The excuse me dance of physical therapy in a hospital situation

Optimization of the occupancy of the physical therapy department

Yke van Dijk

June 2010

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Master thesis of: Y. A. van Dijk
University: University of Twente in Enschede
Supervisor: E.W. Hans and L.L.M. van der Wegen
Organization: Hospital
Supervisor: R. de Wit

Management Summary

Problem description

This thesis concerns the physical therapy department. A major issue in this department is the occupancy of the examination rooms. The hospital is short in the number of square meters and having a department with a low occupancy of their rooms might be a chance for the hospital board to find some spaces for other specialties. The actual occupancy of the examination rooms is low, but the therapists experience during some parts of the day an occupancy that is too high.

Research objective

The research question that is central in this thesis is:
"How can the productivity of the physical therapy department be increased?"

Before getting to an answer of the research question the most important problem areas of the physical therapy department need to be addressed. The first problem is the presence of therapists, on some days during the week a lot of therapists are present and on other days there not enough therapists are present. So the therapists are not evenly spread during the week. The second problem is the occupancy of the examination rooms, which is too low (33.7%). Third, patients are rejected because there is no room available to treat them in.

Approach

Solving these problems will ideally improve the productivity of the physical therapy department. There are a number of ways to solve these problems. They can be solved at an operational level, and at a tactical level.

On the operational management level, the introduction of a new planning method will lead to an improvement in the efficiency of the department. The main part of the new planning method is done by the receptionists instead of by the therapists themselves. The receptionist will not only take the agenda of the therapists into account, but also the occupancy of the examination rooms. This way the examination rooms can be planned optimally and the number of examination rooms can be reduced. On the other hand double planning of the examination rooms will no longer be an issue, this results in fewer rejected patients and the patients can receive treatment in the most suitable situation.

Aside from the change in planning of the patients, another contribution of the new planning method is a more even distribution of the therapists during the week. Consequently, there are enough therapists to treat all clinical patients on Friday afternoon. Moreover, the problem on Monday morning, when there are so many therapists, there is almost no room to treat the patients, is solved.

On the tactical management level, a change in the number of examination rooms can solve the problem of the occupancy of the examination rooms. In order to calculate the number of examination rooms needed to perform the treatments a simulation model is presented. The interventions in the simulation model concern the number of patients, the number of therapists and the number of examination rooms. The effects of the interventions can be calculated without disturbing the actual process at the department.

Results

Based on the simulation study, an increase of 65% (to 3565 patients) of the number of patients is needed to reach an occupancy of 57% of the examination rooms. To be able to treat all these patients, a total of 33 FTE are necessary.

According to the simulation study and based on the current number of patients (2161) and therapists (24.5 FTE) the number of examination rooms can be reduced from nine to five, resulting in an overall occupancy of the rooms of 49%. However, with the use of a better planning method a higher

occupancy can even be obtained. The five examination rooms need to be used more flexibly; there should be two pelvis rooms and three multi-functional rooms (where all patients can receive treatment except pelvis patients).

However, an increase of 65% is not likely to be obtained. An increase of 15% (to 2493 patients), will be more likely when the extra effort is made to recruit more patients. According to the simulation study, the number of examination rooms can be decreased by three and achieve an occupancy of 57%. The number of therapists needed is 26 FTE.

Implementation

For these kinds of changes the therapists need to understand the need for the change and the implications it has for them. Also an effort should be made to avoid the resistance against the change to make sure the implementation will be successful.

Conclusion and recommendation

The department should decrease the number of examination rooms by three to six rooms. This way there is growth is still possible. One recommendation is to start implementing the new planning method as soon as possible, with keeping in mind the resistance it brings along, and how to solve it. Another recommendation is to start the register the waiting time of the patient.

Samenvatting

Probleem beschrijving
De Fysiotherapie afdeling staat centraal in deze scriptie. Een belangrijk probleem op de afdeling is de bezetting van de verschillende behandelkamers. Het ziekenhuis heeft een tekort aan vierkante meters, dus een afdeling waar de bezetting van de kamers laag is, is een kans voor het ziekenhuis om ruimte te vinden voor andere specialismen. De werkelijke bezetting van de behandelkamers is laag, maar het gevoel is dat op bepaalde delen van de dag er te weinig behandelkamers zijn.

Onderzoeksdoel
De centrale onderzoeksvraag is:
"Hoe kan de productiviteit van de Fysiotherapie afdeling verhoogd worden?

Voordat er een antwoord gegeven kan worden op de centrale onderzoeksvraag, moeten de belangrijkste probleemgebieden van de fysiotherapie afdeling besproken worden. Het eerste probleem gaat over de aanwezigheid van de therapeuten, de aanwezigheid van de therapeuten is niet gelijk verspreid over de week. Op sommige dagen tijdens de week zijn er veel therapeuten aanwezig en op andere dagen niet genoeg. Het tweede probleem gaat over de bezetting van de behandelkamers, die erg laag is (33,7%). En ten derde worden er patiënten naar huis gestuurd die niet behandeld kunnen worden omdat er geen kamer vrij is.

Aanpak
Als deze problemen opgelost worden zal de productiviteit van het afdeling omhoog gaan. Er zijn twee manieren waarop deze problemen aangepakt kunnen worden. Ten eerste kan er iets gedaan worden op operationeel niveau en ten tweede op tactisch niveau.

Op operationeel niveau zal de introductie van een nieuwe planningsmethode een grote verbetering van de efficiëntie van de afdeling met zich meebrengen. Het belangrijkste deel van de nieuwe planningsmethode is dat de patiënten door de receptionisten worden gepland in plaats van door de therapeuten zelf. De receptionist zal niet alleen rekening houden met de beschikbaarheid van de therapeuten, maar ook met de beschikbaarheid van de behandelkamers. Op deze manier kunnen de behandelkamers optimaal gepland worden en kan het aantal behandelkamers gereduceerd worden. Een ander voordeel is dat er geen dubbele boeking van de behandelkamer meer plaats vindt, dit betekent dat er minder patiënten naar huis worden gestuurd omdat ze niet behandeld kunnen worden. Bovendien, de patiënten krijgen hun behandeling in de voor hun meest geschikte ruimte.

Naast de verandering van de planning van patiënten is de meer gelijke verdeling van de therapeuten over de week een belangrijk onderdeel. Op deze manier komt het niet meer voor dat er niet genoeg therapeuten zijn om de klinische patiënten op vrijdagmiddag te behandelen en dat er op maandagochtend niet zoveel therapeuten zijn dat er bijna geen ruimte meer is om patiënten te behandelen.

Op tactisch niveau kan een verandering in het aantal behandelkamers een oplossing zijn voor de bezetting van de behandelkamer. Om het aantal behandelkamers dat nodig is om de behandelingen uit te voeren te berekenen, met de huidige bemensing en aantal behandelingen, is een simulatiemodel gemaakt. De interventies in het simulatiemodel zijn het aantal patiënten, het aantal therapeuten en het aantal behandelkamers. De effecten van deze interventies kunnen bekeken worden zonder dat het werkelijk invloed heeft op de patiënten en de manier van werken.

Resultaten
Gebaseerd op deze simulatiestudie en gebaseerd op het huidige aantal patiënten (2161) en therapeuten (24,5 FTE), kan het aantal behandelkamers gereduceerd worden van negen naar vijf. Dit resulteert in een bezetting van de behandelkamers van 49%, maar met het gebruik van een goede

planningsmethode kan deze bezetting hoger worden. De overige behandelkamers moeten wel meer flexibel ingezet worden, er blijven twee bekken kamers (waar ook andere patiënten geholpen kunnen worden, maar geen kinderen) en drie flexibele kamers (waar alle patiënten behandeld kunnen worden, behalve bekken patiënten).

Volgens de simulatiestudie, is er een verhoging van 65% (naar 3565 patiënten) in het aantal patiënten en behandelingen nodig om een bezetting van 57% van de huidige aantal behandelkamers (negen) te behalen. Om al deze patiënten te kunnen behandelen is er in totaal 33 FTE nodig. Als de specialismen van de therapeuten gecombineerd worden kunnen hier nog één of twee FTE van af.

De verwachting is dat een verhoging van 65% niet haalbaar is. Een verhoging van 15% (naar 2493) patiënten is realistischer, wanneer er extra moeite wordt gedaan om patiënten te werven. Volgens de simulatiestudie, kunnen het aantal behandelkamers gereduceerd worden naar zes en er is dan 26 FTE nodig. Dit resulteert in een bezettingsgraad van 57%.

Implementatie
Om deze veranderingen te realiseren is het belangrijk dat de therapeuten de noodzaak inzien van de verandering en de implicaties die het voor hun heeft. Daarnaast moet er moeite gedaan worden om het verzet tegen de verandering tegen te gaan zodat de implementatie van de verandering een succes zal worden.

Conclusie en aanbevelingen
De afdeling moet het aantal behandelkamers verminderen met drie, naar zes kamers. Op deze manier is groei nog steeds mogelijk. Een aanbeveling is dat de afdeling zo snel mogelijk moet beginnen met het implementeren van de nieuwe planningsmethode, met in het achterhoofd het verzet die de verandering met zich mee brengt en hoe deze op te lossen. Een andere aanbeveling is het starten van het registreren van de wachttijd van de patiënt.

