2011 [5]), [2] (Menzis, 2011 [4]), [3] (Menzis, 2011 [6]), [4] (Menzis, 2011 [3]), [5] (Menzis, 2011 [1])

When a consult is scheduled, it is registered by the X/Care system. Comparing the scheduling date with the actual consult date could enable calculation of the *actual* access time (instead of the "third available slot in planning"-method). It is already possible to retrieve the necessary data from the systems of MST, but this is not easily done and not considered as a method for access time determination. When patients are put on the waiting list, their diagnosis date is documented. The waiting time to surgery can be determined using this data from admission scheduling in ORsuite.

Service-level
Service-level indicators (e.g. % of patients scheduled within .. weeks) are not used for performance measurement in MST. These indicators are closely related to the access and waiting times, as they can give an idea of the distribution around these (average) times. No additional data, compared to access and waiting times, is needed to calculate the service-levels.

2.4. Conclusions

The patient process

- OC (as the start of the care trajectory) generates demand for OR
- OC and OR are critical resources in the patient process
- Logistic indicators can help describe the patient process
    - Demand (numbers multiplied by planned durations)
    - Supply (available time)
- Knowledge of the patient process can help forecast demand
    - Steps in the process and transition probabilities and times

Planning and control

- Resource capacity planning is supply-oriented
  - Availability of specialists provides the starting point for planning
  - OC and OR capacity are not calculated from/do not match production targets
  - OR planning determines availability for OC planning
- Planning is organized separately per function (for OC and OR, and per specialty)
  - Exchange of OR blocks is not centrally organized (and exceptional)
- Static/outdated rosters are used
  - OC capacity is divided in preset slots for consult types (often an outdated division)
  - The OR uses a quarterly roster (minimally modified over time)
- Patient categories are not used for (tactical) planning (apart from orthopedics)

Performance of outpatient clinics and operating rooms

- Not all defined indicators are used in MST
  - Not all provide in the right information
- Most indicators have the required data available (in Data Warehouse)
  - Data is not always easily converted to information
- Lacking performance in:
  - Realization (A-segment day admissions (heavy), B-segment for a few specialties)
  - Access times, for many outpatient clinics
  - Waiting times, for a few treatments

	Performance indicators					Key performance indicators	
	(Occupancy and) utilization rates	Work in progress	Cancellation rate	Overtime	Outpatient waiting time	Realization	Access, waiting, and throughput times
Used in MST					incidental		
- Right information provided			-	-	(from systems)		
Data available				(only OR)			
- Easily converted to info.			-	(for OR)	-		

Table 6: Overview of use and data availability of (key) performance indicators, YES (green) and NO (red)

Concluding: MST can benefit from increased communication and coordination on the tactical level to improve patient care and also enable more efficient use of capacity, especially in allocation of OR capacity to specialties. Allocation over patient categories is lacking, which requires establishment in the organization including (indicator) information on this level. Use of accurate logistic information (demand characteristics and transition probabilities and times) can improve planning and provides control mechanisms for key performance indicators. Required information on indicators for tactical planning performance measurement is not always as readily available, which requires improvement.

3. Literature research

Section 3.1 first introduces tactical capacity planning, further it discusses tactical planning literature for outpatient clinics, operating rooms, and integrated planning. Section 3.2 describes a tactical planning concept from practice; tactical planning in Ziekenhuisgroep Twente (ZGT). Section 3.3 describes a tactical planning concept from theory, through one specific article, which discusses integrated planning of resources in patient care pathways.

3.1. Tactical capacity planning

Tactical capacity planning is first described, introducing the characteristics mentioned in scientific literature. Table 7 gives the summary. Sections 3.1.1 and 3.1.2 then discuss literature on tactical planning for outpatient clinics and operating rooms respectively. This is done separately first, as many articles only focus on one department or resource (Hulshof, Boucherie, Hans, & Hurink, Working Paper). Section 3.1.3 describes literature with an integrated approach.

Characteristics	Sources
Elective patients	[3]
Intermediate term planning horizon	[2], [3], [4]
- Translating strategic into tactical goals	[3], [4]
Allocation of available capacity, using block planning/rostering	
- Over specialties	[2], [4]
- Over patient categories	[1], [3]
Flexibility, temporary capacity expansions	
- Overtime	[2], [4]
- Staff	[2], [4]
- Working hours	[1]
Tactical capacity planning goals	
- Equitable access times	[3]
- Equitable throughput times	[3]
- Realization of production agreements	[3]
- Maximization efficient use of resources	[3], [4]
- Balanced workload	[3], [4]

***Table 7*: Summary of tactical planning characteristics from literature**

[1] (Glöckner, et al., 2009), [2] (Hans, Van Houdenhoven, & Hulshof, 2011), [3] (Hulshof, Boucherie, Hans, & Hurink, Working Paper), [4] (Van Houdenhoven, 2007)

Hans, Van Houdenhoven, & Hulshof (2011) describe tactical planning on an intermediate term planning horizon. As Figure 4 shows, they consider allocation of resource capacity over specialties through block planning, staffing, and admission planning on the tactical (hospital) planning level. They acknowledge the flexibility property of tactical planning, of temporary capacity expansions like overtime or hiring extra staff.

Van Houdenhoven (2007) also considers resource allocation over specialties through rostering and defines tactical planning on the intermediate horizon, translating strategic into tactical goals. Flexibility is obtained on the tactical level through the longer planning horizon, compared to operational planning, and the possibility of temporary capacity expansion (overtime and additional personnel).

Hulshof, Boucherie, Hans, & Hurink (Working Paper) describe tactical capacity planning to consider allocation planning of elective patients. Clear goals for tactical planning are described: equitable access and treatment times, realization of production agreements, efficient use of resources, and a balanced workload. Allocation of resource capacity takes place on the intermediate term, over patient categories. Allocation over patient categories, together with determination of working hours, is a characteristic also acknowledged by Glöckner, et al. (2009).

In ZGT, tactical planning is already implemented in the organization. Section 3.2 further discusses their tactical planning concept. The core characteristics of tactical planning in ZGT are a trend analysis (how did we perform in the previous period?), a forward view (what can we expect in the periods to come?), and optimization (how can we best allocate demand?) (Quik, 2011).

Operations management considers three basic principles: reduction of waste (Lean manufacturing), variability (Six Sigma), and complexity (JIT, TOC). Tactical planning tries to balance the focus on variability and complexity reduction, in order to reduce waste. Variability cannot always be reduced, but flexibility in planning accommodates changes when needed. Preferences for working days, ORs, etc. increase complexity. Planning helps to find order in this complexity, but a static planning does not account for variability. Periodic evaluation of planning increases flexibility, enables anticipation to variability, and in turn minimizes waste (mainly in the form of unused capacity).

3.1.1. Outpatient clinics

In outpatient clinic literature there is a fine line between planning and scheduling. The focus often lies on the internal processes and outcome measures (Elkhuizen, Das, Bakker, & Hontelez, 2007). These articles consider patient scheduling, many including appointment systems, but often also address some kind of capacity block or staff planning. As tactical and operational level literature are hard to distinguish, we therefore included a broad spectrum of outpatient clinic literature.

Cayirli & Veral (2003) evaluate literature on appointment systems. Different characteristics considered and possible performance measures in patient scheduling are discussed. Further, they describe the different appointment systems/rules found in literature and different analysis methodologies. Appointment system design consists of three decision areas: the appointment rule (# of patients scheduled per block/slot, # scheduled in initial block/slot, and appointment interval), the use of patient classification, and adjustments for no-shows, walk-ins, etc. (Cayirli & Veral, 2003).

Gupta & Denton (2008) also discuss appointment scheduling literature and describe the related challenges and opportunities. They acknowledge three application areas for appointment scheduling: primary care, specialty clinic, and elective surgery scheduling. Appointment scheduling in primary care or a family clinic is often considered in literature (for instance by: Côté (1999), Green & Savin (2008), Liu, Ziya, & Kulkarni (2010), Murray & Berwick (2003), and Taylor III & Keown (1980)). In the specialty clinic utilization becomes more important as a specialist's time is considered to be more expensive than a physician's, consult durations may be characterized by higher variability (including differences per diagnosis), and quick access is needed for urgent cases (Gupta & Denton, 2008). The principles from primary care articles may still apply to specialty clinics, even though the characteristics differ.

Bailey (1954) considers both the size of a clinic session and the appointment system (number of patients assigned to each slot), using queuing theory with service in batches of patients. Bailey's

(1954) formulas for clinic size makes it possible to check whether waiting is due to fluctuations in a stable system, large backlog, or other delays. The optimal appointment system found, considering patient waiting time and consultant's idle time, includes a batch of two patients for the initial block with block sizes equal to the average consultation time. Brahimi & Worthington (1991) also include the block size and evaluate the influence of the number of slots and the number of patients assigned to a slot on the patient waiting time, the number of waiting patients, and doctor busy time. Rohleder & Klassen (2000) compare different appointment scheduling methodologies and include Bailey's rule of two patients in the initial block. Bailey2 is used to obtain low server idle time and combined with a rule in which patients with high variability in service time are scheduled later in the program, to minimize patient waiting time. Rohleder & Klassen (2000) also evaluate the impact of special appointment requests and include appointment scheduler uncertainty.

Green & Savin (2008) demonstrate the applicability of queuing models in determining patient panel sizes for practices implementing advanced access scheduling (further described under patient classification). State dependent no-shows are included; the longer someone is waiting for an appointment, the greater the chance that he/she does not show. The impact of preferred appointment slots is also evaluated. The cancellation factor and the rescheduling probability (patients may reschedule after cancellation or a no-show) have a significant impact on the maximum panel size and the performance of the system, measured in the expected backlog in days and the probability of a same-day appointment. Liu, Ziya, & Kulkarni (2010) also consider an increasing no-show probability as the appointment delay increases. Heuristic policies for scheduling are proposed, with the "net reward" of serving a number of patients on a day with a certain number of scheduled appointments as a performance measure. Muthuraman & Lawley (2008) consider overbooking to deal with patient no-shows in an outpatient clinic appointment schedule. Their objective is to maximize a profit objective with a positive value for attended patients and costs for patient waiting and staff overtime. A decrease in the profit objective serves as a stopping criterion for adding more patients.

Performance measurement

Performance measurement in outpatient clinics can be defined through four main indicators: queuing, throughput, utilization, and overtime. Figure 6 gives an overview of these indicators and the part of the patient visit and outpatient clinic session they relate to. Table 8 summarizes the evaluated outpatient clinic literature on these performance indicators. Table 28 in Appendix H gives a more detailed summary.

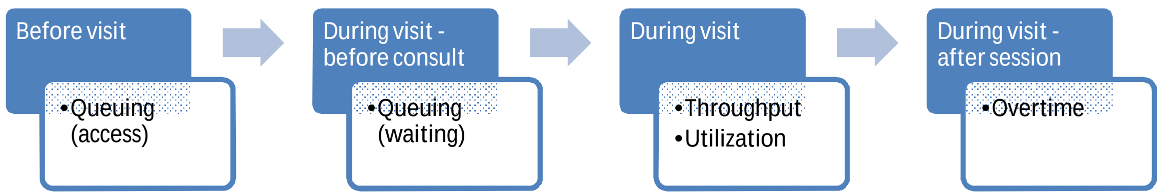


***Figure 6*: Performance measurement areas, related to patient visit**

Queuing before the visit considers the number of patients waiting for service (also included as the expected backlog (Green & Savin, (2008); Silvester, Lendon, Bevan, Steyn, & Walley, (2004))) and the access time to the outpatient clinic (also called delay (Liu, Ziya, & Kulkarni, (2010); Murray, (2000); Murray & Berwick, (2003); Vanden Bosch & Dietz, (2000)) or indirect waiting time (Gupta & Denton, (2008); Liu, Ziya, & Kulkarni, (2010))). Queing before the consult, during the visit, considers the number of patients in the actual waiting room (also considered as waiting room congestion (Brahimi & Worthington, (1991); Côté, (1999); Muthuraman & Lawley,(2008)) and patient waiting time (or direct waiting time (Gupta & Denton, (2008); Liu, Ziya, & Kulkarni, (2010))). Throughput and utilization outcomes are determined during the visit. Throughput considers the number of patients served, the time the patient spent in the outpatient clinic (or patient flow (time) (Côté, (1999); Hashimoto & Bell, (1996))), and staff productivity. Utilization can be expressed as a rate (for staff, room and/or session use), defined through idle time, and indicated by the number of vacant slots. Overtime is considered after the planned session and is indicated by the number of consults in overtime, the staff overtime, and the session ending time.

Other performance indicators are: probability of a same day appointment (Green & Savin, 2008), profit indicators (Liu, Ziya, & Kulkarni, (2010); Muthuraman & Lawley,(2008)), and appointment availability, mentioned by Murray & Berwick (2003) (indicated by the third available appointment).

Performance indicators	**Sources**
Queuing (access)	[1], [5], [7], [8], [9], [13], [14], [15], [19], [21], [22]
Queuing (waiting)	[1], [2], [4], [5], [6], [11], [12], [16], [18], [20], [21]
Throughput	[2], [6], [11], [12], [13], [16], [17]
Utilization	[1], [2], [3], [4], [5], [6], [8], [11], [12], [16], [17], [18], [19], [20], [21], [22]
Overtime	[5], [11], [16], [18], [21]

***Table 8*: Summary of performance indicators from outpatient clinic literature**

[1] (Bailey, 1954), [2] (Benninger & Strode, 1998), [3] (Bowers, Lyons, Mould, & Symonds, 2005), [4] (Brahimi & Worthington, 1991), [5] (Cardoen & Demeulemeester, 2008), [6] (Côté, 1999), [7] (Creemers & Lambrecht, 2009), [8] (Elkhuizen, Das, Bakker, & Hontelez, 2007), [9] (Green & Savin, 2008), [10] (Gupta & Denton, 2008), [11] (Hashimoto & Bell, 1996), [12] (Huarng & Lee, 1996), [13] (Liu, Ziya, & Kulkarni, 2010), [14] (Murray, 2000), [15] (Murray & Berwick, 2003), [16] (Muthuraman & Lawley, 2008), [17](Qu, Rardin, Williams, & Willis, 2007), [18] (Rohleder & Klassen, 2000), [19] (Silvester, Lendon, Bevan, Steyn, & Walley, 2004), [20] (Taylor III & Keown, 1980), [21] (Vanden Bosch & Dietz, 2000), [22] (Vermeulen, Bohte, Elkhuizen, Lameris, Bakker, & La Poutré, 2009)

Silvester, Lendon, Bevan, Steyn, & Walley (2004) identify four possible reasons underlying high access times for medical care in the UK. They consider the main reason for waiting in the National Health System to be the mismatch between variation in demand and in capacity, but also that queues are used as a buffer in order to achieve high utilization rates. Creemers & Lambrecht (2009) and Elkhuizen, Das, Bakker, & Hontelez (2007) both consider access time but take different approaches.

Creemers & Lambrecht (2009) develop a customer assignment system, with the purpose of obtaining the waiting list performance measures of the number of patients in the queue and the average waiting/access time of the patient. The model can be used to evaluate supply, frequency and batch size of service sessions, and demand. Elkhuizen, Das, Bakker, & Hontelez (2007) develop a model to evaluate required capacity in an outpatient department. They measure the utilization (on planning level, by dividing demand over capacity), access time, and the length of the queue. A basic indication of performance is given by a queuing model and discrete event simulation is developed to further evaluate capacity requirements. Both structural and temporary capacity expansions and/or reductions can be evaluated.

Benninger & Strode (1998) strive to maximize efficiency of space and staff in an otolaryngology clinic and determine the optimal ratio of support staff and examination rooms per practicing physician. Simulation is used to experiment with different settings and found the most effective use in 1.5

support staff and three rooms per physician. Hashimoto & Bell (1996) also include staffing numbers (registrar, triage nurse, physician, and discharger) in their simulation to evaluate patient flow in an outpatient clinic. Sensitivity analysis evaluates the impact of changes in staffing, appointment intervals, no-show rate, and doctor task time characteristics on the patient's time in the clinic.

Patient classification

Cayirli & Veral (2003) consider patient classification for appointment systems in their review and describe the limitations as opposed to homogeneous FCFS scheduling, which is assumed in the majority of studies. Patient classification decreases scheduling flexibility and increases the possibility of unused slots and delays between requests and appointments. Classifications used are: new/return, variability level of service time, and procedure types, but these are only used for sequencing in appointment scheduling literature (Cayirli & Veral, 2003).

Murray (2000) and Murray & Berwick (2003) describe the need for advanced access or open access scheduling ('do today's work today') to limit waiting and delays for medical care. An advanced access system offers patients an appointment on the same day, not making any distinction between patients. Other systems include the differentiation between urgent and elective patients. In the traditional model non-urgent demand is pushed back to make room for more urgent cases, while a carve-out model reserves capacity in planning based on the expected demand for urgent cases (Murray & Berwick, 2003). Others considering advanced access are: Green & Savin (2008), Liu, Ziya, & Kulkarni (2010), and Qu, Rardin, Williams, & Willis (2007). Liu, Ziya, & Kulkarni (2010) find that advanced access only performs well when average demand is smaller than average capacity, while Silvester, Lendon, Bevan, Steyn, & Walley (2004) emphasize that carve-out typically worsens the access time for patients.

Qu, Rardin, Williams, & Willis (2007) evaluate the optimal percentage of prescheduled and open-access appointments. A balance must be found between a higher no-show rate for prescheduled appointments and a possibility of unused capacity with open-access scheduling, maximizing the number of served patients. The percentage mainly depends on the ratio of open-access demand to capacity and the ratio of show-up rates for both appointment types.

Many articles consider elective patient planning or scheduling, without stating the patient types included. Whenever a distinction is mentioned, usually new patients are concerned (e.g. Bailey (1954) and Elkhuizen, Das, Bakker, & Hontelez (2007)), sometimes combined with follow-up consults (by Bowers, Lyons, Mould, & Symonds (2005), Cardoen & Demeulemeester(2008), and Côté (1999)). Further, planning and scheduling using diagnosis related groups or clinical pathways is limited (done by: Benninger & Strode (1998) and Cardoen & Demeulemeester(2008)). Only Rohleder & Klassen (2000) and Vermeulen, Bohte, Elkhuizen, Lameris, Bakker, & La Poutré (2009) specifically mentioned a carve-out for urgent patients.

Muthuraman & Lawley (2008) use a categorization of patients with different no-show probabilities, based on their attributes. Vanden Bosch & Dietz (2000) use patient classification in scheduling to estimate a more accurate service time. The optimal order in which patients types should be scheduled is examined, taking into account patient waiting time and the doctor's overtime. The patient schedules are used to come up with a combination for several days, to incorporate the expected demand for each class.

Vermeulen, Bohte, Elkhuizen, Lameris, Bakker, & La Poutré (2009) address resource allocation over patient categories for CT-scans, but this may be applicable to outpatient clinic capacity allocation. Slots are reserved for specific patient types; there are five categories, which include two urgency levels with different planning windows. The slots are either of size one or 2 times the size which makes reallocation possible. The objective is to minimize the deviation from the planning window of the patient. They describe a dynamic scheduling procedure that reallocates the patient categories to previously reserved, but yet unfilled, slots as the appointment date approaches.