Preface

"Walking is man's best medicine"
Hippocrates

This research report has been written to finish my Master study Industrial Engineering and Management – track Health Care Technology Management at University of Twente. This thesis concerns the improvement of the productivity of the physical therapy department .

Writing this thesis has been a process that took 1 year, but during this time I have learned a lot. At first I wondered why a hospital actually needs a physical therapy department. In fact, it is essential for many patients, who need rehabilitation before discharge from the hospital. It is also essential for the hospital, to reduce the length of stay of the patients. Like Hippocrates stated: Walking is man's best medicine. But as in many departments not everything goes as smoothly as could be, so I found promptly that there are a lot of things that could be done to improve the department.

Thanks to the therapists at the physical therapy department and Ronald de Wit I got a clear image of how things work, which enabled me to find a suitable solution to improve the productivity of the department. For this solution not only the technical aspects come into play, but also the human aspect of professionals and patients are very demanding. I thank Ronald de Wit and all the therapists of the physical therapy department for explaining me how the department works and what its value is for the hospital.

I thank my supervisors from University of Twente, Erwin Hans and Leo van der Wegen. Because of their critical opinions, their time spent on reading my drafts and explaining me how to improve them I have experienced this period as a very valuable one.

Finally I thank my father for working through my entire thesis to improve my writing skills and of course for his support during my entire studies.

Yke van Dijk
Enschede, May 2010

Content

1. Introduction

For the physical therapy department there are a number of ways to increase the efficiency and, as a result, generate more economic profit for the hospital. One way to increase the efficiency is by improving the occupancy of the examination rooms, which is the subject of this thesis.

By taking a closer look at the occupancy of the examination rooms we came across two things. First, the average actual occupancy of the examination rooms is low. Second, although the average actual occupancy is low therapists perceive the occupancy as high. This is caused by the fluctuation in the number of therapists present during the week, at a given time a day.

Keeping these points in mind we need to find a way to improve the occupancy of the examination rooms. Condition for this improvement is that the quality of patient care should remain the same, or preferably, be improved.

This chapter first gives a description of the physical therapy department in section 1.1. This leads to the problem definition with the problem statement that is central in this research, and is described in section 1.2. Section 1.3 discusses the research questions used to answer the problem statement and the chapter concludes in section 1.4 with the constraints that should be met.

1.1 Physical therapy department

The subject of this research is the physical therapy department because the hospital board has indicated that this department could improve the occupancy of their examination rooms.

The department provides both physical and occupational therapy and offers therapy to a diverse range of patients. Some patients are admitted at the hospital and need help with their movements: clinical patients. These patients are the priority of the department because they are their target group. Next to them, there are outpatient patients that receive treatment at the outpatient clinic of the department.

At the moment, the physical therapy department has to deal with a number of problems:

- The financial structure of the physical therapy is changing every couple of years. This makes it difficult to make long term plans on how the department should be managed;
- The reorganization will change the range of clinical specialties. In the future specialties might leave one of the hospital locations or will be added to one. This means that the content of the work performed by the physical therapy department will change as well, which can cause shifts in the specialties of the employees necessary;
- The aging of staff which means a reduction of the available effective FTE because of the extra leave hours from staff above a certain age;
- Retirement of staff in the next five years. This means that new employees should be hired right now because they need about five years to be fully trained;
- The low occupancy of the examination rooms. There is a shortage of rooms at the hospital and having a low occupancy means reducing the number of rooms for the physical therapy department or improving the occupancy.

1.1 Problem definition

As mentioned in the previous sections, the problem in the physical therapy department is the low occupancy of their examination rooms. This makes the head of the physical therapy department problem owner. The changing financial structure, the reorganization, and the aging and retirement of staff are challenges to face as well but, we do not focus on these problems in this research.

This leads us to the following problem statement:

"How can the productivity of the physical therapy department be improved?"

1.2 Research objective and questions

The research objective is to improve the productivity of the examination rooms of the physical therapy department.

1.3.1 Research questions

Before a solution to the problem statement can be formulated, the different processes of the physical therapy department need to be described. The following research questions should be answered concerning the current way of working:

1. **How does the physical therapy department currently operate?**
    - What types of treatments are offered?
    - What types of spaces are used to perform the treatments?
    - How many therapists are employed, and what are their specialties?
    - What types of patients receive treatment?
    - What does the financial structure look like for the physical therapy department?

2. **How are the processes planned and controlled?**
    - How are the processes of the clinical patients organized?
    - How are the processes of the outpatient patients organized?
    - What does the planning of the outpatient patients look like?

3. **How does the department currently perform?**
    - What are the performance indicators?
    - What is the performance of the physical therapy department?
    - What are the problems?

To answer these research questions we analyze the present data concerning the treatments that are performed in the last few years. Next to that, to answer the question the head of the physical therapy department and the physical therapists will be interviewed. Finally, by conducting a registration period to gather detailed information concerning the amount of treatments performed in the examination rooms or practice rooms the last questions will be answered. The answers to questions 1-3 are presented in chapter 2: Context analysis.

At a department, where a lot of therapists work and with limited amount of space to use for treatments, a central planning method would be a reasonable way to plan the patients. The current planning approach does not provide in this. The following question should be answered about a new planning approach:

4. **What should the new planning approach for the physical therapy department look like?**
    - What should the appointment scheduling look like?
    - How should the number of employees be spread during the different days of the week?
    - How can the current administration system be used to facilitate the central planning?
    - What are the advantages and drawbacks of the new planning system?

This question will be answered by interviewing the head of the department, and the therapists, and by conducting a literature review on appointment scheduling in health care. The answer to the question is presented in chapter 3: New planning approach.

In this research we will make use of a simulation model in order to do some experiments to improve the occupancy without negatively influence the working process of the physical therapists. Adjustments can be made (for example the number of examination rooms used) and the performance of the system can be calculated, to end up with interventions that will work in practice. The following research question should be answered:

5. **What does the simulation model of the physical therapy department look like?**

- What are the parameters?
- What are the decision variables?
- What are the system characteristics?
- What is the model structure?

This question will be answered by interviewing the head of the department and using the data collected to answer research questions 1, 2, and 3. The answers to the questions are presented in chapter 4: The simulation study.

Using the simulation model, interventions can be performed to improve the occupancy of the examination rooms. This can be done in two ways: to reduce the number of examination rooms or to increase the number of patients (and the number of treatments performed). The following research questions should be answered:

6. **How many patients are necessary to increase the occupancy with the given amount of examination rooms?**
    - How many therapists with different specialties are needed?
7. **How many examination rooms are necessary to perform the current mix and volume of patients with an increased occupancy?**

These questions will be answered by using the simulation model described in chapter 4. The answers to the questions are presented in chapter 5: Computational results.

Changing working conditions can lead to severe difficulties. These difficulties should be addressed and solved. The following questions should be answered:

8. **What difficulties can arise by changing to the new planning approach?**
9. **What are the solutions to these difficulties?**

These questions will be answered by using information from the implementation literature, especially implementation of change in professional organizations. Next to that, by conducting interviews with the department head of the physical therapy department, the physical therapists and the secretary of the department. The answers to the questions are presented in chapter 6: Implementation of the new planning approach.

1.3 Constraints

This research has two constraints, first: the new planning approach and the model that will be used to solve the problems should meet some conditions. First, the patient focus of the department must remain the same. Thus, the most important patients are the clinical patients, followed by the referrals of specialists, the rehabilitation patients and the referrals of the general practitioner and finally the patients that use the direct access possibility. The second condition is that the quality of care should not deteriorate. The third condition concerns the replacement of therapists. Within five years, five physical therapists will leave. They should be replaced in time in order to train the new physical therapists.

Second: this research does not include a plan to actually increase the number of patients. Instead it provides a number of patients that should be met to increase the occupancy of the examination rooms.

2. Context analysis

This chapter describes the current situation of the physical therapy department. It provides an answer to research questions 1, 2, and 3 about the processes and performance of the physical therapy department.

Section 2.1 gives an answer to research question 1, about the current way of working. Section 2.2 gives an answer to research question 2, about the processes that take place. Section 2.3 gives an answer to research question 3, about the current performance of the department. The chapter concludes with an overview of the most important problems the department faces and can be found in section 2.4.

2.1 Organization

This section gives an answer to research question 1: How does the physical therapy department operate at the moment?

2.1.1 Physical therapy department

Within the physical therapy department both physical as occupational therapy are practiced. The working methods are the same. Target group of the physical therapy department is the clinical patients. Therefore, these patients get priority of the physical therapists. Clinical patients can only be treated on certain times a day at the ward of their stay. During the other parts of the day the physical therapists treat outpatient patients. These patients need exercise and examination rooms where the physical therapists can treat them.

Treatments

The physical therapy department offers three types of treatments: clinical treatments, outpatient treatments and rehabilitation (rehabilitation treatments are a special type of outpatient treatment).

Table 2.1 presents the percentages of patients, treatments and time of the different treatment categories. These numbers are based on the production figures of 2008 from the Paranice system. For more information on this system see section ‘administration’ later on in this section.

Category	Percentage patients (n=11205)	Percentage treatments (n=59703)	Percentage time (n=16928)
Clinical	34.0%	56.8%	34.6%
Outpatient	52.7%	24.8%	47.4%
Rehabilitation	13.3%	18.4%	18.1%

Table 2.1: the percentage of patients, treatments and time in the categories clinical, outpatient and rehabilitation in 2008, based on the production figures of 2008 from the Paranice system.

In 2006 a study was performed by Hoeksma, Homans & Menting about the use of time of the physical therapists in a hospital situation. The research is conducted among 10 hospitals; one of them was the hospital of subject. During a registration period of four weeks all the therapists had to register the kind of work they performed (patient related, direct or indirect or non patient related work) and the treatment category of the patients (outpatient/rehabilitation/clinical).

The Hoeksma, Homans & Menting study shows that the average percentage of outpatient patients is 40%, for the clinical patients this is 59% and the rehabilitation patients this is 5% (IJland, Droeven, Vierke, & Bijlsma, 2006). The hospitals that cooperated in this study are comparable to the hospital. Comparing the study results we can conclude that the hospital has more patients in the outpatient and rehabilitation category than similar hospitals.

Furthermore interesting is the difference between the percentage of treated outpatient and clinical patients (34% en 52.7%) and the percentage of performed treatments of outpatient and clinical patients (56.8% en 24.8%). This difference can be explained by the fact that the clinical patients are seen twice a day, on average 9.1 times. The outpatient patients are seen on average about 2.3 times (These figures are based on the production figures of 2008 of the Paranice system).

Also, the percentage of time spent differs between the clinical and outpatient category, 34.6% versus 47.4%. The percentage of time spent on clinical and outpatient patients in comparison to the percentage of treatments on clinical and outpatient patients is striking: 56.8% versus 24.8%. This can be explained by the time it takes to perform the treatments. The average time of a clinical treatment is approximately 10 minutes and the average time of an outpatient treatment is approximately 35 minutes.

To perform the outpatient and rehabilitation treatments, the therapists have a limited amount of time. Between 10-12 a.m. and 3-5 p.m. is reserved to perform clinical work; in between these hours the outpatient work has to be performed. It is difficult to change the clinical hours because of the other activities on the wards: as washing the patients, lunch and visitor hours.

Rooms
The physical therapy department has different rooms that are used to offer the outpatient care. There are two exercise rooms to offer individual and group therapy in practice sessions. Aside from these exercise rooms there are nine examination rooms to help patients that need treatment in a private environment. Two of the examination rooms are reserved for pelvis therapy and two for child therapy.

The occupational therapy makes use of the examination rooms, but also has its own rooms. The clinical care is performed at the patients ward and is therefore not making use of the rooms.

Employees
The department had 20.80 FTE of physical therapists in 2008. There were 14 part-time physical therapists (in the range of 0.2 to 0.94 FTE) and 13 full time physical therapists. Most therapists are specialized; this specialty is leading in planning the clinical patients and for the allocation of the outpatient patients. Two of the therapists are responsible for the rosters and the end responsibility lies with the head of the department. There are four physical therapists that are allowed to perform pelvis therapy, three therapists that are allowed to perform manual therapy, three oedema therapists and four child therapists.

Administration
The Paranice system is a software program used by the physical therapy department. In this software program the patient information, type of treatment, the treatment time and duration, and finally the therapist that performed the treatment are registered. This is done for the outpatient treatments as well as for the clinical treatments.

However, the administration of the treatments in the Paranice system is based on billing purposes information. The information about, for example, the duration of the treatment is registered based on standard treatment time and not based on the actual time spent to perform the treatment. This causes especially for the clinical treatments a difference in registered time spent and actual time spent per patient.

Paranice also has a planning function like the Microsoft outlook function, but this is not used at the moment.

2.1.2 Patients

The treatments of physical therapy patients are divided in two treatment categories: clinical and outpatient. Figure 2.1 presents the distribution of the clinical treatments among the various departments (this distribution is based on the production figures of 2008 and is comparable to the distribution in 2007 and 2006).

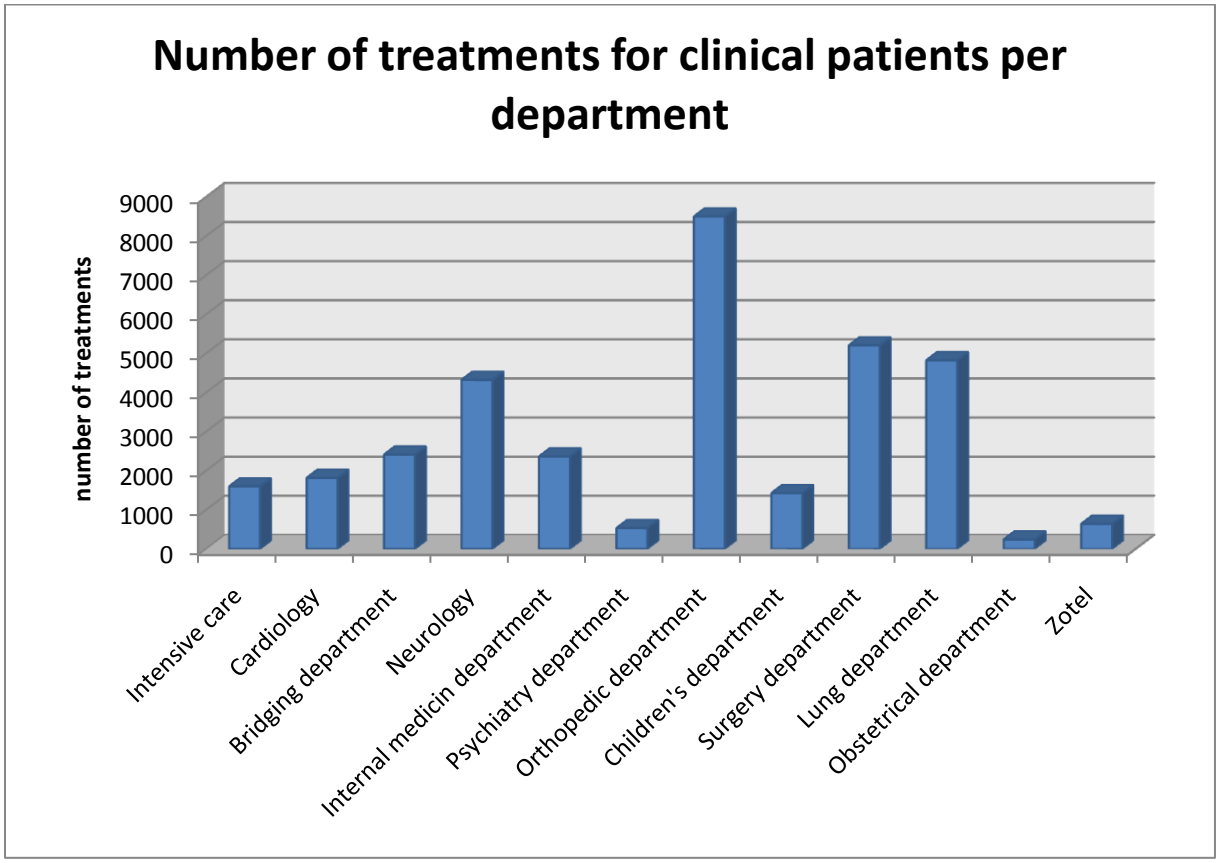

Figure 2.1: Number of clinical treatments by department in 2008, based on the productions figures of 2008 from the Paranice system: in total 33911 treatments

Figure 2.1 shows that the most important department to the physical therapy department is the orthopedic department, where most treatments are performed. The psychiatry and obstetrical department perform the least number of treatments and are therefore least important.

The distribution of outpatient patients are based on the different treatment codes, ranging from physical therapy treatment to heart rehabilitation treatments. The distribution is presented in Figure 2.2 (this distribution is based on the production figures of 2008 and is comparable to previous years).

Figure 2.2 shows that the general physical therapy, heart rehabilitation and rehabilitation treatments are most common. The manual therapy and the physical therapy examination are least performed.