3.1.2. Operating rooms

Planning and scheduling activities concerning operating rooms receive increasing attention in scientific literature. The high costs for development and management and at the same time the large share in a hospital's revenues are important reasons for this focus on the OR (Cardoen, Demeulemeester, & Beliën,(2010); Testi, Tanfani, & Torre (2007)).

Operating room management deals with both in and outpatients and both elective and non-elective (acute or urgent) patients. The main emphasis in literature lies on the elective patients (Cardoen, Demeulemeester, & Beliën, 2010). Of our evaluated articles only three apply to both elective and acute cases (VanBerkel & Blake (2007), Van Houdenhoven, Hans, Klein, Wullink, & Kazemier (2007), and Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier (2007)), the rest mainly focused on elective patient planning and/or scheduling.

Articles often consider patient (type) scheduling instead of planning. As do for instance: Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier (2007), Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008), and Velásquez, Melo, & Küfer (2008).

Performance measurement

Table 9 summarizes the evaluated operating room literature, on the included performance indicators. Especially the utilization rate of the OR has been subject of recent research (Cardoen, Demeulemeester, & Beliën, 2010). All articles evaluate the utilization and/or efficient use of OR capacity (possibly also including complementary resources like staff). Other main performance indicators mentioned are overtime, throughput, and waiting time for surgery.

Performance indicators	Sources
Overtime	[3], [5], [9]
Throughput	[1], [2], [3], [4]
Utilization and/or efficient use of resources	[1], [2], [3], [4], [5], [6], [7], [8], [9]
Waiting time for surgery	[3], [4]

Table 9: **Summary of tactical planning performance indicators from operating room literature**

[1] (Adan, Bekkers, Dellaert, Vissers, & Yu, 2008), [2] (Adan & Vissers, 2002), [3] (Testi, Tanfani, & Torre, 2007), [4] (VanBerkel & Blake, 2007), [5] (Van Houdenhoven, Hans, Klein, Wullink, & Kazemier, 2007), [6] (Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier, 2007), [7] (Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier, 2008), [8] (Velásquez & Melo, 2006), [9] (Velásquez, Melo, & Küfer, 2008)

Van Houdenhoven, Hans, Klein, Wullink, & Kazemier (2007) describe a method to determine a theoretical maximum utilization rate for the OR per surgical department. They include duration of both elective cases and emergency surgeries. The variability in surgery duration is included by reserving capacity (planned slack) using the standard deviation of duration, which they include to higher or lesser extent depending on the accepted probability of working in overtime. Low accepted risk of overtime results in low utilization rates, while high accepted risk results in higher rates. When the patient mix is less complex (has a lower standard deviation in duration) the achievable utilization rate is higher than in complex cases.

Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier (2007) apply mathematical algorithms to improve OR efficiency by reducing the total required OR time through reallocating elective surgeries over ORs. They include the portfolio effect for planned slack calculation.

Patient classification

Five out of the nine evaluated articles consider allocation over a categorization of patient types or categories. Table 10 lists the criteria used for these categories. Categorization is based on logistical principles by Adan, Bekkers, Dellaert, Vissers, & Yu (2008), Adan & Vissers (2002), and Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier (2007), of which Adan & Vissers (2002) also acknowledge the importance of medically recognizable categories. This medically homogeneous principle is used by VanBerkel & Blake (2007) and Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008), where categorization is based on diagnosis. The number of categories used varies from 4 to 11. Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008) evaluate the maximum number on different planning horizons, but no specific number of categories that should be used was mentioned.

Source	Categorization - OR	# Categories	Medically homogeneous
[1]	Operation duration	8	No (not specifically)
[2]	Operation time	11	Yes
[4]	Diagnosis type	8	Yes
[6]	Frequency, mean and st.dev. of operating time	4-8	No
[7]	Diagnosis, department	-	Yes

Table 10: **Categorization criteria for patient categories**

[1] (Adan, Bekkers, Dellaert, Vissers, & Yu, 2008), [2] (Adan & Vissers, 2002), [4] (VanBerkel & Blake, 2007), [6] (Van Houdenhoven, van Oostrum, Hans, Wullink, & Kazemier, 2007), [7] (Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier, 2008)

3.1.3. Integrated capacity planning

Hulshof, Boucherie, Hans, & Hurink (Working Paper) emphasize the need for integrated capacity planning. Taking a care chain perspective is required to temper the bullwhip effects in the chain, resulting from fluctuations in demand and resource availability. Most literature only focuses on one or a few resources and steps in the entire care trajectory. As Hulshof, Boucherie, Hans, & Hurink (Working Paper) include the entire pathway of the patient, therefore also the combination of OC and OR, their article is further elaborated in Section 3.3.

Outpatient clinics

From the perspective of the OC in an integrated approach, most often diagnostics are included. For instance by: Bowers, Lyons, Mould, & Symonds (2005), Côté (1999), Huarng & Lee (1996), and Taylor III & Keown (1980). Bowers, Lyons, Mould, & Symonds (2005) include diagnostics in the outpatient clinic in the form of a diagnosis treatment center. Taylor III & Keown (1980) integrate diagnostic and bed facilities in a network model. Cardoen & Demeulemeester (2008) integrate the outpatient clinic and the OR in a simulation model, using clinical pathways.

Bowers, Lyons, Mould, & Symonds (2005) construct an outpatient planning model for a diagnosis treatment center, which includes the expected demand for diagnostics following expected demand for outpatient clinic consults. The model is developed as a decision support tool for managers, which can be used to examine the effect of expected changes in demand and strategic choices about specialties to include in the DTC and can be used to calculate the required capacities.

Côté (1999) uses discrete event simulation to provide insight in the delivery of health care in a family practice including physician examination, a nurses station, and diagnostics (lab and X-ray). The model also takes into account initial and same-day return consultations. The impact of the patient arrival rate and the number of available rooms per physician is calculated on examining room utilization, examining room queue length, the probability of two occupied rooms, and patient flow time.

Huarng & Lee (1996) simulate an outpatient department including: general medicine, general surgery, skeletology, dermatology, a cash desk, pharmacy, immunology, and lab. They evaluate patient waiting time (also total time spent in the clinic), number of waiting patients, utilization rate, number of patients served, and idle and busy times of all functions. Simulation shows that the performance of dermatology (worst performing) can be improved by adding capacity.

Taylor III & Keown (1980) demonstrate network modeling of an outpatient clinic. They include registration, physician consultation, nurse's clinic, psychiatrist, allergy clinic, gynecologist, pharmacy, x-ray and infirmary, with queues before each station, a number of servers, and a certain server time (distribution). Patients have a certain transition probability of flowing from one stage in the network to the next. The model evaluates the numbers of patient waiting, patient waiting time, and server utilization and idle time at each stage and is used for scenario analysis.

Cardoen & Demeulemeester (2008) use discrete event simulation for clinical pathways in which they include both the consultations in the outpatient clinic and the surgery in the OR. They enable strategic analysis and improvement of these pathways, analysis of resource use, and insight in variations. Three scenarios are simulated with different standard consultation times and eliminating the need for same-day appointments (after the doctor became idle). Sequencing rules for the different patient categories are evaluated, where it is found that higher variability cases are better scheduled at the end of a session.

Operating rooms

From the perspective of the OR, most researchers who choose an integrated approach include the ward utilization (Cardoen, Demeulemeester, & Beliën, 2010). For instance: Adan & Vissers (2002), Adan, Bekkers, Dellaert, Vissers, & Yu (2008), Testi, Tanfani, & Torre (2007), VanBerkel & Blake (2007), Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008), and Velásquez, Melo, & Küfer (2008). To a lesser extent, the PACU and ICU are also included (Cardoen, Demeulemeester, & Beliën, 2010).

Adan & Vissers (2002) and Adan, Bekkers, Dellaert, Vissers, & Yu (2008) use similar approaches. The yearly demand for the OR and subsequent departments (IC, and ward or MC respectively) is included and categories for patients are used, based on workload for these resources. The main difference lies in the respective deterministic and stochastic nature of length of stay. Both include set targets for throughput and utilization of beds, OR capacity, and nursing staff and use the deviation from these targets for optimization, using (mixed) integer linear programming.

Testi, Tanfani, & Torre (2007) define a three-phase approach for operating room scheduling, integrating the ward and OR. In the first phase the available operating theatre time is distributed among wards in a bin packing-like problem, based on both the historical demand and the length of the waiting list (in sessions) subject to the maximum number of available sessions and a lower and upper bound for sessions of that ward. In the second phase a Master Surgical Schedule (MSS) is developed that maximizes the surgeon preference subject to the values from phase one. The third phase considers the scheduling of the actual patients based on their clinical status, expected operating time, expected length of stay, and updated waiting time.

Velásquez, Melo, & Küfer (2008) use a similar method to Testi, Tanfani, & Torre (2007). They include a bin-packing approach that includes desired scheduling periods. They consider tactical planning on the level of finding an appointment for elective surgery. For performance they further include the over and underutilization of resources, bed use leveling, and staff overtime. Velásquez, Melo, & Küfer (2008) define tactical planning for the OR as dealing with finding an appointment for a certain patient over a planning horizon of several weeks.

The aforementioned MSS is not extensively found in literature (Testi, Tanfani, & Torre, 2007). Also different definitions exist on what an MSS is exactly (Cardoen, Demeulemeester, & Beliën, 2010). Testi, Tanfani, & Torre (2007) for instance use a different definition from Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008).

Van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, & Kazemier (2008) also include both the OR and ward in their research. They propose a method for the construction of a cyclic MSS, which in their definition is a cyclic schedule in which frequently performed elective procedures are assigned to ORs over days of the week. Their definition differs from that of Testi, Tanfani, & Torre (2007), as they consider procedure types instead of a division over specialties and surgeons. The procedure types are of the same diagnosis and are performed by the same surgical department, both medically and logistically similar (same surgery duration and bed requirement). The schedule only includes frequent elective procedures, for other procedures generic time is reserved in the schedule. The objective is both minimization of OR capacity and leveling of bed requirement.

VanBerkel & Blake (2007) developed a discrete event simulation model to enable capacity planning decisions and to evaluate performance of a (general) surgery division. The waiting time for surgery and the throughput of patients, connected to the resource capacities of beds and OR time and their efficient use, are the main performance characteristics concerned. Long waiting times are more dependent on availability of beds and OR time utilization is improved by allocation on surgeon demand (instead of an equality principle). Patient categories are both logistically and medically recognizable, including diagnosis, OR time, and length of stay for categorization.

3.2. A tactical planning concept from practice

In ZGT (Ziekenhuisgroep Twente), tactical planning is already part of common procedure. The outpatient clinic (OC) and the OR, as well as the ward are incorporated in tactical planning. It was first started with three large surgical specialties. After half a year and evaluation of the process, it was expanded further into the organization and a system was set up to help generate information overviews. In ZGT, tactical planning has resulted in better use of OR and ward, decrease of access times to the OC, and less cancellations of OR blocks due to underutilization. Tactical planning is organized around tactical planning meetings, where they allocate capacity over specialties and patient groups, using management information. Sections 3.2.1 to 3.2.3 consider these three aspects. Section 3.2.4 further considers the creation of support for tactical planning within the organization.

3.2.1. Tactical planning meeting

Tactical planning in ZGT is organized around a tactical planning meeting, where capacity allocation is discussed. This meeting is held every two weeks, attended by representatives of (the larger) surgical departments, chief OR, chief admission, and the director care. The meeting is prepared by a manager care. Data analysis is done with DynamicPlanner™, an advanced decision support and optimization environment (Care Dynamics, 2011). During the tactical planning meeting the findings, prepared during a pre tactical planning meeting with the chief OR and admission, are presented and discussed with the specialists. It is important to validate the used data and to focus on the visible trends, not the exceptions.

3.2.2. Patient groups

Capacity is allocated over patient groups, which are formed based on similarities in OC pattern, surgery duration, and length of stay. The main groups from DBC coding were used as a starting point. Surplus-groups were defined for types that are too different to include in another group. Using patient groups, it is possible to construct an OR master plan for which the expected bed use at the ward(s) is known and therefore can be leveled.

3.2.3. Management information

To enable planning, management information is formed from gathered data. Capacity allocation is performed based on this information. Considering demand, the inflow of patients is evaluated, looking for a probable in or decrease. Performance is measured by the access times for the OC, work in progress of OC and OR, and utilization rates for OR (assigned vs. used capacity) and ward (bed use).

Allocation of OR blocks is based on the utilization rates of past periods (8-12 weeks) and the expected work in progress; overviews are composed in deliberation with the process coordinator of the OR. Is capacity sufficient, or is possibly more or less capacity required? Decreasing utilization rates and waiting lists for the OR could indicate a low inflow from the OC. Possibly not only a decrease in OR time is required, but the OC/OR time ratio may be changed, increasing the OC time for new patients.

3.2.4. Support

To create support from within the organization, Jasper Quik of ZGT emphasizes the importance of an external party. In ZGT Ernst&Young is approached for this purpose. In higher management levels the need for tactical planning is acknowledged, but especially the specialists need to be convinced as their standard way of working changes. Trust can be created through the focus on utilization (instead of decreasing use of resources) and honoring agreements on capacity allocation. Also insight in performance (especially improvement) helps for creation of support (Quik, 2011).

3.3. A tactical planning concept from theory

Hulshof, Boucherie, Hans, & Hurink (Working Paper) use mixed integer linear programming to model tactical resource allocation and elective patient admission planning on an intermediate term planning horizon. The model deals with fluctuating demand and resource availability, use of the model results in improvement of reaching target values for access and throughput times and production numbers. Section 3.3.1 gives the model characteristics. Section 3.3.2 describes the method used to come to the patient admission plan.

The main objectives of tactical planning in hospitals are to:

- Achieve equitable access for patient groups
- Achieve equitable treatment duration for patient groups
- Serve the strategically agreed target number of patients (production targets or quota)
- Maximize resource utilization
- Balance workload (Hulshof, Boucherie, Hans, & Hurink, Working Paper).

3.3.1. Model

Resources

The model includes different hospital resource types (OC, diagnostics, OR, ward). The available capacity per time period is limited and allocated over different patient care pathways.

Patient care pathways

The patient process is modeled using patient care pathways. These pathways consist of different stages with a certain requirement at a resource type (e.g. consult duration at the OC or surgery duration at the OR) and a minimum time delay between these stages. Pathways can differ from each other in the number of stages, the resource requirements, and minimum time delays. Patients are assigned to a certain pathway. They can enter at each stage (deterministic demand from outside the system) and after completion of the stage have a certain probability that they will either leave the system or continue to the next stage of the pathway.

Queues and waiting lists

Before each stage of the pathway patients may have to queue for service. The queues before a certain (shared) resource are modeled seperately for each patient pathway. Queueing is modeled by waiting lists which consist of the number of patients that have been waiting for a certain number of periods. Patients are serviced at their pathway stage from this waiting list, following the FCFS principle. A maximum is included to prevent unreasonable waiting times for service.

Patient admission plan

For each period in the planning horizon a patient admission plan is determined. This plan consists of the number of patients to serve at each queue/stage. These numbers are based on the waiting lists, being the length of the queues and the number of periods the patients in the queue have been waiting.

3.3.2. Method

Objective function

The objective function of the Mixed Integer Linear Programming model aims to minimize the number of patients waiting at each queue over the planning horizon, multiplied by a weight. These weights are included to prioritize the different queues before (shared) resources.

Iterative procedure

The weights, consequently also the patient admission plan, are determined following an iterative procedure. An initial value is chosen for the weights, after which the MIP is solved. The weights are then updated based on the performance on the objectives of equitable access and treatment duration and realization of agreed production numbers. After which the MIP is solved again. This process is repeated until the adjustment of the weights reaches a certain small value.

Weights

The weights incorporate the objectives of equitable access and treatment duration and realization of agreed production numbers. These objectives are compared to a target value to determine the weights for different queues and waiting times (waiting lists). Therefore targets are required for the access time, including a percentile of patients to be treated within this time, and the number of patients to serve at each queue in each time period (Hulshof, Boucherie, Hans, & Hurink, Working Paper).

3.4. Conclusions

Tactical capacity planning

- Tactical capacity planning considers:
  - Flexibility in supply to match demand (on intermediate term)
  - Block planning
    - Over specialties (hospital level)
    - Over patient categories (specialty level)
- Scientific literature is not directly applicable to tactical planning for MST
  - Integration of OC and OR is limited
  - Complex mathematical models are used
  - Models often provide "one optimal solution" for a certain point in time
    - The solution can differ extensively per planning period
    - Cannot include all restrictions and preferences
- Patient categories
  - Outpatient clinic
    - Elective/urgent
    - New/follow-up
    - No categories, advanced/open-access scheduling (often researched)
  - Operating rooms
    - Surgery duration (logistically similar)
    - Diagnosis types (medically similar)
    - 4-11 categories used (maximum around ten?)
- Performance measurement
  - OC: Queuing, throughput, utilization, and overtime
  - OR: Utilization, overtime, throughput, and waiting time
    - Main focus on efficiency/utilization

Tactical planning from practice

- In ZGT tactical planning is already part of common procedure
- OC, OR, and ward are included
- Tactical planning is organized in meetings
  - Capacity (re)allocations over patient categories are discussed
  - Management information is the main input for choices
- Patient categories are based on:
  - Similar patterns for OC, OR, and length of stay (logistically similar)
  - DBC coding (medically similar)
- Support (of specialists) in the organization is created through:

    - Involvement of an external party
    - Honoring agreements on capacity allocations
    - Insight in process and performance

Tactical planning from theory

- Hulshof, Boucherie, Hans, & Hurink (Working Paper) use mixed integer linear programming
- Resource allocation over patient pathways
    - Pathway: steps with certain resource capacity requirement, minimum time delays
- Model objective: minimize waiting of patients
    - Also: equitable access and treatment duration and production realization
- Practical limitations (in our view)
    - Resulting planning can differ extensively per period
    - Very detailed information is required (especially for demand and production targets)
    - Pathways are the same for each patient in it
    - Specialists have minimal influence on the resulting work schedule (acceptance?)

Concluding: MST needs a workable method. Choices made on the tactical level about capacity are restricted by many factors (availability of specialists, personal preferences). Mathematical methods from literature do not provide a solution on their own as they often provide "one optimal solution" for a certain point in time, which does not include all restricting factors and may differ extensively between periods, which complicates acceptance by specialists. The insights we gathered from different tactical planning approaches in literature, is taken into account for the design of tactical planning for MST. Further, the tactical planning concept for MST will include tactical planning meetings. By making the right information available it should be possible to make intuitive and analytical decisions in these meetings, creating a workable method.

In the next chapter the design of a tactical planning approach for MST is elaborated upon further.

4. Design of a tactical planning approach for MST

This chapter describes how to get from the current organization of planning to tactical planning through different projects. Section 4.1 gives an outline of the tactical planning concept for MST. Section 4.2 shortly describes the projects to undertake, corresponding to the requirements to facilitate tactical planning. Sections 4.3-4.6 consider the project steps required for the start of the pilot project. Section 4.7 describes this project and with it the organization of the tactical planning process.