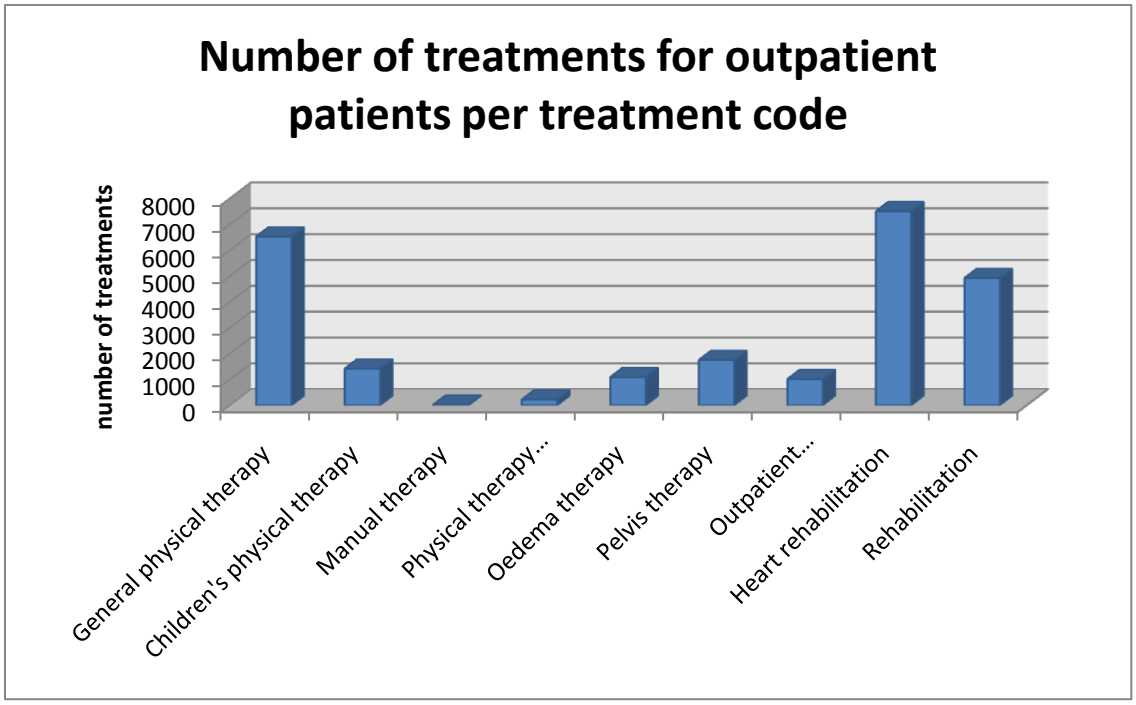

Figure 2.2: number of outpatient treatments per treatment code in 2008, based on the production figures of 2008: in total 24492 treatments

2.1.3 Financial structure

Physical therapy can be given as care that is part of a treatment plan, as care referred by a general physician or specialist and as direct access care. When the care is part of a treatment plan, for example the patient is in the hospital and needs to rehabilitate before he or she can go home, then the treatment is part of the Diagnose Related Groups (DRG) (Diagnose Behandel Combinatie in Dutch). Treatments that are part of the clinical work are financed through a part of the DRG budget.

The outpatient treatments are financed by the health care insurers. The physical therapy department gets paid by the number of treatments they perform. There is a difference in fees among the different treatments: general physical therapy treatments have a lower fee than the specialized pelvis treatments. The total number of treatments the department gets paid has to be negotiated in advance with the health care insurers. Most of the time this is based on the production of the year before.

2.2 Planning and control

This section gives an answer to research question 2: How are the processes planned and controlled?

2.2.1 Clinical process

When a patient is admitted in the hospital and receives treatment of a physical therapist, the clinical process is applicable.

Intake

In case of the clinical process, the physical therapy department receives a request for physical therapy of the wards. The receptionist of the physical therapy department makes sure the patient is put on the list of patients that need treatment that day by the physical therapist.

Treatment

The working schedule tells all therapists to go to one of the wards. They treat patients once or twice a day depending on the need of the patient. This treatment will be performed between 10-12 a.m. and 3-5 p.m. After the patient leaves the ward, it is possible that they need continuous treatment by the physical therapist. When they leave the ward and go to the Zotel (the Zotel is used by patients that

cannot go home yet, but for which it is not necessary to stay at the ward) the therapist responsible for the Zotel patients will continue the treatment. If the patient goes home and still needs treatment he or she can go to the outpatient clinic or another practice nearby their home.

Administration
The physical therapists report the progress of their patient into their files but also into the nursing files. This enables the nursing staff to see what the patient is allowed to do and what they are not allowed to do.

Planning
All therapists are assigned to clinical work. However, in practice therapist can have other obligations as well during the clinical time. Because the planning is not based on actual availability in practice too little or too many therapists are present at the wards. During weekends clinical patients are seen once a day, because of the availability of the number of therapists. The therapists are scheduled to perform weekend duties once every few weeks.

2.2.2 Outpatient process

When the patient receives treatment from the physical therapy department in the hospital but is not admitted in the hospital the outpatient process is applicable.

Intake
When a new outpatient patient presents himself at the reception (with or without a referral) of the physical therapy department the receptionist puts the patient on a list. This list is available to the physical therapists that individually can call in these patients when they have time to treat them.

Treatment
When a patient is treated for the first time, the physical therapist will perform an intake. This intake needs to be operated in a closed examination room because of privacy issues. It depends on the diagnosis what the treatment looks like and where it should take place: in the examination rooms, in the pelvis examination rooms or in the practice rooms. The therapy continues until the physical therapist and the patient decide it is not necessary anymore.

Administration
At the end of each treatment the therapist fills out the progress of the patient in the patient file and reports to the receptionist that the patient has been seen for the financial settlement.

Ideally, after the therapist makes an appointment the waiting time of the patient should be registered in order to evaluate the performance of the department concerning the waiting times. At the moment this does not happen.

Planning
After each therapy session the therapist makes an appointment with the patient without taking into account the availability of the rooms where the treatment should take place. The planning of the patients is practiced by each individual therapist.

The therapists are scheduled according to their availability. In the past the therapists have made appointments with the head of the department about the days a week they work and about the number of hours per week they work. This causes nowadays problems for the available workforce. Because of the team meeting every Monday, most therapists have to be present on Monday morning, which causes an overload of therapists on the Monday morning. Another issue is the 36 hours working week, which in a lot of cases means that the therapists are free at Friday afternoon.

2.3 Performance

This section gives an answer to research question 3: How does the department perform at the moment?

2.3.1 Performance indicators

The physical therapy department has various stakeholders that assess the performance of the department in different ways. In Table 2.2 the different stakeholders are linked to the performance indicator(s) they use to assess the department.

Stakeholder	Performance indicator
Management of the hospital	Production figures
Head of the department	Production figures Average number of treatments Number of therapists Occupancy Direct vs indirect work
Employees	Rejected patients
Patients	Time before getting an appointment

Table 2.2: The stakeholders linked to the performance indicator

The following sections explain the performance indicators.

2.3.2 Production figures

Definition

The production figures of the physical therapy department consists of the number of patients treated and the number of treatments performed per FTE. The production figures are of importance to the management of the hospital and the head of the physical therapy department. The management of the hospital get information on the amount of patients treated by the department and the department head can indicate differences between the years and can use these differences to manage the department.

Current situation

Table 2.3 presents the production figures of 2006, 2007 and 2008. The total time spent on a treatment is the amount of time registered per treatment.

The available hours used in Table 2.3 are calculated using the total hours of the FTEs available minus the holidays (9%), ill days (5%) and old age days. This results in an effective FTE for 2006 of 18.28, for 2007 of 18.37, and for 2008 of 18.34.

The general trend for the clinical patients is that the total amount of time spent is decreasing. Especially the difference in total time spent in 2006 (28798 hours) and 2007 (24201 hours) and 2008 (16928 hours) is remarkable. This can be explained by the fact that the registered time spent per treatment has decreased. The registered time spent in 2008 is more in line with the actual time spent for each treatment compared to 2006 and 2007.

The general trend for the outpatient patients is the same as the trend for clinical patients; the total time spent on treatments is decreasing. This can be explained because the numbers of treatments is decreasing too. Also the increasing number of rehabilitation treatments causes the decrease of the number of outpatient treatments.

	Clinical	outpatient	rehabilitation	total
2008				
Number of patients	3810	5906	1489	11205
Number of treatments	33893	14829	10981	59703
Total time spent on treatments in hr	5851	8016	3061	16928
Time spent in min/treatment	10	32	17	17
Time spent in hr/available hours(effective FTE)	0.17	0.23	0.09	0.49
Number of treatments/patient	8.9	2.5	7.4	5.3
2007				
Number of patients	3840	6674	918	11432
Number of treatments	34521	17675	8908	61104
Total time spent on treatments in hr	12584	9275	2342	24201
Time spent in min/treatment	22	31	16	24
Time spent in hr/available hours(effective FTE)	0.36	0.27	0.07	0.70
Number of treatments/patient	9.0	2.6	9.7	5.3
2006				
Number of patients	5347	6183	814	12344
Number of treatments	36729	18916	8409	64054
Total time spent on treatments in hr	15432	11261	2105	28798
Time spent in min/treatment	25	36	15	27
Time spent in hr/available hours(effective FTE)	0.45	0.33	0.06	0.84
Number of treatments/patient	6.9	3.1	10.3	5.2

Table 2.3: production figures of the physical therapy department in 2008, 2007 and 2006 from the Paranice system

The general trend for rehabilitation is an increasing number of treated patient and the increased number of treatments and total time spent on the treatments. Remarkable is that the number of treatments per patient is decreasing. For this, there is no direct explanation.

Overall, each year fewer patients are treated and fewer treatments are performed with about the same amount of effective FTE. The differences found in Table 2.3 are not as remarkable because of the difference in registered time of the clinical patients. The fact that the amount of work performed is decreasing, however, still holds. This might be due to the increased amount of time spent on auditing and quality measurements. The time spent on these activities is not subtracted from the available hours. This auditing and quality measurements are however obligatory for physical therapy departments in order to be allowed to perform treatments.

Desired situation
The total number of treatments performed should, at least, remain the same. Preferably the number of treatment should increase, especially rehabilitation treatments should increase based on the trend in the production figures of the past years

Problem
The work is not executed effectively. In order to be able to treat the same amount of patients with less available time, the department should find ways to work more efficiently. They should also hire new staff to make the new staff ready to fulfill the open positions when it is time.

2.3.3 Average number of treatments

Definition

The average number of treatments per patient is the number of treatments that, on average, are necessary before the patient is discharged from the hospital, getting treatment somewhere else, or has finished the treatment plan. The average number of treatments per patient and its fluctuations are of importance to the department head to manage the department.

Current situation

Figure 2.3 presents the average number of treatments at the clinical departments.

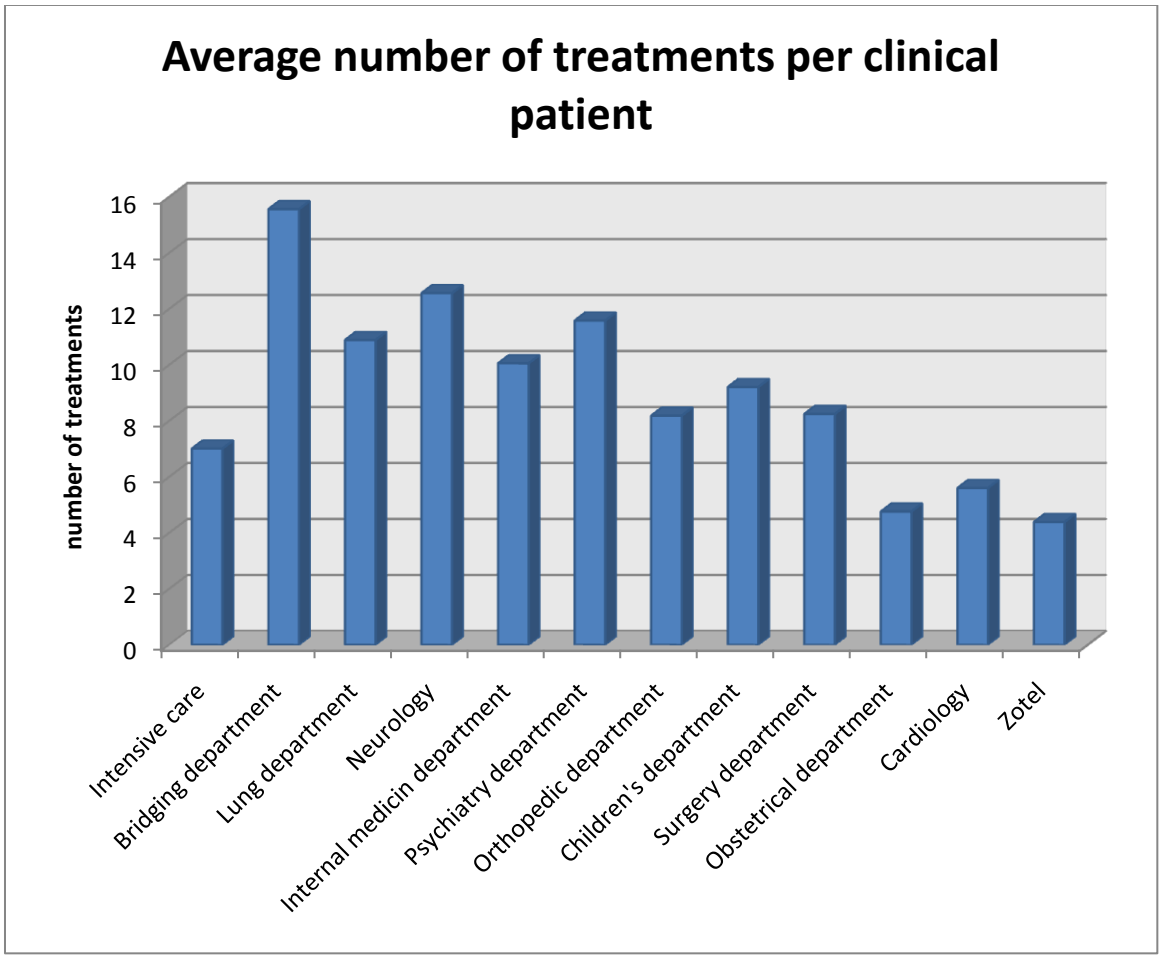

Figure 2.3: the average number of treatments per patient in de clinical departments in 2008, based on the production figures of 2008 from the Paranice system

Especially the average number of treatments per patient in the bridging department and at the neurology and psychiatry department is large. This can be explained because these are departments where patients stay a long time.

The average number of treatments per patient in the intensive care, the obstetrical department, cardiology and the zotel are small. This, again, can be explained by the time the patients stay at the ward. As soon as it is possible patients from the intensive care and obstetrical departments are transferred to other departments in the hospital or go home.

The cardiology department admits patients that had a surgery in the hospital in Enschede, the MST, and were not able to go home yet, but are getting better. This means the patients do not stay long at

the ward. When they are able to return home they are going home and are treated as outpatient patients in the heart rehabilitation groups at the physical therapy department.

Figure 2.4 presents the average number of treatments per outpatient patient.

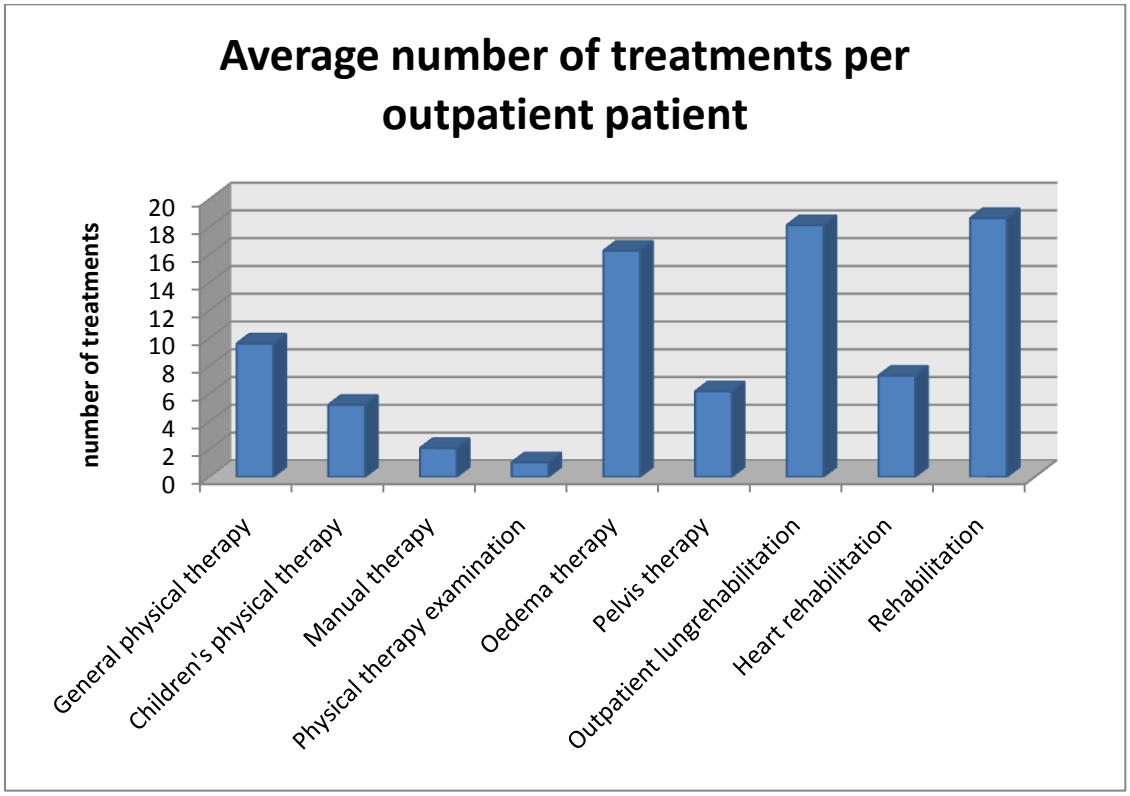

Figure 2.4: the average number of treatments per outpatient patient in 2008, based on the production figures of 2008 from the Paranice system

As Figure 2.4 shows, especially the (lung) rehabilitation and oedema therapy are treatments that need a lot of contact moments with the physical therapist. The rehabilitation takes a lot of practice before it becomes and stays effective, so the number of treatments per patient is high.

Desired situation

The average number of treatments of all clinical patients is 8.5 treatments. According to the research of Hoeksma, Homans and Menting (IJland, Droeven, Vierke, & Bijlsma, 2006), the case mixes of the hospitals are comparable to the hospital. However their average number of treatments per clinical patient is 6.7 treatments. This can be explained by the difference in the percentage of patients with hip problems: the hospital helps more patient than the average hospital that cooperated in the research. Almost two treatments per patient extra. Based on this difference we can conclude that the average number of treatments per patient could be reduced in the hospital.

Problem

The average number of treatments of clinical patients is too high. One of the key ingredients in reducing the average number of treatments per patient is the time the patients stay at the ward. In order to reduce the average number of treatments per patient the length of stay should be reduced. This is not a job for the physical therapy department, but for the wards.

2.3.4 Number of therapists

Definition

The number of therapists is the number of therapists present at each part of the day and the number that needs to be present based on the number of clinical patients. The number of therapists is of importance to the department head, because he is responsible that there are enough therapists present each part of the day.

Current situation

At the moment all the therapists that are present at a part of the day are assigned to the wards to perform clinical work. This also means that the unequal spread of the therapists during the week causes problems here. At some days there are not enough physical therapists to man all the wards and on other days there are too many therapists.