4.1. Tactical planning for MST

This section gives an introduction to tactical planning for MST. It shortly describes our advised tactical planning concept, which is further elaborated in the remainder of this chapter; Sections 4.3-4.7 describe the characteristics in more detail.

Tactical planning for MST concerns elective patient (category) planning on intermediate term. Capacity and demand should be aligned by (re)allocating capacity where needed; we assume sufficient capacity. Decisions about (re)allocation are based on management information. Allocation is done in blocks of OR time between specialties and patient categories, and time reserved for first and follow-up consults for the outpatient clinic. Also, the ratio between OC and OR capacity is evaluated and possibly the overtime policy and working hours can be (temporarily) adjusted. A basic capacity will be guaranteed, but additional (flexible) capacity is only allocated if it is required following expected demand and performance.

Tactical planning meetings

We advise monthly tactical planning meetings in which the allocation of capacity will take place. Meetings should be held on two levels, first on hospital level, second on specialty level. Specialties are represented in the hospital level meeting, capacity is allocated over these specialties and the OC/OR ratio is evaluated. The specialty meeting takes place per specialty, in this meeting the allocated OR time is distributed over patient categories and the ratio of first to follow-up consults is evaluated.

Tactical management information

Tactical management information, on which the decisions about (re)allocation of capacity should be based, consists of demand, supply, and performance information. For both meeting types different information overviews are required. Both past and expected performance should be discussed; evaluation of performance is done per week over the past and following twelve weeks. Process information helps determine expected demand, for surgeries and follow-up consults, from already planned consults and surgeries, to which historically expected demand is added. Expected performance is evaluated through scenarios, in which the expected demand is combined with different capacity allocation settings for the following planning period. We assume the involved actors have the ability to make decisions based on the tactical management information, but additional training may be required.

4.2. Project steps towards tactical planning

Several steps should be undertaken before tactical planning can be embedded into the processes of MST. Sections 4.3-4.7 describe these steps through the formation of projects. We advise the following projects to ensure the required conditions for tactical planning:

- **Strategic planning (4.3)** – strategic choices are made, and strategic goals are set. Strategic planning provides focus in the tension field between management, personnel, and patients and determines the flexibility/degrees of freedom for tactical planning.
- **Availability of process information (4.4)** – information about the patient process (probability of requiring a certain step and time between steps) is made available. This information is required for patient categorization and demand forecasting.
- **Patient categorization (4.5)** – DBC types are clustered into patient categories per specialty. Patient categories are required for capacity allocation on specialty level and enable more precise demand forecasts to be made.
- **Availability of tactical management information (4.6)** – several types of information (demand, supply, and performance information) are made available. This enables informed planning decisions to be made; capacity (re)allocation is based on this information.
- **Pilot tactical planning (4.7)** – a pilot should be started to evaluate the benefits and possible problems with tactical planning for MST. Immediate implementation into the entire organization is too extensive, therefore a small number of larger surgical specialties is included.

Figure 7 gives an overview of the different projects in a time context (Gantt chart). Some projects can run parallel (strategic planning and the data phase of tactical management information availability), others require the completion of a previous project. Process information is required to enable patient categorization and in turn patient categories are required to bring about useful tactical management information, which is a prerequisite, together with strategic planning, for tactical planning.

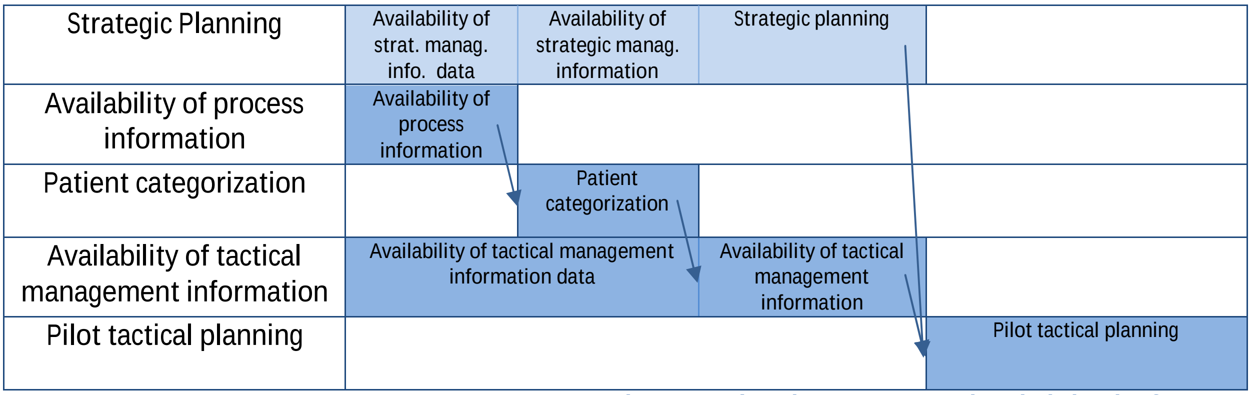


Figure 7: **Project chart; steps toward tactical planning for MST**

To outline the content and purpose of each project the following questions are answered:

- **What** is determined or facilitated?
- **Why** is this important?
- **How** is this done?
- **Who** is involved?
- **When** is it executed?

4.3. Strategic planning

The possibilities on the tactical level are influenced and possibly restricted by the strategic planning and choices made on strategic level. Sections 4.3.1-4.3.5 respectively describe the *what*, *why*, *how*, *who*, and *when* for the strategic planning project(s). Not all aspects of strategic planning are elaborated as extensively, as the focus of or research lies on tactical planning.

4.3.1. What

Strategic planning can be divided in an overall strategy with related strategic choices and strategic goals. Strategic choices shape the organization and working environment for MST. The strategic goals provide long term targets and can be translated to intermediate term tactical goals.

Strategy	Strategic choice
Case mix	Which patient types/categories do we treat? How many patients of each type/category?
Personnel	How many FTE of each function are required? Do we opt for use of flexible personnel?
Working hours and overtime policy	What are the standard working hours? When is deviation from standard hours allowed? What is the accepted risk of working in overtime (in planning)? (When) does overtime result in cancellation?
Available ORs	How many ORs are available? Do we install specialty/dedicated ORs?
Organization of elective vs. acute care	How is acute care organized? (traditional, carve-out, or open access model)

Table 11: Strategy and strategic choices

The following main (logistic) strategic goals are concerned:

- Cost minimization (utilization of resources, overtime limitation)
- Access, waiting, and throughput times
- Production agreement realization (per year)

With strategic goals not only the targets themselves are concerned, but also strategy is formulated to achieve or maintain the target values. In addition to access, waiting, and throughput times there are many *quality* indicators for patient care that are not only internal but also government indicators.

4.3.2. Why

Strategic planning provides the degrees of freedom for tactical planning. Tactical planning should give meaning to the strategic choices and the set targets should be translated to tactical level targets. Strategic planning also provides the focus within the tension field of the three stakeholders: management, patients, and personnel. Figure 8 represents

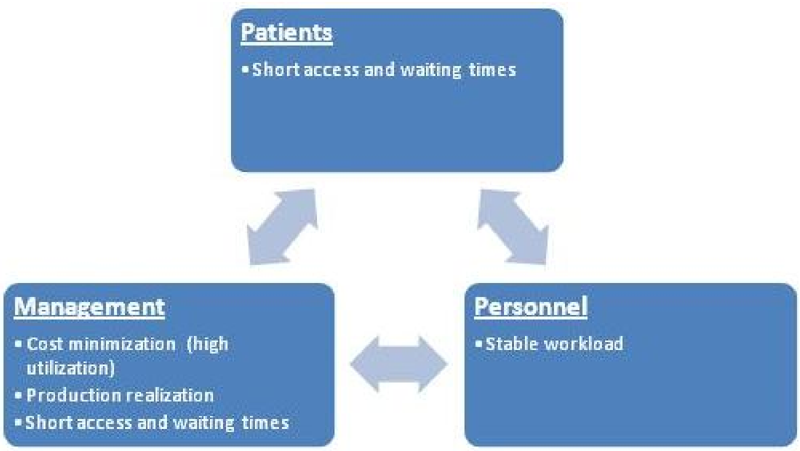


Figure 8: Tension field between patient care performance indicator stakeholders

this tension field including the related logistic indicators. Patients require short access and waiting times, while personnel requires a stable workload, and management requires cost minimization, short access and waiting times, and production realization.

Cost minimization and short access and waiting times are in conflict. To obtain shorter waiting times usually more (over)capacity is required to deal with variation in demand, which increases costs. The workload for personnel is in turn related to the utilization. Figure 9 shows this principle. With a relative high variability in demand it is harder to obtain a high utilization and keep waiting times low as well. The variability needs to be reduced to improve both utilization and waiting times. A relatively low variability in demand makes it easier to obtain high utilization while maintaining low waiting times.

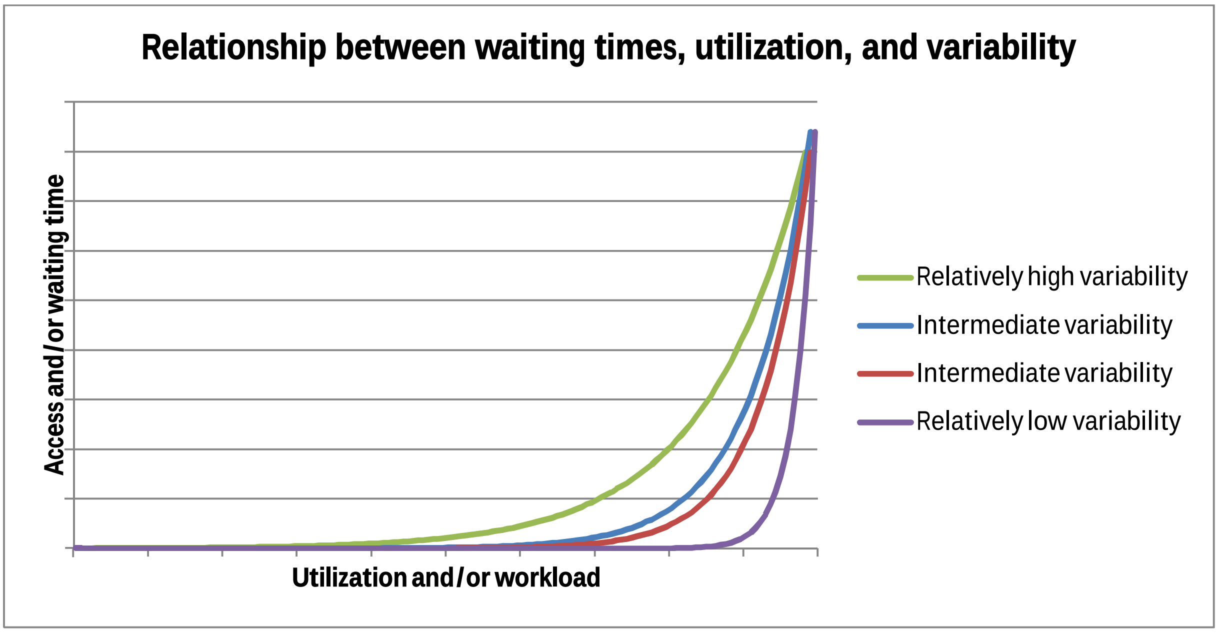


Figure 9: Waiting times and utilization influenced by variability(Howell, Ballard, & Hall, 2001)

4.3.3. How

Strategic choices and strategic goals are determined on the strategic hospital level. Both working hours and overtime policy are determined on hospital level, but overtime policy may require some tuning to specialty characteristics (overtime need not be accepted if there is a low variability in consult and/or surgery durations). The organization of elective vs. acute care especially requires description on the strategic specialty level. Also, specialties may have different norms on performance indicators, within the overall hospital strategy.

Strategic management information is required to enable strategic choices to be made and targets to be set. Most strategic management information has a higher aggregation level (yearly) from tactical management information, but is based on the same data. Section 4.6 further describes the required tactical management information, plus the required data. Additional information required for strategic planning mainly consists of financial information (feeder/bleeder analyses for case mix determination) and information concerning elective vs. acute patient planning (ratio between types and variability in demand).

4.3.4. Who

The main actors included in strategic planning are the board of directors, medical and business managers, and a care logistics, F&I (Finance and information), and/or BPR (Business Process Redesign) employee. The ***board of directors*** is the strategic management of MST. The ***medical and business managers*** are the tactical management of an RVE and have knowledge of the functioning of the various specialties. Further, an ***F&I or BPR employee*** is required ***with knowledge of data gathering and programming*** as the required data must be obtained and converted to useful and reliable information. These employees are also present in the speed dates for evaluation of specialty performance and are familiar with government requirements.

4.3.5. When

The required data can already be obtained from MST systems. For most data this can be done at the same time for strategic and tactical management information. Also together with tactical planning, the possibilities regarding setting up a system that can make required information readily available from the existing data systems can be investigated. After the required information is made available strategic choices can be made and targets can be set.

4.4. Availability of process information

Process information is used for demand forecasting and is required for the patient categories, which in turn are required for tactical planning. Sections 4.4.1-4.4.5 describe the *what*, *why*, *how*, *who*, and *when* for the availability of process information project(s).

4.4.1. What

The goal of this project is to make the required process information available. The information about the patient process is evaluated per DBC-code (soon: DOT). Figure 27 in Appendix D includes the required process information:

- Steps in the patient process
    - First consult
    - Follow-up consults (before and/or after treatment)
    - Treatment (outpatient clinic or surgery at the OR)
- # of patients per step
- Transition probabilities
    - % of patients leaving the process after first consult
    - % of patients requiring surgery
        - % of patients with a follow-up consult before surgery
        - % of patient with a follow-up consult after surgery
    - Etc.
- Transition times (minimum and maximum time between steps)

4.4.2. Why

Process information is required for three reasons. Firstly, it gives insight in the standard patient process of a certain diagnosis and shows variations between patients. Secondly, process information enables patient categorization on logistic similarities. Finally, the transition probabilities and times are used for demand forecasting.

4.4.3. How

Both process data and specialist insight are required for the desired process information. Specialists can provide insight in the basic process for a certain diagnosis and data obtained from the systems of MST represents the realization, desired for the actual steps, # of patients, and transition probabilities. The transition times may be obtained from data (especially when considering a minimum time delay due to diagnostics) but do not provide in the actual *desired* minimum and maximum time between steps, which can be obtained from a specialist.

Data collection

The Data Warehouse provides in the required data of patient numbers, from which the transition probabilities can be obtained. For each individual patient the steps in the process can be shown. It is not as easy to obtain the processes of the entire patient population from this data set. Table 13 shows the data required including the evaluation period, display or aggregation level, and MST source. The patient process data can be obtained from a query to the Data Warehouse, which includes all (financial) patient registration:

- Over the previous 1-3 years (shorter if significant changes were made to the process)
- Including all closed DBCs
    - Per DBC
        - For locations OR and OC
        - For each patient (number) all actions with date (including caregiver)

Uitvoerdatum	DBC Dataset	ACT Patient Code	Interne Verrichting Code	Zorgverlener Naam	LU Afdeling Code
Realization date	DBC code	Patient code	Internal action code	Caregiver name	Location code

Table 12: Result of a query to the Data Warehouse of MST

Table 12 shows a possible result from a Data Warehouse query. The number of patients in each step is obtained from this table using pivot tables. Some programming is required to also obtain the numbers from previous steps which are required for the transition probabilities. The same holds for the time between the steps, this is easily calculated for one individual patient but for assessment of the entire dataset some programming is required. All information obtained straight from data should be checked with specialists.

OC/OR	Information	Data	Period	Display/aggregation	Source
Both	Steps in the patient process	Action types	Previous 1-3 years	Per year, per DBC	Data Warehouse
Both	Numbers and transition probabilities per DBC	# of patients per process step (from previous steps) # of patients from outside the system	Previous 1-3 years	Per year, per DBC	Data Warehouse
Both	Time between process steps, per DBC	Per patient, steps with date	Previous 1-3 years	Per year, per DBC	Data Warehouse

Table 13: Required data for process information, including evaluation period, display/aggregation level, and source

Take note: Registration mentioned includes financial first patient consults, which are not the logistic new patient consults we require for process information. Also, for the aggregated information (transition probabilities and times) outliers may need to be deleted. Outliers can for instance be an extremely high number of follow-up consults (compared to other patients) or a long time between diagnosis and treatment (due to patient preferences). Longer term follow-up consults will have higher variability in transition times. These consults may be excluded from the patient process, and can be included from historic demand in demand forecasting.

4.4.4. Who

The main actors included in the availability of patient process information project(s) are the specialists and a care logistics, F&I (Finance and information), or BPR (Business Process Redesign) employee. The ***specialists*** are directly involved with the patient and will be able to give a basic view of the patient process. Also specialists will know the desired minimum and maximum transition times. Further, an ***employee*** is required ***with knowledge of data gathering and programming*** (in Excel). The required data must be obtained and converted to useful and reliable information (number to probabilities for instance). The project is initiated and supported by the ***business manager(s)***.

4.4.5. When

Data gathering can start immediately, as well as the deliberation with specialists. As some programming is still required to obtain all useful information, an interim solution can be used. It is possible to use the information obtained from specialists (steps in the process and transition probabilities) as a starting point, a sample of patients can then be taken from the data to check for (in)consistency. Later, a model is required to automatically obtain the information from the data.

4.5. Patient categorization

Patient categories are part of tactical planning (on specialty level) and are defined using process information. Sections 4.5.1-4.5.5 describe the *what*, *why*, *how*, *who*, and *when* for the patient categorization project(s).

4.5.1. What

The goal of this project is to define patient categories for each specialty separately. The DBC codes are clustered into categories. These categories should be medically and logistically similar and limited in number (about ten maximum). Possibly some residual categories are required.

4.5.2. Why

Patient categorization enables capacity allocation; OR time is allocated over patient categories on specialty level. For the outpatient clinic, patient categories are usually not required. It is possible if the expected diagnosis is known in advance and the expected consult duration differs extensively from other diagnoses, but a significant number and/or stable demand is required for capacity reservation. Time in the OC is mostly divided among new patient and follow-up consults.

4.5.3. How

Patient categories should be both medically recognizable and logistically similar for planning purposes. The medically recognizability of categories is obtained by using the main DBC coding categories as a starting point and by involving specialists in the formation process. Process information is used to ensure the logistic similarity of DBCs included in one category. DBCs in a certain category require a similar patient process and transition probabilities and times. Also a similar capacity demand (consult and surgery duration) per step is included, for which additional data collection is required. A proposition for categories is made from the data first, taking into account the DBC codes, which is then secured with the specialists. When the categories are determined, the previously calculated process information is aggregated from DBC to category level.

Data collection

Table 14 gives the required data to determine similar capacity demand. To calculate the capacity demand per DBC, defined by the average and standard deviation of duration, the surgery durations of patients are evaluated per DBC. By evaluating the surgery duration per quarter over the past 1-3 years it is possible to see if a change (in or decrease) has occurred. Evaluation per specialist may also be required (not directly for planning, more for scheduling purposes). Box plots can be used to visualize the duration per DBC and evaluate possible clusters. Figure 10 gives an example of the visualization in a box plot. For the OC the planned consult durations are used as they are often the same over DBCs.