The distribution of the present number of therapists during the week differs. This is due to a lot of part-time staff. The part-time staff has been allowed to plan their own working week. Also, because the working week of a full time physical therapist consists of 36 hours, some of the therapists are free one day every two weeks instead of half a day a week. This results in a fluctuation of the people present every week. Figure 2.5 presents this fluctuation. Appendix A presents the calculation of the number of therapists necessary.

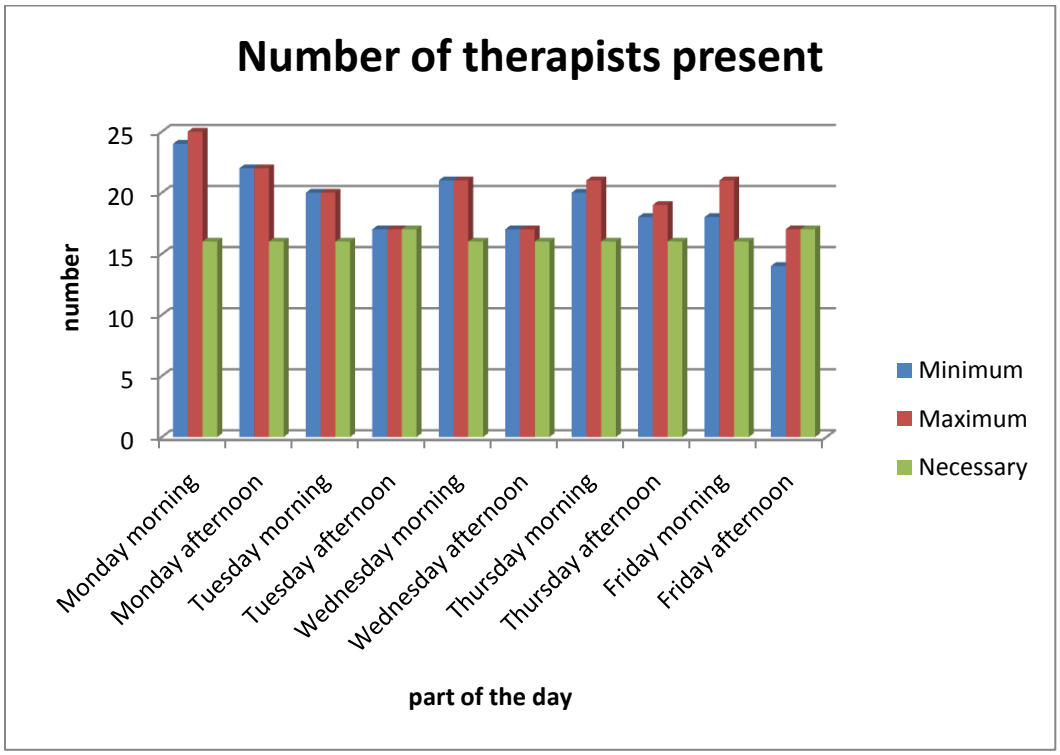

Figure 2.5: Number of therapists present: the minimum number, the maximum number and the necessary number present (based on the number of clinical patients in 2008 from the Paranice system)

As Figure 2.5 shows there is an unequal distribution of the therapists during the week. At some parts of the day not enough therapists are present and at other parts of the day there are too many.

The therapists that would like to take a day off fill out a note (without a deadline) and the therapists responsible for the rosters need to fill the occurring gaps. The therapists that make the rosters have not been given the responsibility to refuse their colleagues to take the day off. This is the responsibility of the head of the department, but he does not always have a complete overview to prevent unwanted situations.

Desired situation
The desired situation is that every time of day there are the same number of therapists present. This makes sure that the occupancy of the examination rooms can be spread equally over the week. Furthermore, the responsibility of the therapists that make the rosters should be expanded with the possibility to reject a leave application.

Problem
First, based on the rough estimation of the number of therapists necessary and the number of therapists present we can conclude that there is a problem with the number of therapists present on Friday afternoon. One week there are just enough therapists present and the other week there are not enough therapists present. When for some reason one therapist is absent there is a problem on Tuesday and again Friday afternoon.

Second, the therapists present should not be occupied with other activities during the clinical time. When this is the case there should be more than the 16 or 17 therapists at that part of the day present. Aside from the problem that there are not enough therapists present, the amount of therapists present on a Monday (at least 24) can cause problems with the occupancy of the examination rooms because there are only nine examination rooms available.

Concluding, a more even spread of physical therapists during the week is necessary and at least 16 or 17 therapists should be present during the day. Next to that, the responsibility to refuse leave applications should be given to the therapists responsible for scheduling.

2.3.5 Occupancy

Definition
The occupancy rate is the percentage of time the nine examination rooms are in use. The occupancy of the examination rooms is of importance to the department head, because he can use the occupancy to manage the department.

Current situation
As has been described before, the physical therapy department has nine examination rooms and two exercise rooms in use. The occupancy of these different rooms is of importance in order to make decisions about the number of examination rooms necessary or the number of employees to hire.

A distinction is made in the overall occupancy during the year, the occupancy during the different days and also the occupancy during the day, like during the clinical and non-clinical time.

In order to make a calculation of occupancy we need to know which treatment takes place in the examination and in the exercise room. For a number of treatments this is clear like child treatments and pelvis treatments. For general physical therapy treatments, however, a number of treatments are performed in examination rooms and a number is performed in exercise rooms. The same goes for occupational treatments and rehabilitation.

To be able to make a correct estimation of the number of treatments performed in the examination room, a registration period was executed. The registration took about four weeks and based on the results the percentage of treatments performed in the examination rooms was calculated as stated in Table 2.4.

	General physical therapy	Rehabilitation	Occupational therapy
# treatments measured in four weeks	623	208	191
% examination room	74.80%	35.10%	46.60%
Total # treatments in examination room in 2008	4883	1728	1402

Table 2.4: number of treatments in the examination rooms based on a 4 week registration period in July 2009

The treatments that are performed in the examination rooms are randomly chosen out of a list of all the treatments performed sorted by the treatment codes: general physical therapy, rehabilitation and occupational therapy. Aside from these three treatment codes, also the treatments of the pelvis, child, manual, and oedema therapy are performed in the examination rooms. This results in a total of 8628 treatments in the nine examination rooms in 2008. Based on these treatments the occupancy is calculated.

The average occupancy of the nine examination rooms is 33.7%. This number is low, but we have to keep in mind that at the moment the used hours of the examination rooms is less than nine hours because of the current allocation of all therapists to the clinical departments.

Still, the occupancy is low. In Appendix B: table B.1, the contribution of the different types of treatments to the occupancy is presented. This shows that physical therapy and pelvis therapy are the main users of the examination rooms, followed by child treatments and finally occupational treatments.

In section 2.3.4 the problem of distribution of therapists during the week is mentioned. Table 2.5 presents the occupancy of the examination rooms during the week. Appendix B, table B.2, presents the influence of the different types of treatments to the occupancy during the week.

2008	Total Occupancy
Monday	37.1%
Tuesday	33.2%
Wednesday	38.5%
Thursday	34.3%
Friday	25.8%

Table 2.5 occupancy during the days of the week, based on the production figures of 2008 from the Paranice system

As expected, based on the number of therapists present on the different days of the week, the occupancy on Monday is higher than on Friday. On Wednesday and Monday the occupancy is the largest. Many therapists are present on Monday and Wednesday.

Table 2.6 shows the occupancy during different parts of the day. In Appendix B, table B.3, the influence of the different types of treatments to the occupancy during the day is presented.

2008	Total occupancy
8.00 a.m - 10.00 a.m	55.6%
10.00 a.m - 12.00 p.m	21.7%
12.00 p.m - 3.00 p.m	42.6%
3.00 p.m - 5.00 p.m	16.6%

Table 2.6 Occupancy during the different parts of the day, based on the production figures of 2008 from the Paranice system

Desired situation
The department aims for an occupancy for the examination rooms during outpatient time of 70% and during clinical time of 40%.

Problem
The occupancy does not match the occupancy aimed for by the department. The occupancy between 8:00 a.m. and 10:00 a.m. and 12:00 p.m. and 3:00 p.m. is the highest. This can be explained by the reservation of the clinical times. Also, the occupancy during clinical hours is too low, especially between 3:00 a.m. and 5:00 p.m.

Overall, the occupancy should be more evenly spread during the week and during the day the occupancy should be increased, both during outpatient time and during clinical time.

2.3.6 Direct vs. indirect work

Definition
One way to measure how effective the physical therapy department works is to compare the amount of direct work with the amount of indirect work. To do this a distinction has been made between the direct patient related work, indirect patient related work and non patient related work.

Direct patient related work includes all activities with direct contact between the physical therapist and the patient, which is the actual treatment. The indirect patient related work includes the activities where there is no direct patient contact, but the work is carried out on behalf of the patient, like patient reviews and walking time. The non patient related work are activities that cannot be converted to individual patients: management tasks, job related conferences etcetera. The direct vs indirect work is of importance to the department head, in this way he can judge if the employees work efficiently.

Current situation
It is important that the amount of indirect work, especially the non patient related work does not exceed the amount of direct work. The physical therapy department in The hospital spends about 84% of their time on patient related work (indirect plus direct related). 64% of their total time is spend on direct patient related work.