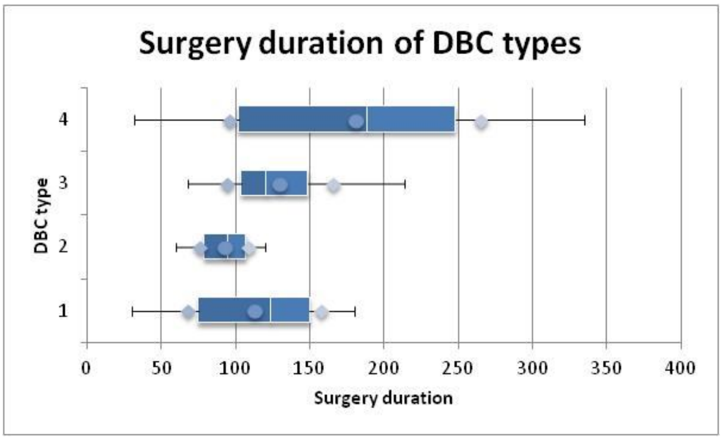


Figure 10: Boxplots for four DBC types, including average and average -/+ standard deviation

OC/OR	Information	Data	Period	Display/aggregation	Source
OR	Capacity demand per DBC (average and st.dev.)	Surgery duration per patient	Previous 1-3 years	Per DBC (Boxplot and average)	OR Suite

Table 14: Required additional data for patient categorization, including evaluation period, display/aggregation level, and source

Take note: There may be outliers in the surgery duration due to incidents. Outliers are excluded if they occur with exception, as they obscure the required information.

4.5.4. Who

The main actors included in the patient categorization project(s) are the specialists, a care logistics, F&I (Finance and information), or BPR (Business Process Redesign) employee, and an OR or admission planner. The ***specialists***, who can possibly be represented by their medical manager, will work with these categories and are involved for the medical recognizability of the patient categories. An ***employee*** is required ***with knowledge of data gathering and visualization***. The required data must be obtained and represented as useful and reliable information. Some additional knowledge of the ORsuite system may be required, for which an ***OR or admission planner*** is included. The project is initiated and supported by the ***business manager(s)***.

4.5.5. When

Data gathering and representation from ORsuite can start immediately. After the process information is available the actual categorization can take place. Later, the patient categories may be used for an MSS, and can be included in the ORsuite system for patient scheduling.

4.6. Availability of tactical management information

Tactical management information is required to make informed decisions for tactical planning. Both the patient categories and process information are required at this stage, as well as additional management information data. Sections 4.6.1-4.6.5 describe the *what*, *why*, *how*, *who*, and *when* for the availability of tactical management information project(s).

4.6.1. What

The goal of this project is to make tactical management information available, which is required for tactical planning. It provides in the analysis of previous period performance and a forward view of expected demand, supply, and performance:

- Demand
  - Outpatient clinic
    - Currently scheduled
    - Expected
      - Historic expectation
      - From current planning (Follow-up)
  - OR
    - Current waiting list
    - Expected additions to waiting list
      - Historic expectation
      - Expected from current OC planning
- Supply
  - Available outpatient clinic hours
  - Available OR blocks
  - Availability of personnel (specialist, OR personnel, etc.)
- Performance
  - Utilization
  - Access, waiting, and throughput times
  - Waiting lists (WIP)
  - Realization

4.6.2. Why

The tactical management information should provide the basis for tactical planning meeting(s). It enables the adjustment of supply/allocation of capacity based on expected demand and past and expected performance. On the hospital level capacity allocation between specialties is concerned; basically, the possible exchange of OR blocks between specialties. Tactical management information on specialty level is concerned with allocation over patient categories. The allocation of specialist time over OC and OR may be discussed on both levels. Tactical management information is required for decision making.

4.6.3. How

The first part of tactical management information is concerned with data collection. The defined patient categories from the previous project are required to aggregate information on patient category level. The collected data, patient categories, and patient process characteristics provide the *input* for tactical management information. Transition probabilities and times are required for a foreward view/forecast calculation, the *process* part of tactical management information. The last part consists of information representation, the *output* of tactical management information.

Data collection (input)

Much data is required for tactical management information. Table 15, 16, and 17 give the required tactical management data for demand, supply, and performance information respectively.

Demand data and information is required for both the OC and OR. The current schedule (OC) and waiting list (OR) are evaluated, the expected (historic) demand is calculated, and the previously performed consults are evaluated for forecasting purposes. The current schedule and waiting list provide the starting point for forecasting, added is the expected historic demand and expected demand from consults and surgeries in the previous planning period. The expected historic demand is defined as an expected number of new requests (distinguishing between low/medium/high demand periods) and "long term" follow-up consults, evaluated over the last 1-3 years. The performed and new and "short term" follow-up consults in planning, combined with process information (transition probabilities and times), provides in a forecast for follow-up consults and surgery requests (diagnoses).

Take note: It may be hard to distinguish between longer (not planned from the patient process) and shorter term follow-up consults. The total expected number from historic figures may be used to determine follow-up capacity, but only short term follow-up consults will be included in forecasting. This may result in a standard forecasted underutilization for follow-up capacity.

OC/OR	Information	Data	Period	Display/aggregation	Source
OC	Currently scheduled	Scheduled consults incl. duration	Next planning period	# per week (new and follow-up) per category (if known)	X/Care
OC	Expected (historic)	Consult requests	Previous 1-3 years	# per week (new and follow-up) per category	X/Care(?)
OC/OR	Expected (from current schedule /planning)	Scheduled consults (open DBC)	Previous periods	# per week (new and follow-up) per category	X/Care
OR	Current waiting list	Patients on waiting list incl. diagnosis date	-	# per category , per waiting time	ORSuite
OR	Expected additions (historic)	Surgery requests (diagnoses) not from consults	Previous 1-3 years	# per week, per category	ORSuite

Table 15: **Required data for tactical management information (demand), including evaluation period, display/aggregation level, and source**

Supply data consists of outpatient clinic hours, OR blocks, and the availability of personnel, which together define the maximum capacity for planning. The outpatient clinic capacity in the next periods (before (re)allocation of capacity) are evaluated on their total availability, including also the dedicated slots/capacity for new and follow-up patients. The available OR blocks are found in BLOKplan. The availability of specialists is harder to determine. This consists of the total available hours in the week, but is limited by other activities and is already allocated to OC and OR as well. The availability of the OR staff limits the availability of OR blocks.

OC/OR	Information	Data	Period	Display/aggregation	Source
OC	Available outpatient clinic hours	Planned clinic hours Available slots for new patients Available slots for follow-up consults	Next planning period	Per week	X/Care
OC/OR	Available specialist capacity	Available specialist hours (total) Hours allocated to: - other activities - OC - OR	Next planning periods	Per week	X/Care, BLOKplan, Outlook(?)
OR	Available OR blocks	Allocated OR blocks	Next planning period	Per week	BLOKplan
OR	Availability of OR personnel	Max available ORs following availability of staff	Next planning period	Per week	-

***Table 16*: Required data for tactical management information (supply), including evaluation period, display/aggregation level, and source**

OC/OR	Information	Data	Period	Display/aggregation	Source
OC	Utilization	OC hours in planning Performed consults and (planned) duration	Previous quarter	Per week (for new and follow-up)	X/Care
OR	Utilization	OR blocks in planning Performed surgeries and (planned) duration	Previous quarter	Per week, per category	BLOKplan ORSuite
OC	Access time	Per patient: consult request date and consult date	Previous quarter	Per week (request date) for new and follow-up consults	X/Care
OR	Waiting time	Per patient: surgery request date and surgery date	Previous quarter	Per week (request date), per category	ORSuite
OC	Work in progress	Opened DBCs	Previous quarter	# per week, per category	Data Warehouse
OR	Waiting list (WIP)	Patients on waiting list incl. diagnosis date	Previous quarter	# per week, per category , per waiting time	ORSuite
OC	Realization	# executed EPBs	Previous quarter	# per week (current year), per category	X/Care
OR	Realization	# admissions (per type)	Previous quarter	# per week (current year), per category	X/Care (?), Admission bureau

***Table 17*: Required data for tactical management information (performance), including evaluation period, display/aggregation level, and source**

Performance data provides in the current performance and the performance over the previous periods. The previous period performance is used to show possible trends and overview average performance (evaluated over the past quarter (three months)) and is displayed per week. The same performance measures (utilization, access and waiting time, WIP, and realization) are used for forecasting based on the previously described demand and supply data.

Take note: There may be outliers in access and waiting times due to patient preferences, these can be excluded from the evaluation. Performance evaluation is based on trends, not incidents, therefore the same may hold for incidental low utilization rates, high/low realization rates, etc. There may also be outliers in the surgery duration due to incidents. Outliers are excluded if they occur with exception as they obscure the required information.

Calculation (process)

The basic patient process consists of three types of appointments for which demand can be forecasted: the first consult, a follow-up consult (before and/or after surgery), and surgery. The first consult is only forecasted from expected demand (historic), but the demand for follow-up consults and surgeries can be forecasted from previous steps in the process. Once the patient category is known forecasting becomes more accurate, as better estimates of surgery durations and transition probabilities and times can be used as they are specific to the diagnosis of the patient.

First patient consults

The number of requests for first consults is found from historic demand and can be divided in low/medium/high demand if there are significant differences between periods. An average demand per week is used.

Follow-up consults

Follow-up consults will take place before or on short term after the surgery; longer term follow-up consults are not included in the basic patient process. This means that the expected number of follow-up consults is calculated from first patient consults, surgeries, and from historic demand.

With a certain probability, a request for a follow-up consult before surgery is expected from the first consult, increasing the follow-up demand for that week. The consult is expected to be scheduled in the week of the first consult plus $max(follow\ - up\ access\ time;\ minimum\ transition\ time)$.

With a certain probability a patient will require a follow-up consult after surgery. This consult request is expected once the surgery date is known (max. one week in advance in MST). The surgery week can therefore be used as the request date for a follow-up consult after surgery, again taking into account the access time and minimum transition time the consult will take place in the surgery week plus $max(follow\ - up\ access\ time;\ minimum\ transition\ time)$.

Further there may be additional longer term follow-up consults which cannot be forecasted from current planning. Each week a certain number of this type of consult may be expected.

The total demand for follow-up consults in a certain week can therefore be calculated from the scheduled first consults (in the previous and following planning period), the scheduled surgeries, and expected additional consults.

Surgery

Surgeries are expected to follow from either the first consult or a follow-up consult, but a patient may be referred from another hospital or specialty as well. A request is expected at the date of either the first or the follow-up consult, increasing the waiting list and WIP (with one patient and duration (average if type is not yet known)) for the OR. The actual surgery date depends on the length and composition of the waiting list. If surgeries are already scheduled or have been performed, the follow-up consult request and date can be processed as explained before. As the surgery schedule is not known in advance an average number of surgeries per week could be used to calculate the subsequent follow-up consults.

An example:

The demand for health care consists of four processes. Table 18 shows the steps of each process and the probability a patient belongs to that type of process. The corresponding transition times are: 2 weeks to a follow-up consult before surgery, 5 weeks to surgery, and 3 weeks to a follow-up consult after surgery. Figure 11 shows the results from 100 first consults on the subsequent steps if the method as described before is applied. Figure 12 shows the requests associated with these appointments.

	First consult	Follow-up (before)	Surgery	Follow-up (after)	Prob.
Process 1	1	0	0	0	0,1
Process 2	1	1	0	0	0,2
Process 3	1	0	1	1	0,4
Process 4	1	1	1	1	0,3

Table 18: Example process characteristics

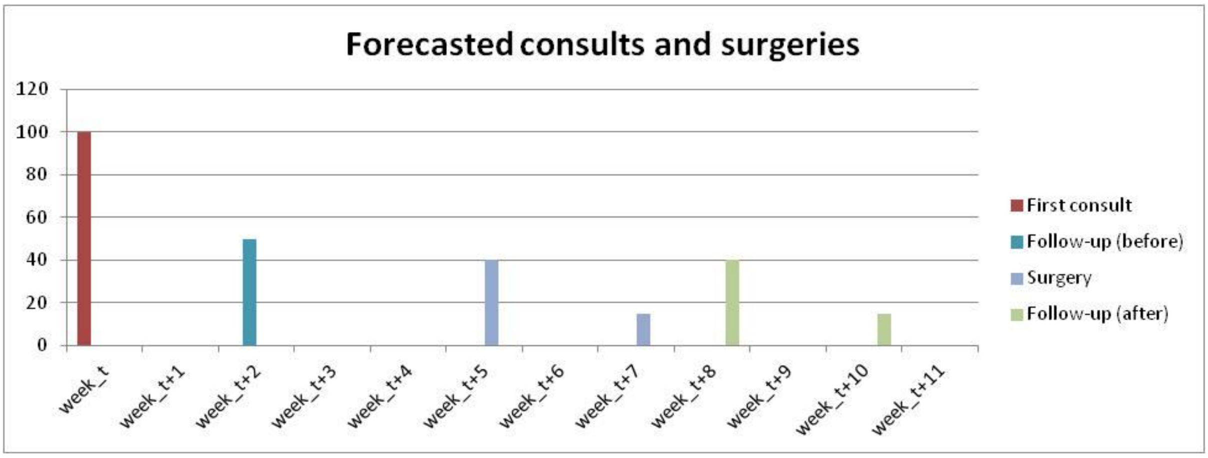


Figure 11: Forecasted consults and surgeries from 100 first consults

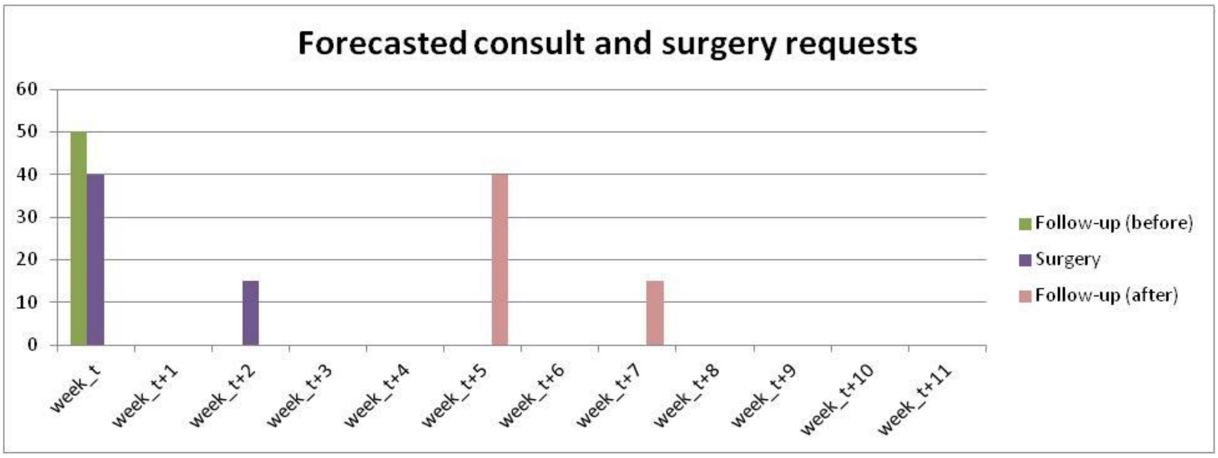


Figure 12: Forecasted consult and surgery requests from 100 first consults

Figures 13 and 14 show forecasts including different first consults numbers for a number of weeks.

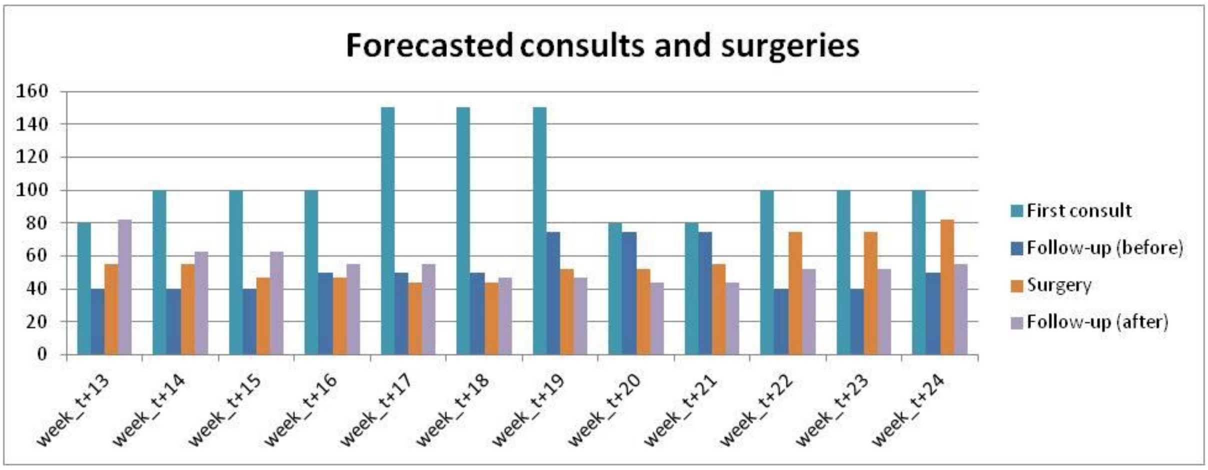


Figure 13: **Forecasted consults and surgeries from first consults**

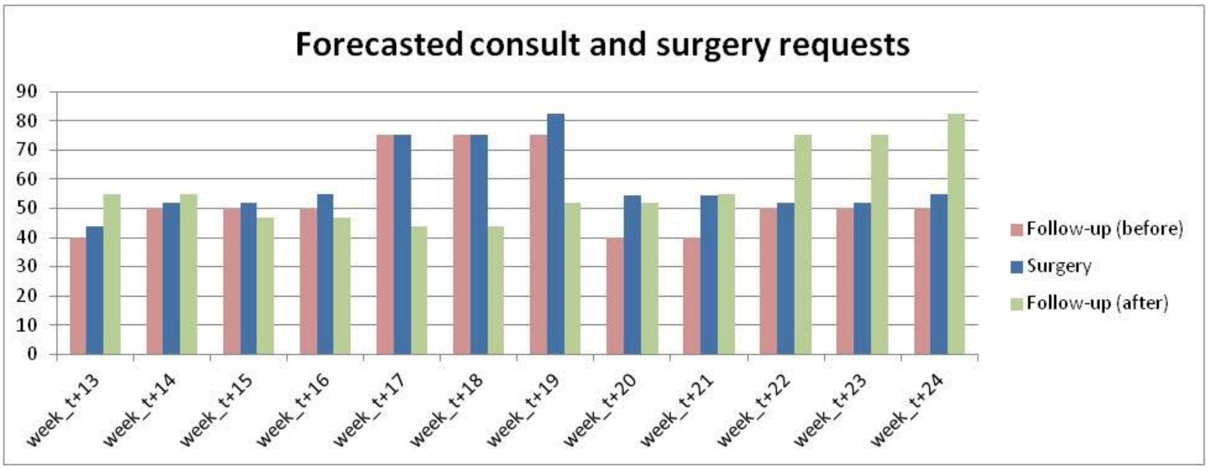


Figure 14: **Forecasted consults and surgery requests from first consults**

The numbers of consults and surgeries can be converted to times and if this combined with the available capacity, it becomes possible to calculate the expected utilization, access and waiting times, and realization. The requests following from previous steps determine demand and available capacity, while taking into account the minimum transition times, determines the actual access or waiting time per patient. The WIP for the OR can be calculated from adding the requests and subtracting the performed surgeries.

Presentation (output)

Tactical management information is presented over two main categories: current/past performance and expected/forecasted performance. The forecasts are calculated based on patient processes and expected demand and supply, as explained in the previous section. The following sections give possible presentations of the tactical management information.

Utilization

Utilization is shown on both hospital and on specialty level. On hospital level the gross utilization rates of different specialties are compared. Evaluation on specialty level gives an overview of the available and used capacity. Figure 15 and 16 give the hospital and specialty level presentation respectively. Table 19 gives an overview of the representations of utilization information.

		Hospital level		Specialty level
Current/past performance	OC	• Gross utilization rates • Previous quarter (12 weeks) • All specialties	OC	• Gross utilization rate, available and used capacity • Previous quarter (12 weeks) • Per specialty, for first and follow-up consults
	OR	• Gross utilization rates • Previous quarter (12 weeks) • All specialties	OR	• Gross utilization rate, available and used capacity • Previous quarter (12 weeks) • Per specialty
	Ex.	Figure 15 (OR)	Ex.	Figure 16 (OR)
Forecasted performance	OC	• Gross utilization rates • Next quarter (12 weeks) • All specialties	OC	• Gross utilization rate, available and used capacity • Next quarter (12 weeks) • Per specialty, for first and follow-up consults
	OR	• Gross utilization rates • Next quarter (12 weeks) • All specialties	OR	• Gross utilization rate, available and used capacity • Next quarter (12 weeks) • Per specialty
	Ex.	-	Ex.	-

***Table 19*: Representation of utilization information on hospital and specialty level, for current/past and forecasted performance**

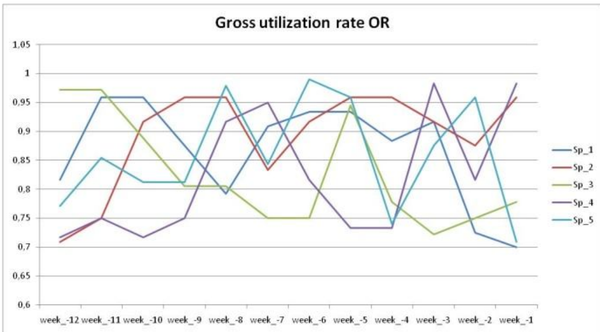


***Figure 15*: Hospital level presentation of OR utilization rates**

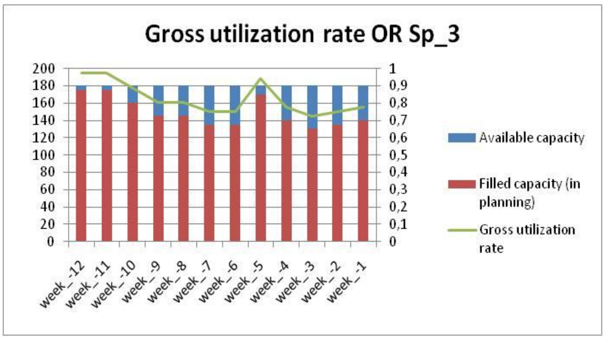


***Figure 16*: Specialty level presentation of OR utilization rate**

Access and waiting times

Access and waiting times are shown on hospital and specialty level, for the comparison of specialties and patient categories respectively. Figure 13 and 14 show the possible presentations for waiting time. Waiting time is evaluated per specialty and patient category, while access time is evaluated per specialty and first vs. follow-up consults. Table 20 gives an overview of the representations of access and waiting time information.

		Hospital level		Specialty level
Current/past performance	OC	• Access times (average) • Previous quarter (12 weeks) • All specialties	OC	• Access times • Previous quarter (12 weeks) • Per specialty, for first and follow-up consults
	OR	• Waiting times (average) • Previous quarter (12 weeks) • All specialties	OR	• Waiting times • Previous quarter (12 weeks) • Per specialty, per patient category
	Ex.	Figure 17 (OR)	Ex.	Figure 18 (OR)
Forecasted performance	OC	• Access times (average) • Next quarter (12 weeks) • All specialties	OC	• Access times • Next quarter (12 weeks) • Per specialty, for first and follow-up consults
	OR	• Waiting times (average) • Next quarter (12 weeks) • All specialties	OR	• Waiting times • Next quarter (12 weeks) • Per specialty, per patient category
	Ex.	-	Ex.	-

***Table 20*: Representation of access and waiting time information on hospital and specialty level, for current/past and forecasted performance**

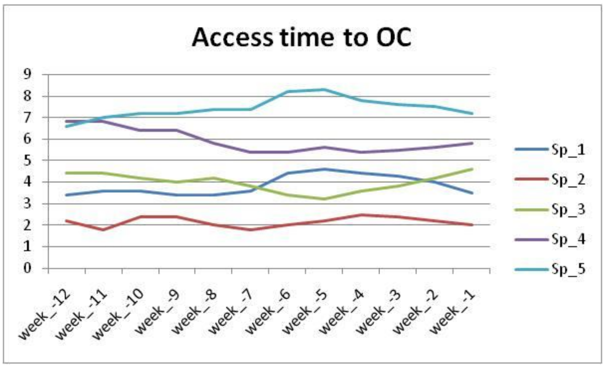


***Figure 18*: Hospital level presentation of access time**

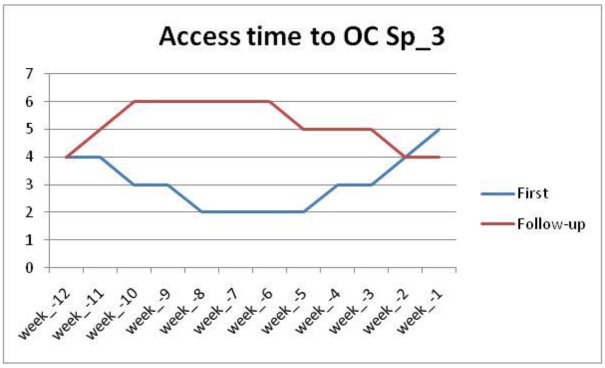


***Figure 17*: Specialty level presentation of access time**

Work in progress

The work in progress is typically expressed as a number of patients, but can be more useful for comparison with available capacity if the numbers are multiplied by the expected duration. These durations can then be compared to supply, to see if the current allocated capacity is sufficient to deal with demand. Figure 19 and 20 show a possible difference between the two approaches for current WIP for the OR; while Specialty 9 has the longest waiting list in terms of number of patients waiting, it has an average length in duration. Figure 21 and 22 show the same principle on specialty level, which considers different durations per category. Table 21 gives an overview of the representations of work in progress information.

		Hospital level		Specialty level
Past performance	OC	• WIP (opened DBCs) • Previous quarter (12 weeks) • All specialties	OC	• WIP (opened DBCs) • Previous quarter (12 weeks) • Per specialty, for patient categories
	OR	• Waiting lists incl. average waiting time (# and *duration) • Previous quarter (12 weeks) • All specialties	OR	• Waiting list incl. average waiting time (# and *duration) • Previous quarter (12 weeks) • Per specialty, for patient categories
	Ex.	-	Ex.	-
Current performance	OR	• Waiting lists incl. waiting time (# and *duration) • Current waiting list • All specialties	OR	• Waiting list incl. waiting time (# and *duration) • Current waiting list • Per specialty, for patient categories
	Ex.	Figure 19 and 20 (OR)	Ex.	Figure 21 and 22 (OR)
Forecasted performance	OC	• WIP (opened DBCs) • Next quarter (12 weeks) • All specialties	OC	• WIP (opened DBCs) • Next quarter (12 weeks) • Per specialty, for patient categories
	OR	• Waiting lists incl. waiting time (# and *duration) • Next quarter (12 weeks) • All specialties	OR	• Waiting list incl. waiting time (# and *duration) • Next quarter (12 weeks) • Per specialty, for patient categories
	Ex.	-	Ex.	-

Table 21: Representation of WIP information on hospital and specialty level, for current/past and forecasted performance

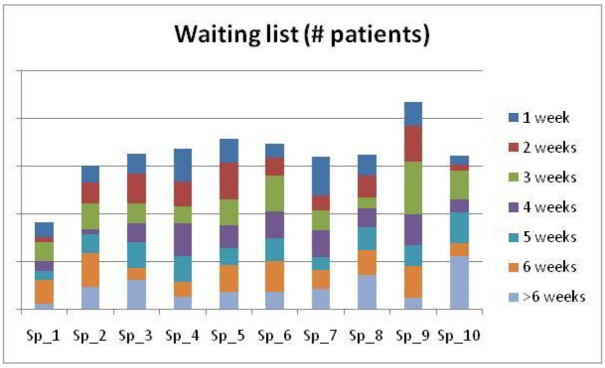


Figure 19: Hospital level presentation of current OR WIP(#)

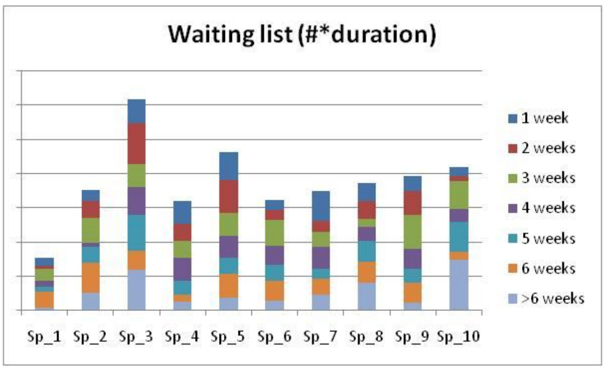


Figure 20: Hospital level presentation of current OR WIP(time)

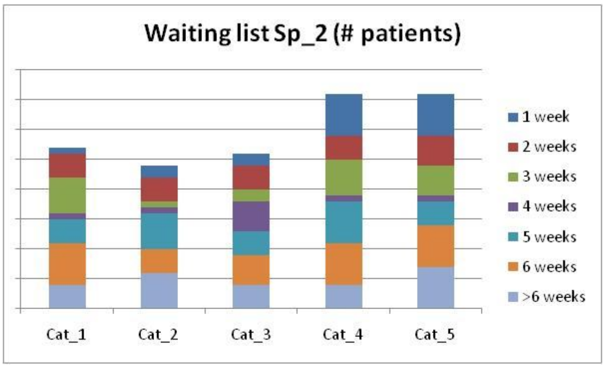


Figure 21: Specialty level presentation of OR WIP(#)

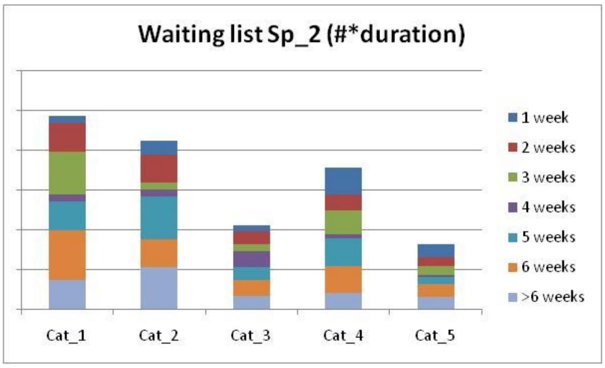


Figure 22: Specialty level presentation of OR WIP(time)

Realization

Realization is represented to see if the current situation is in line with planning. Overviews can include the previous realization, up until "now", and the expected additional realization in the next periods, based on expected demand and supply. Table 22 gives an overview of the representations of realization information. On hospital level the current performance of specialties is evaluated, while on specialty level both the past and forecasted performance are included.

	Hospital level	Specialty level
Current/past performance	OC • Cumulative realization of EPBs, compared to period and yearly target • Previous weeks (same year) • All specialties	
	OR • Realization of admissions, compared to period and yearly target • Previous weeks (same year) • All specialties	
	Ex. Figure 23 and Table 23 (OC)	
Current/past performance + forecasted performance		OC • Cumulative realization of EPBs, compared to period and yearly target • Previous weeks (same year) and next weeks (same year) • Per specialty
		OR • Realization of admissions, compared to period and yearly target • Previous weeks (same year) and next weeks (same year) • Per specialty, for patient categories
		Ex. Figure 24 and Table 24 (OC)

Table 22: Representation of realization information on hospital and specialty level, for current/past and forecasted performance

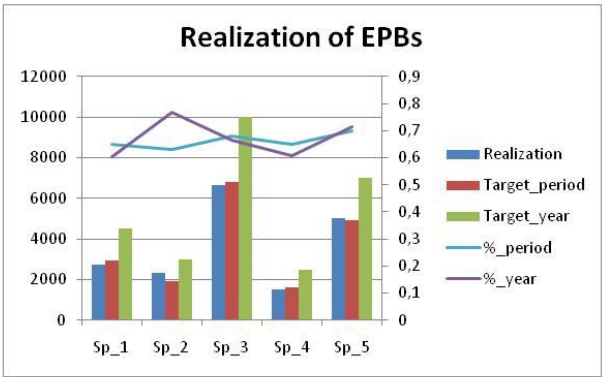


***Figure 23*: Hospital level presentation of current OC realization (graph)**

	Sp_1	Sp_2	Sp_3	Sp_4	Sp_5
Realization	2723	2303	6651	1514	4995
Target_period	2925	1890	6800	1625	4900
Target_year	4500	3000	10000	2500	7000
%_period	1	1	1	0,61	0,71
%_year	1	1	1	0,61	0,71

***Table 23*: Hospital level presentation of current OC realization (table)**

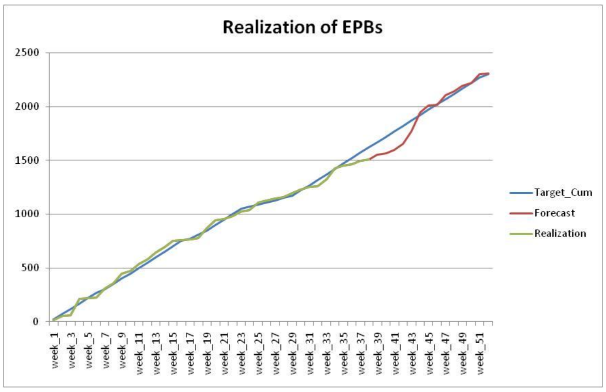


***Figure 24*: Specialty level presentation and forecast of OC realization (graph)**

	Qu_1	Qu_2	week _38	Qu_3*	Qu_4*
Realization	647	1130	1509	1555	2308
Target_period	600	1110	1670	1670	2300
Target_year	2300	2300	2300	2300	2300
%_period	1,08	1,02	0,90	0,93	1,00
%_year	0,28	0,49	0,66	0,68	1,00

***Table 24*: Specialty level presentation and forecast of OC realization (table)**

4.6.4. Who

The main actors included in the tactical management information project(s) are the medical and business managers, a care logistics, F&I (Finance and information), or BPR (Business Process Redesign) employee, and an OR or admission planner. The ***medical and business managers*** are concerned with the tactical planning for their specialty and are involved in strategic planning. An ***employee*** is required ***with extensive knowledge of data gathering and visualization***. The required data must be obtained and represented as useful and reliable information. Some additional knowledge of the ORsuite system may be required, for which an ***OR or admission planner*** is included.

4.6.5. When

Data gathering can start immediately. Also the possibilities regarding setting up a system that can make required tactical information readily available from the existing data systems can be investigated. After the patient categorization it is possible to turn data into actual management information.

4.7. Pilot tactical planning

Once the previous projects are completed, a pilot for tactical planning can be started. Section 4.7.1 gives a short introduction to tactical planning for MST and describes the basic *what*, *why*, *how*, *who*, and *when* for the pilot project. Sections 4.7.2 and 4.7.3 describe in further detail the tactical planning process for hospital and specialty level respectively. Section 4.7.4 addresses the evaluation and revision of the project and management and process information (data).

4.7.1. Introduction

Tactical planning considers capacity allocation for elective patients on intermediate term. Tactical planning is organized around tactical planning meetings. The goal of these meetings is to align demand and supply, adjust current capacity allocation/planning where needed, based on tactical management information (discussed in Section 4.6). Meetings take place on hospital level, where allocation of capacity is done over specialties, and on specialty level, where the allocated or available time is distributed over patient categories. We assume sufficient capacity and the ability to make decisions based on tactical management information.

What

The pilot tactical planning considers actual tactical planning, which is concerned with the interpretation of the tactical management information and the following capacity allocation decisions. A pilot project is started which includes the characteristics of tactical planning for MST on a smaller scale. For the pilot a small number of larger surgical specialties is included.

Why

Establishing tactical planning for all specialties within the entire hospital at the same time would be too extensive. The pilot includes a small number of specialties, which is easier and also provides a point of assessment before tactical planning can become an integral part of the organization.

How

Tactical planning is organized in tactical planning meetings. These meetings are held on hospital level first, for the allocation of capacity over specialties, and then on specialty level, where it is decided how the allocated capacity is used. Sufficient capacity is assumed (until tactical management information proves otherwise), as well as the ability to make intuitively right decisions from the presented data. Some training in information interpretation may be required for participants (what do we see and how do we react?). The pilot and tactical planning in itself will be supported by BPR and/or patient logistics.

Who

The actors responsible for tactical planning and the proper execution of the pilot project are the business managers of the participating specialties, BPR, and the business manager OR. The ***business managers*** are concerned with the tactical planning for their specialty/RVE and are involved in strategic planning. ***BPR*** is responsible for many improvement projects in MST and has knowledge of data gathering, management information, and processes. Also, BPR is involved in the RVE speed dates, which will involve the performance on indicators used for tactical planning. An employee of BPR can be made responsible for the training of participants. Further the ***business manager OR*** is concerned with the performance of the OR department.

The actors involved in the actual planning meetings are discussed in Sections 4.7.2 and 4.7.3.

When

The participating specialties should be determined as soon as possible (the obvious choices seem: Orthopedics, Neurosurgery, and General Surgery). The medical and business managers of the corresponding RVEs can then be approached and involved. Once the participants are known, it is possible to evaluate different meeting time options. Once the required tactical and strategic management information is available the pilot can be started.

4.7.2. Hospital level

What

Hospital level tactical planning concerns the basic capacity allocation among specialties and consists of a monthly tactical planning meeting. This meeting is prepared per specialty using the past/current performance and expected performance based on different capacity allocations. Scenario analysis provides for expected future performance when a certain amount of capacity is allocated (+/- one OR block and/or added OC capacity).

Why

The tactical planning meetings on hospital level are to match supply and demand. There is a basic planning available (for the shared resource OR and for OC separately), but reallocations may be necessary for better performance on the access and waiting time and realization indicators. Scenario analyses for expected performance provide the input at this point, as some specialties may require more while others can do with less capacity for a certain period of time. The allocation among patient categories (and with it among specialists, due to case mixes) is too detailed to perform at hospital level and is therefore concerned in a specialty level meeting.

How

In the tactical planning meeting the past/current and expected performance for all specialties is presented, as well as the expected performance due to reallocation of capacity per specialty.