Desired situation
The average proportion of direct vs. indirect work of physical therapy departments in a hospital in the Netherlands is 57%. This means that more than half of the time a physical therapist is having direct patient contact. 20% of the time is spent on non patient related work (IJland, Droeven, Vierke, & Bijlsma, 2006).

Problem
There are no direct problems with the amount of direct work in comparison to the amount of indirect work. But given the number of effective FTE reducing the next couple of years and the wish to maintain the same production, it might be a good idea to look at the proportions of direct and indirect work to increase the efficiency of the department to be able to maintain the same production.

2.3.7 Rejected patients

Definition
Rejected patients are patients that cannot be helped because there is no examination room available. These are not only patients that are sent home, but also patients that are treated in rooms that do not meet the requirements of the treatment. The rejected patients are of importance to therapists for reputational reasons: a rejected patient means that they cannot help that patient even if they want to. For the patient it is very unpleasant to come to the hospital for treatment which cannot be delivered. The patients will consequently express their dissatisfaction to the therapists, which demotivates them.

Current situation
At the moment, on average, one patient is sent home every two weeks and there are six patients a week that are treated in a different room than desired. Especially the occupational patients are treated in another room than desired, because there is one room available for this type of patients.

Desired situation
The aim of the department is to send zero patients home and to be able to help all patients in the room the treatment prescribes.

Problem
Too many patients are send home without treatment or are treated in rooms that are not suitable for their treatment.

2.3.8 Time before getting an appointment

Definition
The time before getting an appointment is the time between the moment the patient presents himself at the desk of the department and the time the department can tell the patient when their appointment will take place. The time before getting an appointment is of importance to the patients, because it indicates the time it takes before they know when their treatment will start and their satisfaction with the service of the department.

Current situation
In the current system the physical therapists make their own appointments. The time before getting an appointment for a new patient is almost never less than a day.

In case a new patient presents himself at the desk he almost always has to wait for the therapists call to make an appointment. For the majority of the treatments the time before getting an appointment is less than three weeks, as it is supposed to be according to the TREEK standard. This is an estimation as the time before getting an appointment is not registered at the moment by the physical therapy department.

For a few treatments like the pelvis treatment the time before getting an appointment can be longer than three weeks. This is because there are four therapists trained to perform these types of treatments and the average number of treatments necessary is large.

Desired situation
It is the wish of the department that the patients can be given an appointment immediately when they come to the desk. This means that the time before getting an appointment should be less than a day.

Problem
The time before getting an appointment is too long and is not registered. By changing the working methods it might be possible to give the patient an appointment at the moment they present themselves at the receptionists, which reduces the access time to less than a day. In order to be able to determine if the access time reduces, we recommend a registration method.

2.4 Conclusion

Based on the context analysis of the physical therapy department there are three problem areas. The first one concerns flexibility in the presence of the therapists: some days during the week there are too many, where at other days there are not enough therapists to perform all the clinical work.

The second problem area is the occupancy of the examination rooms. The occupancy during the different days of the week and during the day is not evenly spread. Also, the overall occupancy is too low.

The third problem area is the number of rejected patients. Too many patients are send home without treatment or are treated in rooms that are not suitable for their treatment.

In this research the problem of the occupancy of the examination rooms is the central problem.

3. New planning approach

This chapter describes the new planning approach. It provides an answer to research question 4: What should the new planning method for the physical therapy department of The hospital look like?

Section 3.1 describes the way appointments should be scheduled and the function of therapists and secretary. Section 3.2 provides insight in the number of therapists that need to be present. Section 3.3 explains the use of the Paranice system as a planning instrument. Section 3.4 describes the advantages and drawbacks of the new planning approach. The conclusions are presented in section 3.5.

3.1 Appointment scheduling

At the moment each therapist schedules his own appointments. As a consequence, the situation occurs that a patient should be treated in an unavailable examination room. The new planning approach should consider availability of therapist and examination room. A central planning approach makes sure the therapist is available as well as the examination room.

3.1.1 Appointment scheduling according to the literature

Appointment scheduling is a tradeoff between efficiency and timely access to health services. The goal of a well designed appointment system is to deliver in time and convenient access to health services for all patients. Appointment systems also smooth work flow, reduce crowding in waiting rooms and allow health systems to honor patient and provider preferences while matching supply and demand (Gupta & Denton, 2008).

Most appointment systems in an outpatient health care setting, described in literature, are based on the combination of scheduled patients and walk-in patients (Gupta & Denton, 2008). Also the variability in treatment times for the different patients is an issue (Dexter, 1999); (Welch, 1964); (Brahimi & Worthington, 1991).

Outpatient patients need to receive treatment by the same therapist each treatment. This means that, after the first appointment, the appointment system can be described as an one server environment. This one server environment can be used to describe the way the slots of appointments for patients are designed. The appointment systems described in literature can be applied for the physical therapy department. However, the systems can be simplified, due to the fact there are no walk-ins and the variability of most treatment times are almost zero.

There are multiple options to design the appointment slots for a one server environment:

- Individual-block/fixed interval (IBFI): schedules patients individually at intervals equal to the mean treatment time of patients (Cayirli, Veral, & Rosen, 2006);
- 2BEG rule: two patients are called at the beginning and the rest individually at fixed intervals (Bailey, 1952);
- OFFSET rule: Individual block, variable interval. The new patients are scheduled earlier and the rest are scheduled later compared to the IBFI (Ho & Lau, 1992);
- Multiple-block/fixed interval (MBFI): schedules patients two at the time with intervals set equal to twice the mean service time (Soriano, 1966);
- DOME pattern: the intervals increase gradually toward the middle and slightly decrease at the end of the session (Robinson & Chen, 2003);
- Variable-sized multiple block (VSMB): a variable number of patients can be assigned to a block (Fries & Marathe, 1981).

Figure 3.1 shows graphically the most important appointment systems.

Individual-block/fixed interval

Multiple-block fixed interval

Variable-sized multiple block

Figure 3.1: The most important appointment schedules

According to Cayirli, Veral & Rosen (2006) the 2BEG, MBFI and IBFI rules are performing the best based on average waiting time. The appointment systems based on individual block rules perform however best with short consultation times. When time of the patients is indicated as valuable as time of the therapists the individual block rule is preferred even when consultation time is long.

At the moment the physical therapy department of The hospital uses an individual appointment system, where patients are given unique appointment times. This system performs well on the waiting times of the patients, but less on the idle time of the therapists and the idle time of the examination rooms (Fries & Marathe, 1981).

To increase the occupancy of the examination rooms the variable-sized multiple block rule should be used. Variable because of the difference in treatment time of, for example, general and pelvis treatments. The individual-block/fixed interval should be used as appointment rule for therapists. The fixed intervals of the specialized therapists should be in line with the different blocks of the examination rooms.

3.1.2 Function of secretary

When a patient first presents himself at the desk with a referral note, the first appointment will be made by the secretary. The therapist with the most available time and trained to treat the specialty, based on the referral note, will be assigned.

After each session, the patient receives information from the therapist about the next appointment: in what time period and what kind of room. The secretary uses this information to schedule the next appointment. Time for this appointment will be reserved in the agenda of the therapist as well as in the agenda of the examination room. A side from scheduling appointments, the secretary still has to perform the current tasks.

3.1.3 Function of the therapist

The therapists perform the intake of the patient, and treat them. The therapists decide if the patient should be treated in an examination room or in an exercise room. The intake always takes place in an examination room to preserve the privacy of the patient.

After each treatment the patient receives information concerning time and type room for the next treatments. The patient takes this information to the secretary where the next appointment will be scheduled.

The occupational therapy also uses the examination rooms. In case of occupational treatment the same working method has to be applied.

3.1.4 Block scheduling

In the new planning approach not only the availability of the therapist is needed, but also the availability of the examination room. The best way to schedule appointments is with the use of blocks as is described in section 3.1.1.

The blocks for the examination rooms should be 1.5 hours. This means in these 1.5 hours two patients can be assigned to the room with a treatment duration of 45 minutes, or three patients with a treatment duration of 30 minutes. This can increase the waiting time, but increases the occupancy rate of the examination rooms.

The appointment times with the therapists should be based on an individual block scheduling system, with variable size. The times of the appointments should be in agreement with the times of the different blocks of the examination rooms.

3.2 A change in the assignment of therapists

The perceived high occupancy of the examination rooms is caused by the distribution of the therapists during the week and the unnecessary assignment of almost all therapists to clinical work in the clinical hours. Not assigning all therapists to clinical work can improve the occupancy of the examination rooms during clinical time.

3.2.1 Number of therapists that should be present each day

The therapists should be able to perform all the clinical work that is present each day. According to the calculations in Appendix A there should be 16 therapists present during each part of the day, and because of extra work at the orthopedic department on Tuesday afternoon and Friday afternoon there should be 17 therapists present. This is in correspondence with the estimates of the department.

According to Figure 2.5 in Chapter 2: Context analysis, there are more therapists needed on the Tuesday, Wednesday and Friday afternoon. These therapists can, for example, be distracted from Monday. The reason that there are many therapists present on Monday morning is the team meeting. To make sure all the therapists are informed about the state of affairs, the team meeting should switch between days, for example on the even weeks on Monday morning and the odd weeks on Tuesday morning. This way all the therapists should get all the information they need.