The preparation for the tactical planning meeting consists of the availability of tactical management information for all specialties, and scenario analyses per specialty. The main question for the scenarios is how the performance can be improved under expected demand by making adjustments in capacity. In preparation it is also important to carefully consider the maximum availability. More OR time could be required, but if no specialist is available (or not the right specialist due to case-mixes) no additional OR time should be requested.

Analysis and reallocation – outpatient clinic

Realization information provides insight in the need for additional (filled) first patient consult slots. Combined with the utilization information it is possible to see if there is indeed a capacity, or a demand problem. Additional OC capacity may be required if utilization is high and realization is lacking.

Access time information gives insight in the performance of OC planning. The connection to the utilization information needs to be made to see if there is a problem with the capacity, or there is another underlying cause altogether. Additional OC capacity may be required if utilization is high and access times are increasing. OC capacity may be decreased if utilization is low and access times are as well.

The WIP for the OC gives insight into the throughput time of patients. Considering the utilization rate insight is given in the role of OC capacity in this case. If work in progress is increasing, and utilization rates are low, the problem may lie in the OR capacity, or OC capacity can be decreased.

Analysis and reallocation – operating rooms

Waiting times provide insight in the current performance of the OR planning. When waiting times are increasing, probably more OR capacity is required. If the waiting times are decreasing (within norms) and utilization is low as well, probably less OR capacity is still sufficient and another specialty can benefit from additional capacity.

The work in progress for OR gives insight in the length of the waiting list, utilization information is required to see if the allocated capacity is used efficiently. If utilization is high and waiting lists are increasing the specialty can benefit from additional capacity. If utilization is low and waiting lists are still increasing, something else may be the underlying cause (illness of a specialist for instance), which needs to be investigated and OR capacity may still be decreased.

Low realization for the OR typically requires more surgeries and with it more capacity, but the cause may lie in the allocation to surgery types (patient categories) as well.

Analysis and reallocation – outpatient clinic/operating rooms

If a decrease in waiting time and utilization in the OR is detected, this may result from a low inflow from the OC. If these OR characteristics are combined with high utilization and access times for the OC, adaptation of the OC/OR capacity ratio is required. Temporary decrease of OR capacity keeps utilization at an acceptable level, while the freed capacity can be used for consults in the OC.

Basic/flexible capacity

Cancellations should be kept at a minimum. As OR schedules are made one week in advance, no cancellations have to result from changes in capacity allocation, but the OC may have to cancel scheduled consults if OC capacity is decreased. We assume that capacity is only decreased if utilization is low, which means that not many patients need to be rescheduled.

It is possible to dedicate some OC capacity to possible cancellation, which is filled later than other slots in the week. Also, to account for in advance planning and to increase the chances of acceptance a basic capacity can be used. This basic capacity determines the minimum number of OR blocks or OC hours that is always allocated to that specialty or consult type respectively. This minimum may still differ between periods based on demand and supply (it can for instance be lowered during summer holidays).

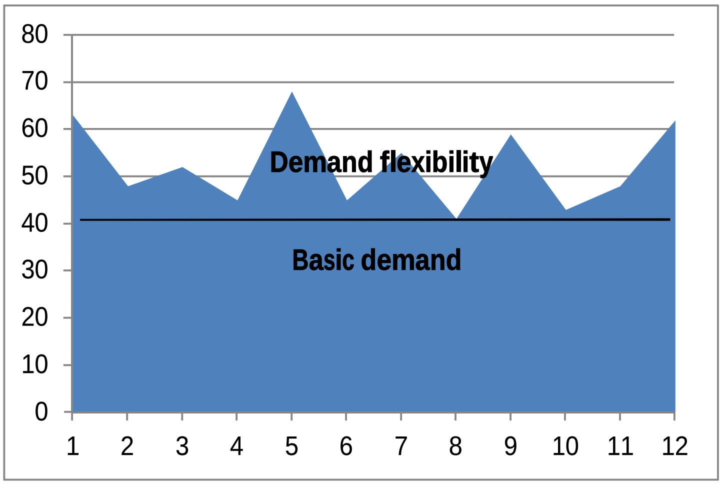


Figure 25: **Demand for first consults, a simple example of basic and flexible demand**

Figure 25 shows a simple example of basic and flexible demand, in which case the basic demand is determined by the minimum demand for first consults. Use of the basic demand will result in an increasing backlog and access time for patients as requests can be scheduled in upcoming weeks as well. The basic demand may also be determined by the minimum that can be filled in for instance 95% of the weeks, which allows for a higher basic demand. Using the basic/flexible demand principle, capacity is added, as described, when performance under basic demand is lacking and scenario analysis proves that additional capacity improves expected performance.

Who

Preparation for the meetings is done by the **care logistics/BPR employee**, both for specialty comparison and specialty specific scenarios. For the specialty scenarios this is done in collaboration with the **business and medical managers**.

The ***meeting*** on hospital level is attended by the **employee responsible for the tactical management information**, an **OR planner**, an **admission employee**, and the **business and medical managers** of participating specialties.

When

The meeting takes place once each month. The management information is considered over the previous 12 weeks and 12 weeks to come. Decisions are made for two weeks from now to allow for specialty level allocation and planning changes. The preparation takes place shortly before the meeting (max. one week) to make sure that up-to-date information is used. After the hospital meeting a specialty level meeting takes place (within a week).

4.7.3. Specialty level

What

Specialty level tactical planning concerns the division of allocated capacity from the hospital level meeting over patient categories. It is organized in a monthly tactical planning meeting. The basic preparation is already done for the hospital level planning, but the allocation among patient categories is now to be made. This means that the OR block division over specialists is concerned on this level. As the hospital level capacity allocation already determined the allocated OR capacity, OR capacity is considered static, but OC capacity can still be altered.

Why

The tactical planning meetings on specialty level are to match supply and demand on patient category level. There is a basic planning available, but this may need to be adjusted due to reallocations on hospital level and/or to improve future performance on access and waiting time and realization indicators. Expected demand provides the main input; some categories may require more capacity in the next periods than others. With the categories also comes the allocation of capacity over specialists, based on past/current and expected performance.

How

In the tactical planning meeting the past/current performance of patient categories is presented, as well as the expected performance following settings for capacity allocation over categories.

The preparation of the tactical planning meeting consists of the availability of tactical management information for patient categories, and allocation scenarios. The main question for the scenarios is how the performance of the categories can be improved under expected demand and allocated capacity, by making adjustments in allocation to categories and OC capacity. In preparation it is also important to carefully consider the maximum availability of specialists. More OC time could be required, but if the specialist is also required in the OR no additional time can be planned.

Analysis and reallocation – outpatient clinic

Realization information provides insight in the need for additional (filled) first patient consult slots. Combined with the utilization information for first consults it is possible to see if there is indeed a capacity, or a demand problem. Additional OC capacity may be required if utilization is high and realization is lacking. If follow-up consult utilization is low (there is overcapacity), no additional capacity may be required, but a different ratio of first and follow-up consults can be used.

Access time information gives insight in the performance of per consult type. The connection to the utilization information needs to be made to see if there is a problem with total capacity, or use of a different first to follow-up ratio may be sufficient. Additional OC capacity may be required if utilization is high and access times for both are increasing. OC capacity may be decreased if utilization is low and access times are as well.

Analysis and reallocation – operating rooms

Waiting times provide insight in the current performance of the OR planning per patient category. When waiting times are increasing, probably more OR capacity is required, but if only a few have increasing waiting times there may be an allocation problem or a certain specialist is unavailable. If the waiting times for a certain category are decreasing, more capacity may be allocated to other patient categories.

The work in progress for OR gives insight in the length of the waiting list per patient category. If the waiting lists are increasing for a certain category, it may benefit from additional capacity. Important to take into account, is not only the length of the waiting list, but also the time patients are already waiting. Long waiting times require short term capacity expansion, while longer lists with shorter waiting times are less urgent and require a larger portion of total capacity some weeks from now.

The cause of low realization for certain admission types may lie in the allocation of capacity to the corresponding patient categories. Realization performance is a longer term performance measure and does not need immediate adjustment if waiting time and waiting list performance issues are more pressing. On a larger scale it is important to take into account the realization numbers and more capacity may be allocated to certain categories for a period of time.

Analysis and reallocation – outpatient clinic/operating rooms

The WIP for the OC gives insight into the throughput time of patient categories. There may be differences between patient categories (past/current). The OC utilization rate provides insight in the role of OC capacity in this case. If work in progress is increasing and OC follow-up utilization rates are low, the problem may also lie in the OR capacity (or allocation of capacity to categories) and follow-up capacity can be (temporarily) decreased.

Who

Preparation for the meetings is done by the **care logistics/BPR employee**, both for patient category overviews and allocation scenarios. The preparation for the scenarios is done in collaboration with the **medical manager**.

The ***meeting*** on specialty level is attended by the **employee responsible for the tactical management information**, an **admission employee**, the **medical manager**, and **specialists**.

When

The meeting takes place once each month, within a week from the hospital level meeting. The management information is considered over the previous 12 weeks and 12 weeks to come. Decisions are made for one week from now to allow for planning changes. The preparation takes place shortly before the meeting (after the hospital level meeting) to make sure that up-to-date information is used.

4.7.4. Evaluation and revision

The pilot enables evaluation of the tactical planning process. There may have been problems with the information gathering, displays, or understanding that need to be solved before tactical planning becomes an integral part of the organization. The collaboration and the willingness of specialties and specialists should be evaluated. If this is still insufficient further training and insight in (improved) performance may be required. The main focus point in evaluation is the performance (and if improvement is realized). If the exchange of capacity provides hard, this may result from unwillingness of specialties, but also from insufficient total capacity. After a year the pilot project is evaluated on the aforementioned points. This can be done by the BPR employee/RVE controller. The outcome from the evaluation provides the input for further implementation of tactical planning in MST. All specialties may still be too extensive, but more specialties may be included.

Tactical planning depends on tactical management information, it is therefore important to ensure this information is accurate and up-to-date. The tactical management information is updated before each meeting, but is based on process information and patient category characteristics. The process information (steps in the process and time between steps) should be adjusted once a year. No large changes are expected and the analysis is not easily made. Patient categories are partly based on the process information, but also consist of the connected durations. Especially the surgery durations may change over time and should be adjusted every three months, or incidentally when a new technique is introduced. Net (actual) and gross (planned) utilization rates may be compared to see if adjustment is needed. Because the gross utilization is used in planning it becomes more interesting to have a higher expected surgery duration (gross utilization will be higher), it is therefore important to keep these numbers up-to-date. Table 25 gives the information types and their revision periods.

Information type	Revision period
Tactical management information	Before each meeting
Process information	Once a year
Patient categories	Once a year
- Durations	Every 3 months (sooner if required due to technique changes)

***Table 25*: Information revision periods**

5. Conclusions and recommendations

This chapter gives an overview of the conclusions and recommendations from our research. Section 5.1 gives an overview of the drawn conclusions during our research. Section 5.2 describes the related recommendations in a short summary of Chapter 4. Section 5.2.1 gives the recommendations for further research.

5.1. Conclusions

Our research considers tactical resource capacity planning for MST. The objective of the research is to design a tactical planning concept for the outpatient clinics and operating rooms of MST and determine the necessary steps for implementing this concept in the organization. The context analysis and literature review provide the input for the design and recommendations.

We focus on the specialist's time and the time in the OC and OR. The OC and OR are critical resources, generate demand for one another, and provide added value to most patient processes. Current resource capacity planning in MST is supply-oriented. Tactical planning on hospital level consist for the OR of a quarterly roster for which the exchange of OR blocks is not centrally organized and basically non-existent. Apart from orthopedics, no tactical planning is made on specialty level, allocating capacity over patient categories. MST should benefit from increased communication and coordination on the tactical level to improve patient care and enable more efficient use of capacity. Accurate information on performance indicators is required to enable tactical planning on both hospital and specialty level, but while most data is available from MST systems not all information is accurately used or made available. Logistic indicators can be used to forecast demand and performance for the near future by combining knowledge of the patient process and consults and surgeries already in planning.

Tactical planning considers planning on the intermediate term and requires flexibility in allocation, to match supply and demand. OC literature focuses mainly on operational level issues; internal processes and individual patients. Performance measurement for the OC in literature is done on four main indicators: queuing, throughput, utilization, and overtime. OR literature mainly considers elective patient scheduling and evaluates performance based on utilization or efficient use. Other indicators used are: overtime, throughput, and waiting time. Surgery duration is often used to determine logistically similar patient categories; diagnosis types are used for medical recognizability. Integrated planning for OC and OR is limited in literature. Integrated planning does show the applicability of transition probabilities for calculating demand for subsequent steps. Mathematical methods from literature do not provide a solution on their own as they often provide "one optimal solution" for a certain point in time, which does not include all restricting factors and may differ extensively between periods, which complicates acceptance by specialists. In ZGT, tactical planning is part of common procedure, organized in tactical planning meetings in which capacity reallocations are discussed and determined based on management information.

MST requires a workable method which increases the communication and coordination between specialties. Accurate information is required to make informed decisions about (re)allocation of capacity.

5.2. Recommendations

Tactical planning for MST concerns elective patient (category) planning on intermediate term. Assuming sufficient total capacity (until proven otherwise), supply and demand should be aligned by reallocating capacity among specialties and patient categories when needed. Decisions about reallocations should be made in tactical planning meetings, based on management information of supply, demand, and past and expected performance. Scenarios should be used, in which the effect of different capacity planning decisions/adjustments on performance is evaluated, enabling decisions on reallocation of capacity. Two meetings should be held each month, first on hospital level (allocating OR capacity among specialties), second on specialty level (allocating capacity among patient categories).

We advise to start tactical planning in a pilot project, including a small number of larger surgical specialties (obvious choices seem: Orthopedics, Neurosurgery, and General Surgery), supported by BPR, the business manager OR, and the business managers of the participating specialties. Before the pilot can start several projects should be undertaken, which consist for a large part of making the required information available. The following projects are required before tactical planning can start: Strategic planning, availability of process information, patient categorization, and availability of tactical management information.

Strategic planning

In the strategic planning project strategic choices should be made and strategic goals should be determined, which provide the degrees of freedom for tactical planning and can be translated to tactical goals. Strategic planning provides focus in the tension field between management, patients, and personnel. Strategic choices concern the case-mix, personnel, working hours and overtime policy, available ORs, and the organization of elective vs. acute care. The goals considered are cost minimization, access, waiting, and throughput times, and production realization.

The board of directors, medical and business managers, and an F&I or BPR employee should be involved in strategic planning. The required information corresponds for a large part to the tactical management information, with a higher aggregation level. This means that the data gathering can start immediately and is done simultaneously. A system may be set up to automatically retrieve the required information from MST systems. The possibilities regarding setting up such a system should be evaluated.

Availability of process information

In the process information project(s) the patient processes should be evaluated and process information should be generated. This information consists of the steps in the process, numbers of patients per step, and transition probabilities and times per DBC code, and can be used for patient categorization and forecasting. Conversations with specialists provide for a large part in the insight in patient processes (basic process and desired times). Data collection is required to obtain the actual patient processes. Data is obtained from the Data Warehouse: Actions per patient, for locations OC and OR, per DBC for all closed DBCs in the previous 1-3 years.

Specialists and an (F&I or BPR) employee who can obtain the required information from the data together should make the process information available. This should be initiated and supported by their business manager(s). Data gathering and deliberation between specialists and the employee with data and information knowledge can start immediately. If data gathering turns out to be too extensive on short term, process information may consist of specialist insight checked for a sample of patients.

Patient categorization

In the patient categorization project(s) the patient categories should be determined, per specialty. Each category consists of a selection of DBC codes. The categories should be both medically and logistically similar. The basic DBC categories therefore provide the starting point, which enables medical recognizability. Further, logistic similarity can be obtained by clustering based on similar patient processes and capacity demand (consult and surgery duration). For capacity demand additional data is required, which can be obtained from ORSuite for the OR.

Specialists and an (F&I or BPR) employee who can obtain and process the required data together should divide the DBC codes into a maximum of ten categories. They may be assisted by an OR or admission planner. The patient categorization should be initiated and supported by their business manager(s). Surgery duration data can be obtained immediately, the rest of the project can be started once the process information is available.

Availability of tactical management information

The tactical management information project is concerned with the availability of the tactical management information required for tactical planning. This information consists of demand, supply, and performance information. Performance should be evaluated over the past weeks, but also a forecast should be made based on the expected demand and supply. Tactical management information can be displayed for hospital and specialty level separately and should emphasize the different allocation levels (on hospital level over specialties, on specialty level over patient categories). The input consists of additional data for demand (historic evaluation and current planning), supply (available OC, OR, and personnel hours), and performance (for calculation of utilization, access and waiting times, WIP, and realization). The current consults and surgeries in planning should be combined with the process information for demand forecasting. Combining these forecasts with available capacity enables calculation of expected performance.

A care logistics, F&I, or BPR employee should be concerned with the availability of the tactical management information. An OR or admission planner may help if additional knowledge of the ORSuite system is required. The medical and business managers are concerned with tactical level goals. Data gathering can start immediately; simultaneous with the strategic management information data. A system is required that can make the information presentations easily available from the underlying data; the possibilities regarding setting up such a system should be investigated.

It is important that the tactical management information speaks for itself, which makes sure that intuitive decisions are the right decisions. For instance, by evaluating the capacity adjustments in the scenarios a possible exchange of OR blocks between specialties should follow as a logical result. It is also important that the medical managers and specialists are involved in the projects from the beginning. They may require some additional training to work with the tactical management information in the meetings. If they know what choices to make following certain performance outcomes, they can make the decisions among themselves and do not have to be told what to do by someone else.

5.2.1. For further research

We defined a tactical planning concept in which a (basic) planning is adjusted based on expected performance under expected demand. Adjustment is done on a week level; total weekly capacity is determined. The total capacity in one week should be allocated over the days of the week. We did not address this characteristic. It is for instance important to consider waiting room congestion and the secretary workload, which is higher when many specialists work in the OC at the same time. Also, when many specialists work the same days it may be harder to deal with semi-acute and urgent patients if the busiest day has just passed or utilization may be lower due to more reserved capacity for these patients.

When considering daily capacity, the OR's connection to the ward becomes apparent. The day and type of surgery together determine the expected days a bed is filled. Specialties/specialists/surgeries with a longer 'Length of Stay' (LOS) should probably not be operated on Friday, as the bed capacity is decreased during the weekend; explaining also why surgery types with a LOS of 3 to 4 days should probably be operated on Monday of Tuesday. An MSS can include the OR-ward characteristic and help level bed utilization. The MSS can not only provide in a better use of beds, it can also help to improve the utilization of OR time. If surgeries with the same standard deviation are scheduled in the same OR the expected deviation from planned durations is lower (risk pooling).

Orthopedics has already started using an MSS, other specialties can benefit from this as well. Further research is required. Each specialty's demand needs to be analyzed and a certain basic demand per category is required for an MSS to work. Another possibility may be to not determine the MSS as a cyclic schedule, but to compose a number of blocks that include certain surgery types which can be included in planning on certain days depending on demand, which take into account specialist availability, LOS characteristics, and standard deviation (the risk pooling effect).

An MSS is in principle a carve-out model. This may, or may not, depending on demand characteristics, apply to the OC as well. Already in some specialties there are implemented care pathways with dedicated OC capacity. This may be possible for any patient category which is known in advance and has a quite stable (high) demand per week. Including a basic number of slots per week it becomes easier to control performance for that category of patients. Carve-out may be an option for acute patients as well, depending on the characteristics, as was addressed in Section 4.3. Demand needs to be analyzed.

In our tactical planning concept we only included the planned durations. Considering the possibility of overtime and outpatient waiting time the variability of consult and surgery durations needs to be taken into account. Sequencing is an area of research that becomes of relevance here. By applying sequencing rules (e.g. longest processing time, shortest processing time, longest waiting time, earliest start time, latest start time) the expected overtime and/or outpatient waiting time can be minimized. Apparently for the OC the consults with higher variability (usually new patient consults) should be scheduled at the end of a session. This concept should be further investigated and may differ per specialty. Other appointment system characteristics of interest may be: scheduling in batches of patients and overbooking for no-shows.

In our concept demand is forecasted in a deterministic manner; consults and surgeries is planning are translated into a certain expected demand pattern (but which may differ between patient categories). Further research on demand forecasting from current planning, may use computer simulation to include the stochastic nature of the patient processes.

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Appendices

Appendix A: Organizational structure of MST

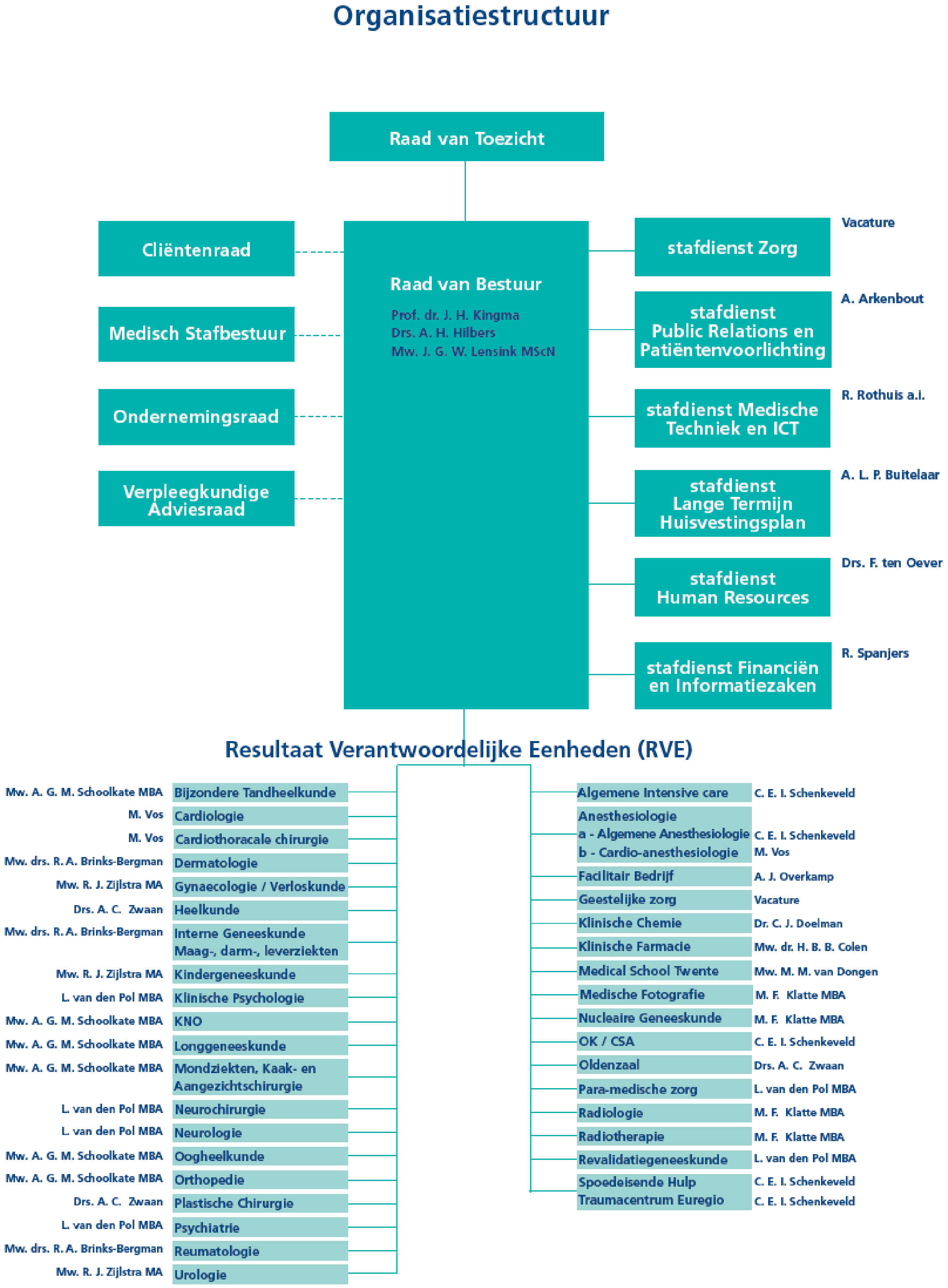

Figure 26: Organizational structure of MST, including business managers (Medisch Spectrum Twente, 2011 [4])

Appendix B: Literature research method

The ORchestra Bibliography was retrieved from http://www.utwente.nl/choir/orchestra/ on February 3rd 2011. The bibliography includes literature concerning Operations Research/ Management Science in health care (CHOIR, 2011). We used the medical categorization to select possibly relevant articles. In a first selection we included the following subjects:

- Admission planning
- Appointments and schedules
- Critical pathways
- Decision making, organizational
- Delivery of health care, integrated
- Diagnosis-related groups
- Education on modeling techniques
- Equitable resource allocation
- Health facility size
- Health services accessibility
- Hospital planning
- Information management
- Models, organizational
- NA
- Operating rooms
- Outpatient clinics
- Total quality management
- Waiting lists

Based on their titles, articles were divided into three categories: ‘interesting’ (primarily or for background information), ‘possibly interesting’ (when further focus in research was determined), and ‘not interesting’. Articles including more than one of the relevant subjects had a higher inclusion probability. No strict criterion for the year of publication was used to enable a broad view on hospital planning literature, but older articles (from before the year 2000) were more critically assessed on their relevance based on their included subjects and title.

The resulting articles, ‘interesting’ and ‘possibly interesting’, were retrieved from scientific web databases or author websites. A start was made reading articles from the ‘interesting’ list. A snowball method, finding new articles through references, was used to widen our literature base with articles outside the ORchestra bibliography. Especially a literature review article for the OR (Cardoen, Demeulemeester, & Beliën, (2010) was very useful in this approach. Cayirli & Veral (2003) review literature on appointment scheduling for the outpatient clinic, but it mainly provided in operational level literature. Elkhuizen, Das, Bakker, & Hontelez (2007) provided in additional insight in outpatient clinic literature. Also references from Hulshof, Boucherie, Hans, & Hurink (Working Paper) were researched. Through this process also articles were found that were already included through the first bibliography search, which sometimes had only seemed “possibly interesting” based on their title.

We shortly summarized the read articles (as to enable quick recall on what the article was about) and we made a structured overview of the discussed planning methods, including the following characteristics:

- Hospital department (OC, OR, IC, ward, etc.)
- Out- vs. Inpatient, acute vs. elective
- Organizational level
- Specialty
- Patient categorization based on…
- Model type
    - .. including (specific characteristics, parameters, and/or performance measurements)
- Planning period

Furthermore, to summarize the applicability to our research (and report), the articles were included in a table to overview the attendance to areas of interest:

- Outpatient clinics
- Operating rooms
- Integrated planning:
    - Outpatient clinics/operating rooms
    - Operating rooms/wards
    - Outpatient clinics/diagnostics

Appendix C: Logistic indicators

Demand

The following indicators are related to the demand side of planning:

- Expected volume
  - Elective or acute?
  - Production agreements
  - New patient consults
  - Follow-up consults and follow-up factor
  - Surgery indications
  - No shows
  - Variance in volume requirements (per period)
- Consult and surgery duration

Expected volume

Elective or acute?

Capacity is required for both elective (patients that can be scheduled in advance) and acute patients (patients that need to be seen (almost) immediately). Acute and urgent patients for the outpatient clinic usually go through the ER. For acute patients that require surgery, a subdivision is made in their urgency:

- Acute – within a couple of hours max. (NFU, 2010)
- Urgent – within 24 hours (NFU, 2010)
- Semi-acute or semi-elective – within a week.

Patients can be categorized for planning purposes. Not all expected patients may require capacity in the outpatient clinic and non-elective patients in the OR interfere with planning and may increase variability.

Production agreements

A starting point in determining the expected required capacity are the agreements with the health care insurers. For the outpatient clinic these consist of the EPBs: the financial first outpatient consults. The EPBs can be split into the A and B segment. For the A-segment of the DBCs a clear number of EPBs (first outpatient consults) is agreed upon. For the B-segment also a number has been decided upon, but this is more for internal purposes. For the OR the agreements consist of numbers on admissions, ward-days, and day admissions (light/heavy).

New patient consults

The expected number of new patients can differ from the expected number of EPBs. After a year, a consult is considered as an EPB, while it may be scheduled as a follow-up consult. Also a patient may be scheduled for a new patient consult, for a new complaint, which within a year is not registered as an EPB. As different consult durations are used in planning, the new patient consults may need to be taken into account (logistic instead of financial approach). The difference in capacity requirement can be evaluated using the following factor:

$$new\ patient\ factor = \frac{\#\ of\ new\ patient\ consults}{\#\ of\ EPBs}$$

Also, it could be useful to evaluate the number of new patient consults that is a real EPB and the number of EPBs registered that is a follow-up consult in the patient process.

Follow-up consults and follow-up factor

After a new patient consult patients may require follow-up consults after treatment, possibly also before treatment, or after further diagnostic tests. For each EPB or new patient consult the follow-up factor can be determined:

$$financial\ \ follow-up\,factor = \frac{\#\,of\ fin.follow-up\ consults}{\#\,of\ EPBs}$$

$$logistic\ \ follow-up\,factor = \frac{\#\,of\ log.follow-up\ consults}{\#\,of\ new\ patient\ consults}$$

The financial follow-up factor is used as a performance indicator of the (medical) patient process. As we consider the logistic side of planning (resource capacity planning not medical planning) this factor is not included as a performance indicator, but only as a process characteristic for planning purposes. The logistic follow-up factor determines the ratio of follow-up and new patient consults in planning. The follow-up factors can be calculated for each DBC type, patient category, or specialist separately, to provide more insight and possibly more specific planning.

Follow-up consults in the outpatient clinic may also result from patients that were seen in the ER.

Surgery indications

For the OR the same holds as for the consults in the outpatient clinic: The real numbers can of course differ from the numbers in the agreements. A first step in determination of the required OR capacity is knowledge of the expected number of patients requiring surgery. This number can be determined per diagnosis type or patient category.

No shows

No shows are the patients that do not turn up for their scheduled consult (also: DNA rates (did not attend) (Bowers, Lyons, Mould, & Symonds, 2005)). This can be without notification, or at too late a time which also means the reserved slot could not be filled. No shows put pressure on planning as they typically require capacity twice, once in the initial planning and then a second time for the replacement consult. Also they lower the utilization of capacity and increase variability in workload.

Variance in volume requirements (per period)

The demanded volume might not be the same for each period (e.g. per week or month) that can be defined. The average demand for first outpatient consults might be lower during holiday seasons as less people visit their GP during this time. Insight in this variance is important in the determination of the required OC and OR capacity. It may be useful to determine periods of low, intermediate, and high demand (depending on the variation between periods). These period characteristics may differ per specialty and diagnosis type or patient category.

Consult and surgery duration

The duration of the consults is needed to determine the required capacity based on the expected volumes. Planned consult duration differs for new patient and follow-up consults, but also between specialists and possibly between DBCs. The same holds for surgeries in the OR.

Supply

The following indicators are related to the supply side of planning:

- Available time
    - For outpatient clinic hours (per period)
    - For surgery (per period)
    - Of the specialist
        - Other activities during the week (study hours, administration time)
- Variance in availability
    - Holidays
    - Absence through illness

Available time

For outpatient clinic hours

The available time in the outpatient clinic is usually determined by the number of rooms available, but possibly depends on the availability of secretaries.

For surgery

The OR department decides on the allocation of OR time to specialties. OR time is distributed in OR blocks of 8 hours. Within one specialty the blocks can be allocated among the specialists. The total OR capacity is limited by the availability of OR personnel.

Of the specialist

The specialists of the outpatient clinic are a critical resource in planning. If they are not available patients cannot come for a consult or surgery. In terms of operations management the specialists can be seen as the servers, with weekly "down time due to planned maintenance" (study hours, administration time, meetings), "unplanned down time" (absence through illness), and "predefined periods of low production" (holidays).

Other activities during the week (study hours, administration time)

Apart from the time spent in the outpatient clinic or in the OR, the specialists have planned study hours, administration time, ward rounds, and meetings during the week. Study hours and meetings give absolute time requirements, while the administration time may be proportional to the time spent in the OC, OR, and ward. These other activities during the week limit the left over (specialist) capacity to schedule the OC and OR hours.

Variance in availability

Holidays

The holidays (predefined periods of low production) need to be considered in planning beforehand. As less capacity is available during these periods (both specialist and OR capacity), relatively more capacity may be required during other periods. Holidays may also play a role in the periodic planning for realization (see Appendix F - Realization). Possibly also for supply, periods of low, intermediate, or high production can be discerned.

Absence through illness

For the determination of the required number of FTE, or the total available capacity for planning (for OC and OR), the absence through illness (unplanned down time) may need to be taken into account.

Absence through illness is usually considered on the operational planning level, with a temporary capacity reduction, but could be included in tactical planning for prolonged illness. Also illness in a previous period may require a capacity increase in the following (tactical) planning period.

Appendix D: Modeling the patient process

Figure 27 shows the patient process. The indicators that are required to model the patient process are included in this figure:

- % of patients requiring a certain step in the process (surgery, further diagnostics, follow-up consult)
- Time between process steps

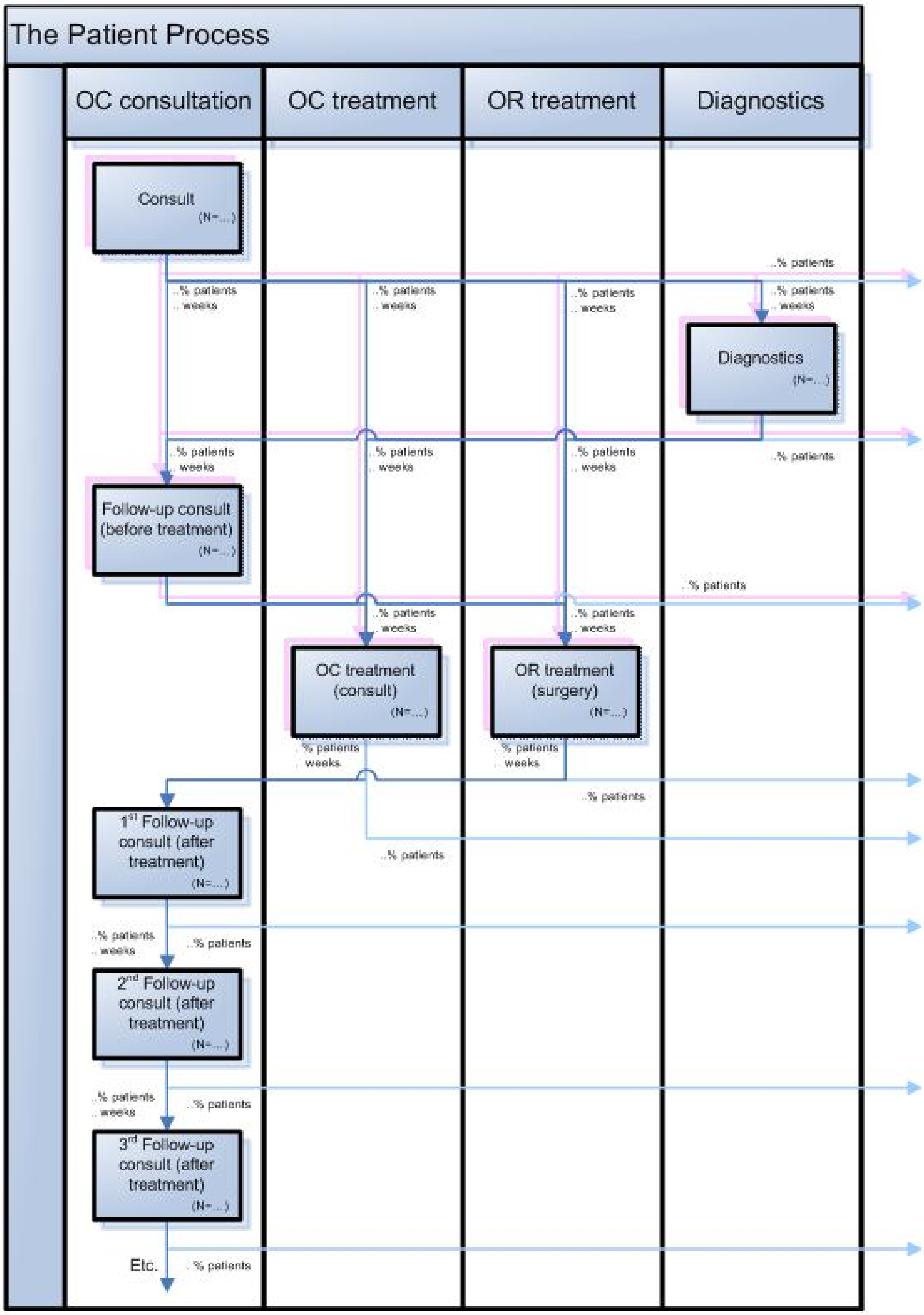

Figure 27: **Flowchart of the patient process, including transition probabilities and times (ER process in pink)**

Time between process steps

For planning and forecasting purposes the expected time between process steps should be made insightful. If this time is known it could for instance be possible to say something now, in week t=0, about the expected demand in week t=6. The time between these steps can be calculated from data obtained from the executed processes. Minimum and maximum values may be in place, known by the specialists. As the results obtained from data depend on the availability of resources (OC, diagnostics, OR), a combination with desired times may be required for forecasting. The times can be calculated per patient and combined per DBC-code or patient category.

Possible time measurements are for instance:

- Time required for further diagnostics (between consults)
- Time from 1st consult to OR
- Time from 1st follow-up consult to OR
- Time from 1st consult to treatment at the outpatient clinic
- Time from 1st follow-up consult to treatment at the outpatient clinic
- Time from 1st consult to 1st follow-up consult
- Time from 1st follow-up to 2nd follow-up consult

These times are closely related to the access and waiting time indicators discussed in Section 2.3.2.

% of patients requiring a certain step in the process

To be able to say something about the demand now, in week t=0, about the expected demand in for instance week t=6, you do not only require the time between the steps in the process, but also the number of patients requiring capacity for these steps. This can be expressed in percentages of the total number of patients, or for instance the total number of patients for a certain diagnosis or patient category. Percentages can be used to calculate the expected requirements following a number of patients in planning, the numbers can be used for determination of required capacity.

Possible calculations are:

- % of patients requiring a certain step in the process (surgery, further diagnostics, follow-up consult) further diagnostics
- % of patients for a 1st follow-up consult before OR
- % of patients requiring surgery at the OR
- % of patients requiring treatment at the outpatient clinic
- % of patients for a 1st follow-up consult after OR
- % of patients for a 2nd follow-up consult
- % of patients for a 3rd follow-up consult

These percentages correspond to the times mentioned before and can be related to the different steps in the basic patient process as given in Figure 2 and Figure 27.

Appendix E: Performance indicators

Performance indicators to measure the performance of (tactical) planning of outpatient clinics and operating rooms:

- Occupancy and utilization rates (management)
  - Experienced workload (employees)
- Work in progress (management, patients, and employees)
- Cancellation rate (patients)
- Overtime (management and employees)
- Outpatient waiting time (patients)

Occupancy and utilization rates

The occupancy rate is an indicator of efficient use of a certain resource and can be calculated for different periods of time. It can for instance be calculated for the use of the available room capacity:

$$Occupancy\ rate_{room} = \frac{\#\ of\ minutes\ \ planned\ outpatient\ clinic\ hours}{\#\ of\ minutes\ \ available\ per\ room\ *\ \#\ of\ rooms}$$

Or for the use of a specialist's time (for outpatient clinic plus OR):

$$Occupancy\ rate_{specialist} = \frac{\#\ of\ minutes\ \ planned\ for\ outpatient\ clinic\ hours\ and\ OR\ blocks}{\#\ of\ \ minutes\ available\ in\ the\ specialist's\ schedule}$$

But also, possibly more insightful for the use of the available OC and OR capacity:

$$Utilization\ rate_{OC} = \frac{\#\ of\ minutes\ scheduled\ consults}{\#\ of\ minutes\ \ planned\ outpatient\ clinic\ hours}$$

$$Utilization\ rate_{OR} = \frac{\#\ of\ minutes\ scheduled\ surgeries}{\#\ of\ minutes\ available\ \ in\ OR\ block\ time}$$

The higher the utilization rate, the higher the access times are expected to be. A queue/waiting list of patients that wait until access to a consult or surgery can be used as a buffer to more efficiently fill available capacity. These two indicators are in trade-off.

For the utilization rate the choice can be made to include the planned slack, breaks, and/or change over time. This would include the entire scheduled capacity requirement for the planned consults or surgeries, as opposed to only their planned duration:

$$Gross\ utilization\ rate_{OC} = \frac{\#\ of\ minutes\ for\ scheduled\ consults\ incl.planned\ breaks\ between\ consults}{\#\ of\ minutes\ \ planned\ outpatient\ clinic\ hours}$$

$$Gross\ utilization\ rate_{OR} = \frac{\#\ of\ minutes\ scheduled\ surgeries\ incl.planned\ slack\ and\ change\ over\ time}{\#\ of\ minutes\ available\ \ in\ OR\ block\ time}$$

Utilization can also be measured with Net utilization rates, which include not the planned durations, but the actual consult and surgery times. These indicators, compared to the Gross rates, can give an idea of the variance and accuracy of the planned durations.

Experienced workload

A high occupancy and/or utilization rate, or at least high at times, contributes to a higher experienced workload for the specialist. Also a high utilization rate in the outpatient clinic contributes to a higher experienced workload for secretaries. A high workload decreases the employee satisfaction and could affect the absence through illness. Differences in utilization over days of the week, or outpatient clinic blocks, indicate workload differences. A leveled workload is usually experienced as positive.

Work in progress

The work in progress (WIP, also: work in process) in hospital functions can be defined as the number of patients that have entered a certain patient process, but haven't finished it yet. This is documented as the opening and closing of DBCs, which can be used as the WIP per specialty, DBC type, and/or patient category. The WIP for the outpatient clinic is the number of patients that is scheduled for a future consult, or is possibly waiting to be scheduled. For the OR the WIP consists of the waiting lists of patients waiting for surgery.

The WIP is closely connected to the cycle time, stated by Little's Law: In a steady-state queuing process, L = λW (Little, 1961). Table 26 gives the definitions of the variables, which can be translated to the following formula: $WIP = TH * CT$. The expected number of units in the system (WIP) depends on the throughput and the cycle time. This means that if an increase in the WIP is detected, for instance caused by an increase in demand, the cycle time will increase as well. When there is an increase in patient demand, the throughput (defined by specialist, OC, and/or OR capacity) should be increased to achieve the same throughput time (= cycle time) for patients.

Little's Law variables		Corresponding indicators	
$\boldsymbol{L}$	Expected number of units in the system	$\boldsymbol{WIP}$	Work in progress/process
$\boldsymbol{1/\lambda}$	Expected time between two consecutive arrivals to the system	$\boldsymbol{TH}$	Throughput/arrival rate - Speed of production
$\boldsymbol{W}$	Expected time spent by a unit in the system	$\boldsymbol{CT}$	Cycle time

Table 26: Little's law variables (Little, 1961) and corresponding indicators (Maiorana & Iuliano, 1997)

Cancellation rate

Scheduled consults or surgeries may be cancelled by the hospital, on short term due to a specialist's illness or acute cases and on longer term due to capacity reallocations (changes in OC or OR rosters or availability of the specialist).

The cancellation rate of consults, over a certain time period, can be calculated as follows:

$$(hospital)\ cancellation\ rate_{OC} = \frac{\#\ of\ cancelled\ consults}{total\ number\ of\ consults}$$

The cancellation rate can be calculated for a certain time period as well, for instance the cancellations made within a number of weeks in advance. It is also possible that not all cancelled consults will have to be rescheduled, as patients may divert to another hospital for care:

$$rescheduling\ rate_{OC} = \frac{\#\ of\ rescheduled\ consults}{\#\ of\ cancelled\ consults}$$

Including a service level for rescheduling, it is possible to include the time diversion from the original date:

$$rescheduling\ service\ rate_{OC} = \frac{\#\ of\ rescheduled\ consults\ within\ ..weeks\ of\ original\ date}{\#\ of\ cancelled\ consults}$$

The service rate could also be evaluated using an (absolute) average number of days or weeks for rescheduling.

For the OR the same formulas apply, replacing consults by surgeries. For the OR this performance indicator can be evaluated per specialty and specialist.

Overtime

Overtime is the time the specialists, secretaries, or OR personnel work outside of the predetermined (or standard) working hours. This could be caused by over booking, or differences in planned and executed consult or surgery duration. Overtime may also result from late starts by specialists and could differ between specialists, days, and periods of the year.

The overtime can be divided in logistic overtime, where overtime occurs any time the planned hours are exceeded, and overtime for financial purposes (in which overtime has additional costs):

$$overtime_{OC} = end\ of\ last\ consult\ - end\ of\ planned\ OC\ block\ (or\ last\ planned\ consult)$$

$$overtime_{OR} = end\ of\ last\ surgery\ - end\ of\ last\ planned\ surgery$$

$$financial\ overtime_{OC} = end\ of\ last\ consult\ (time) - end\ of\ OC\ working\ hours$$

$$financial\ overtime_{OR} = end\ of\ last\ surgery\ (time) - end\ of\ OR\ working\ hours$$

Time allocated to consults or surgeries in the weekend, may also be included for overtime calculation. Depending on the acute strategy, acute cases can be in or excluded from overtime calculations.

Outpatient waiting time

The waiting time in the outpatient clinic is the time a patient has to wait in the waiting room before a consult. This could be a result from overbooking, variation in consult duration, or from badly determined standard consult times. Waiting times may also result from late starts by specialists and could differ between specialists, days, and periods of the year.

The waiting time can be calculated for the delay in the starting time of the consult, or the total waiting time after arrival of the patient:

$$outpatient\ waiting\ time = starting\ time\ of\ consult - scheduled\ starting\ time\ of\ consult$$

$$total\ outpatient\ waiting\ time = starting\ time\ of\ consult - arrival\ time\ of\ the\ patient$$

Also a true waiting time can be calculated (Cayirli & Veral, 2003):

$$true\ outpatient\ waiting\ time =$$
$$starting\ time\ of\ consult - max\ (arrival\ time\ of\ the\ patient; scheduled\ starting\ time\ of\ consult)$$

Appendix F: Key performance indicators

Key indicators related to the performance of tactical planning:

- Realization (management)
- Access, waiting, and throughput times (management and customers)
    - Service level

Realization

The realization of production targets can be expressed as an absolute number or as a realization rate. Measurement of the realization rate determines if and which part of the production numbers is met. This can be done for different time intervals, for instance per month, quartile, or year. For strategic management (the board of directors of MST) the realization for the total year is most important, as this corresponds to the production agreements with insurers. The rate can also be updated and compared to set (tactical) targets in planning on a shorter horizon, for instance each week or month, to enable changes to be made in the planning as a reaction to the current realization.

Realization for the outpatient clinic is measured in consults. For the A-segment the realization can be calculated based on the number of EPBs. For the B-segment this can be approximated by the calculation of the number of EPBs, as the actual goal is defined in turnover.

$$realization\ rate_{OC} = \frac{\#\ executed\ EPBs}{\#\ of EPBs\ in\ agreement}$$

The realization for operating rooms is connected to the admissions/wards and differently presented for A and B segment. The number of admissions to the hospital, day admissions or longer including ward-days, are part of the production agreements (Nederlandse Zorgautoriteit, 2010 [1]). For each specialty there are target numbers, which can be split among DBC types or patient categories.

$$realization\ rate_{OR-admissions} = \frac{\#\ admissions}{\#\ of\ admissions\ in\ agreement}$$

$$realization\ rate_{OR-ward\ days} = \frac{\#\ ward\ days}{\#\ of\ ward\ days\ in\ agreement}$$

$$realization\ rate_{OR-day\ admission\ (light)} = \frac{\#\ day\ admissions\ (light)}{\#\ of\ day\ admissions\ (light)\ in\ agreement}$$

$$realization\ rate_{OR-day\ admission\ (heavy)} = \frac{\#\ day\ admissions\ (heavy)}{\#\ of\ day\ admissions\ (heavy)\ in\ agreement}$$

Access, waiting, and throughput time

The access time is an indicator for the outpatient clinic and is defined as the time from contact with the outpatient clinic to the scheduled consult. For the operating rooms there is a similar indicator, defined as the waiting time, which is the time from an OR indication (diagnosis) to the actual surgery. This time can be between the surgery in the OR and either the first outpatient consult, a follow-up consult, or possibly further diagnostics. The (hospital) throughput time (also: cycle time, Appendix E – Work in progress) can be defined as the time from the request date until the last contact within the process (at which point the DBC is closed), but could also be measured until the surgery, or from the first consult. Figure 2 on page 15 gives a simple representation of the typical patient process, including these time indicators.

$$access\ time = request\ date - consult\ date$$

$$waiting\ time = OR\ indication\ (diagnosis)\ date - surgery\ date$$

$$\begin{aligned} &throughput\ time \\ &\quad = request\ date\ (or\ first\ consult\ date) \\ &\quad - last\ process\ step\ \ date\ (or\ surgery\ date) \end{aligned}$$

For these times (acceptable) maximum values can be determined. Norms exist that define the maximum values, the "treeknorm":

- Access time to outpatient clinic: maximum of 4 weeks.
- Waiting time to diagnostics/indication: maximum of 4 weeks.
- Waiting time to day-surgical (outpatient) treatment: maximum of 6 weeks.
- Waiting time to surgical (inpatient) treatment: maximum of 7 weeks (RIVM, 2011).

For some DBCs there are also predetermined maximums on access time and waiting times, due to a Menzis "top care" indication.

Service-level

The service level can for instance be defined as: the percentage of patients that can be scheduled within .. weeks. The previously mentioned "treeknorm" used to include this kind of performance measurement, where 80% should lie within 3, 3, 3, and 5 weeks respectively (treeknorm.nl, 2010). In theory it is possible that for instance 85% of patients can be scheduled within two weeks from contact, but a few patients need to wait an unacceptable amount of weeks for their consult. The service level could be used as a key performance indicator, but not without evaluating access and waiting times as these give more specific information on how to improve current performance of planning.

The service level can be measured separately for first consults and follow-up consults in the outpatient clinic and per patient category in the OR, over a certain period of time.

$$service\ level_{OC-first\ consult} = \frac{\#\ first\ consults\ scheduled\ within\ ..weeks}{\#\ of\ first\ consults\ scheduled}$$

$$service\ level_{OC-follow-up\ consult} = \frac{\#\ follow-up\ consults\ scheduled\ within\ ..weeks}{\#\ of\ follow-up\ consults\ scheduled}$$

$$service\ level_{OR,\ \ type\ i} = \frac{\#\ surgeries\ of\ type\ i\ scheduled\ within\ ..weeks}{\#\ of\ surgeries\ of\ type\ i\ scheduled}$$

Appendix G: Access and waiting times for MST

Specialty	Access time				Treatment	Waiting time	
	Ens	Old	Los	Haa		Ensch.	Oldenzaal
Anesthesiology	6	-	-	-	**Pain management**	5	-
Cardiology	1	1	-	1	**Ablation**	6-8	-
					Ablation (narcosis)	14-16	-
					Dottering	4-5	-
					ICD implantation	2	-
					Cardiac catheterization	4	-
					Pace maker implantation	3	-
Dermatology	6	6	-	4			
ENT	1	3	3	-	**Adenoids and/ or tonsils**	1	-
					Septum	4	4
					Ear tubes	1	2
Exceptional dentistry							
Anxious and disabled pat.	-	22	-	-	**Anxious and disabled pat.**	-	11
Maxillo facial prosthetics	8	-	-	-	**Maxillo facial prosthetics**	1-2	-
Gastroenterology and Hepatology	7	7	-	-			
General surgery	2	2	1	1	**Carpal tunnel syndrome**	2-3	2-3
Vascular surgery	2	2	-	-	**Gall bladder**	4	4
Gastroenterology	1-2	2	-	-	**Gall bladder (endoscopic)**	4-5	4-5
Breast clinic	-	1	-	-	**Groin hernia**	3-4	3-4
Oncology	1-2	2	-	-	**Varicose veins**	<6	<6
					Sterilization (man)	<2	<2
Gynecology	1	2	2	4	**Hysterectomy**	5-12	-
Oncology	1	-	-	-	**Incontinence (woman)**	8	-
Infertility	6	-	-	-	**Sterilization (woman)**	1	-
Incontinence	8	-	-	-			
Internal medicine	4	8	14	10			
Endocrinology	6	6	-	-			
Nephrology	4	-	-	-			
Infectious diseases	6	-	-	-			
Diabetes	6	6	-	-			
Oncology	3	3	-	-			
Neurology	9	7	5	10			
TIA OC	<1	-	-	-			
Emergency OC	<1	-	-	-			
Hernia OC	<1	-	-	-			
Oncology OC	<2	-	-	-			
Pediatric-neurology OC	<2	-	-	-			
Neurosurgery	5	-	-	-	**Carpal tunnel syndrome**	1	-
					Hernia	5	-
Ophthalmology	9	9	-	9	**Cataract surgery**	-	2
Cataract surgery	2	2	-	2			
Oral surgery	3	-	-	-			
Orthopedics	6	6	6	4	**Carpal tunnel syndrome**	6	?
Total hip surgery	2	2	2	2	**Knee arthroscopy**	5	5
Knee arthroscopy	2	2	2	2	**Total hip surgery**	6	-
Total knee surgery	2	2	2	2	**Total knee surgery**	6	-
Pediatrics	0	0	0	0			

Plastic surgery emerg.	<1	<1	-	-	**Breast enlargement**	-	-
Breast reduction	3	3	-	-	**Breast reduction**	6	6
Abdominoplasty	3	3	-	-	**Abdominoplasty**	6	6
Dupuytren (outp. OR)	3	3	-	-	**Dupuytren (outp. OR)**	-	2
Dupuytren (OR)	3	3	-	-	**Dupuytren (OR)**	6	6
Carpal tunnel syndr.	2	2	-	-	**Carpal tunnel syndrome**	-	2
Psychiatry	4	4	-	4	**Adult treatment**	3	3
Pulmonary disease	0	0	0	0			
Radiotherapy	1	-	-	-			
Rehabilitation	7	5	-	-			
Rheumatology	<1	5	-	1			
Thoracic surgery	0	-	-	-	**Open heart surgery**	1	-
Urology	1	5	-	3	**Prostate (- carcinoma)**	6	-
Oncology	<1	<1	-	<1	**Sterilization (man)**	6	6
Haematuria	<1	<1	-	<1			

***Table 27*: Access times to the outpatient clinics (Medisch Spectrum Twente, 2011 [6]) and waiting times to treatment (Medisch Spectrum Twente, 2011 [5]) of MST, in weeks (retrieved August 18th 2011)**

Appendix H: Performance indicators in outpatient clinic literature

Performance indicators	Sources
Queuing	
- # waiting	[1], [7], [8], [9], [19]
- Access time/delay	[1], [5], [7], [8], [13], [14], [15], [19], [21], [22]
- # in waiting room	[4], [5], [6], [12], [20]
- Patient waiting time	[1], [2], [4], [5], [11], [12], [16], [18], [20], [21]
Throughput	
- # of patients served	[2], [12], [13], [16], [17]
- Patient flow time	[2], [6], [11], [12]
- Staff productivity	[2]
Utilization	
- Utilization rate (%)	[2], [3], [5], [6], [8], [12], [16], [17], [19], [20], [22]
- Busy or idle time	[1], [4], [11], [12], [18], [20]
- # vacant slots	[21]
Overtime	
- # consults in overtime	[5], [16]
- Doctor/staff overtime	[16], [21]
- Session ending time/length	[11], [18]
Other	
- Probability of same day appointment	[9]
- Profit (net reward/patient revenue)	[13], [16]
- Appointment availability	[15]

Table 28: Summary of performance indicators from outpatient clinic literature

[1] (Bailey, 1954), [2] (Benninger & Strode, 1998), [3] (Bowers, Lyons, Mould, & Symonds, 2005), [4] (Brahimi & Worthington, 1991), [5] (Cardoen & Demeulemeester, 2008), [6] (Côté, 1999), [7] (Creemers & Lambrecht, 2009), [8] (Elkhuizen, Das, Bakker, & Hontelez, 2007), [9] (Green & Savin, 2008), [10] (Gupta & Denton, 2008), [11] (Hashimoto & Bell, 1996), [12] (Huarng & Lee, 1996), [13] (Liu, Ziya, & Kulkarni, 2010), [14] (Murray, 2000), [15] (Murray & Berwick, 2003), [16] (Muthuraman & Lawley, 2008), [17](Qu, Rardin, Williams, & Willis, 2007), [18] (Rohleder & Klassen, 2000), [19] (Silvester, Lendon, Bevan, Steyn, & Walley, 2004), [20] (Taylor III & Keown, 1980), [21] (Vanden Bosch & Dietz, 2000), [22] (Vermeulen, Bohte, Elkhuizen, Lameris, Bakker, & La Poutré, 2009)