3.2.2 The assignment of therapists to clinical work

The assignment to the different clinical departments should be based on the affinity of the therapist to a certain kind of patients. Patients from the neurology and psychiatric department, for example, need a different kind of approach in comparison to patients from the orthopedic department.

Not all therapists have be assigned to clinical work, when there are more therapists present than 16 or 17. The overflow of therapists can perform outpatient treatments during clinical time and this can result in an increase of the occupancy of the examination rooms during clinical time.

3.3 The use of Paranice as a planning system

At the moment the department uses Paranice for their administrative tasks, like billing of the treatments that are performed. But Paranice also offers an agenda function which is linked to the administrative part of the system.

3.3.1 Planning of the appointments of the therapist

All the physical therapists have their own agenda which has the features of the Microsoft outlook agenda. The features can be used to plan patients with a slight increase of workload for the secretary. Due to the fact that the agendas are linked to the registration part of Paranice.

To make this way of planning work, it is necessary that all other activities, like: the clinical working hours, the group treatment, quality audits, etcetera, are present in the agendas of the therapists.

3.3.2 Planning of the appointments of the examination rooms

In order to prevent double booking of examination rooms, there are two possibilities.

First, the appointments for treatment should be planned in a separate agenda for the examination room. Second, use the feature of giving a warning when all the examination rooms are full. The disadvantage of the latter feature is that the availability of examination rooms is not known beforehand. So the extra administration of keeping up extra agendas counterbalances the issue of not having the overview of possible openings for the examination rooms.

3.4 Advantages and drawbacks of the new planning approach

The old planning approach had advantages for the therapists, but causes problems.

3.4.1 Advantages

There are three advantages of the new planning approach. First, the planning of the examination rooms is done simultaneously with the planning of the appointment with the therapist. This reduces the chance that an appointment takes place in an unavailable examination room.

Second, the therapists are more evenly distributed during the week. With a more even distribution of the number of therapists, it might be easier to plan the treatments that should take place in the examination rooms.

Third, the overview of the activities of the therapists. This way the double booking of therapists can be prevented and one can easily see the availability of the therapists.

3.4.2 Drawbacks

There are two disadvantages of the new planning approach. First, due to the 36 hour work week, the Friday afternoon off has become an established fact. This established fact has to be given up and this causes resistance.

At the moment there is personal resistance to the problem because therapists are no longer completely in charge of their own agenda. This affects their autonomy, but the autonomy is only allowed when it is medically necessary. And by central planning the flexibility will be improved, and an increase of economies of scale will be provided. This does not result in an medically necessary loss of autonomy of the therapists.

3.5 Conclusion

The new planning approach aims to increase the productivity of the department. By planning the patients centrally through the secretary, more flexibility is obtained, and double booking of the examination rooms and therapists can be avoided.

The therapists do not have to schedule their own agenda’s anymore, which will result in distribution of workload that is fairer.

4. The simulation study

This chapter provides an answer to research question 5: What does the simulation model of the physical therapy department look like?

The simulation model of the physical therapy department is described based on the steps described by Law (2007, pp. 66-70). The first step is the formulation of the problem, which is described in section 4.1. The second step is the data collection and definition of the conceptual model, described in section 4.2. The third step is the formulation of the technical design and the verification, described in section 4.3. The fourth step is the validation of the technical design, described in section 4.4. The last step is the design of the experiments, described in section 4.5. Section 4.6 provides insight in the limitations of the simulation model. The last section, section 4.7 gives conclusions about the use of the simulation model.

4.1 Formulation of the problem

The first step of the simulation study is to formulate the problem that should be solved.

4.1.1 Project objectives

The simulation study is partly based on the central planning approach described in chapter 3: New planning approach. Overall the variable-sized multi block appointment rule is not taken in to account. For the second scenario the more even distribution of therapists is also not taken into account. The objective of the simulation study is to find the interventions that improve the occupancy of the examination rooms. To increase the occupancy of the examination rooms the number of patients (and inevitably the number of FTE) can be increased or the number of examination rooms can be decreased or both.

4.1.2 Project scope

The simulation model considers outpatient patients, excluding the group patients and clinical patients. The time needed for the group patients are represented in the maximum occupancy of the therapists (the maximum occupancy of therapists is calculated based on total time available, minus the sick days, vacation days, indirect patient related work and group patients. Calculation is presented in section 4.2.1). During clinical time 16 to 17 therapists are not available to perform outpatient treatments.

4.1.3 Global working of the model

The simulation model creates patients who need a certain amount of treatments by a therapist in an examination room or an exercise room. On the one hand the model uses a push system: the new arrived patient is tried to be pushed through the system, this succeeds if there is a therapist available and a room. On the other hand the simulation uses a pull system: when a therapist becomes free after performing a treatment a patient from the waiting list is pulled into the system to receive treatment.

4.2 Data collection and conceptual model definition

The second step of the simulation study is to collect data and define the conceptual model.

4.2.1 Data collection

To define the model we need to specify the performance indicators, the decision variables, the parameters and the input probabilities. The data collection concerns the actual situation of the department.

Performance

For the simulation model the following performance indicators are used:

- Total occupancy of the examination rooms: total time the examination rooms are occupied for outpatient treatments divided by nine hours;
- Total number of patients treated by the physical therapy department per year;

  - Number of general patients per year;
  - Number of manual patients per year;
  - Number of oedema patients per year;
  - Number of children patients per year;
  - Number of pelvis patients per year;
  - Number of rehabilitation patients per year;
  - Number of occupational patients per year;
- Total number of treatments performed by the physical therapy department per year;
  - Number of general treatments per year;
  - Number of manual treatments per year;
  - Number of oedema treatments per year;
  - Number of children treatments per year;
  - Number of pelvis treatments per year;
  - Number of rehabilitation treatments per year;
  - Number of occupational treatments per year.

The occupancy of the examination rooms is 33.7% in the actual situation. Table 4.1 presents the values of the performance indicators number of patients and number of treatments in the actual situation.

	# patients in actual situation	# treatments in actual situation
General	686	5604
Manual	42	206
Oedema	65	919
Children	270	1412
Pelvis	279	1736
Rehabilitation	262	4545
Occupational	445	3008
Totaal	2049	17430

Table 4.1: Values of the performance indicators number of patients and number of treatments in the actual situation based on the productions figures of 2008 from the Paranice system

Decision variables and parameters
The decision variables of the simulation model are:

- The total number of patients;
- The total number of FTE of therapists;
  - The number of FTE for each specialty;
- The total number of examination rooms;
  - The number of pelvis rooms;
  - The number of children rooms.

To increase the occupancy of the examination rooms, the number of patients can be increased. The increase in the number of patients causes an increase in the number of treatments that need to be performed. To perform more treatments, more FTE are needed.

Another way to increase the occupancy of the examination rooms is by decreasing the number of examination rooms.

The parameters of the simulation model are divided between the patients and the therapists. The parameters for the patients are:

- Treatment type of patient;
- Number of treatments per patient;
- Examination room?: yes/no;
- Duration of the treatment per patient.

The parameters for the therapists are:

- The number of therapists needed for clinical treatments;
- Parts of the day the therapists are available (in the initial situation);
- Maximum occupancy of the therapist is 50%.

The maximum occupancy of the therapist of 50% is based on the number of sick days, vacation days, direct patient related time and the time for group patients, which are not present in the model.

The sick days and vacation days (sick days are 5% of the total time. Therapists have 28 vacation days per year, which is 12% of the total time) are 17% of the time of the therapists. Direct patient related time is 64% (IJland, Droeven, Vierke, & Bijlsma, 2006) of 83% of the time; consequently therapists can treat patients in 53% of their total time. The simulation model does not take into account group patients, consequently there should be time reserved for these patients in the occupancy of the therapists, 3.58% (There are 26 treatments a week, each taking one hour and two therapists should treat the groups. This means 32 hours a week should be reserved for group patients There are a total of 24,8 FTE present at the moment. 32 hours/(24,8*36) is 3,58%). So the total occupancy of the therapists should not exceed 50%.

Input probabilities

In order to perform a simulation study using random inputs, we have to specify input probability distributions. The following probability distributions should be specified for this simulation study:

- Inter arrival times of the patients;
- The distribution of patient types;
- The total number of treatments per patient type;
- The duration of the treatments for rehabilitation patients;
- The duration of the treatments for occupational patients;
- Time between treatments per patient type.

Unfortunately, there are no statistical distributions that fit the data and pass the goodness-of-fit tests. Therefore, the input probabilities are based on the empirical data (i.e., we use empirical distributions). Appendix C presents example calculations of the statistical distributions for the duration of treatments for rehabilitation patients.

4.2.2 Conceptual model

Figure 4.1 presents an overview of the structure of the conceptual model.

First thing to check, when a patient needs an appointment with a physical therapist, is whether the patient is a recurring patient or not. Recurring patients should get priority over new patients. The specialized patient (Pelvis, manual, oedema, and children patients) should get priority over the patients for rehabilitation, general, and occupational therapy. The queue is based on the priority of the patient, so first the recurring, new specialized patients, and last the new other patients. Within this order a first come first serve policy is used.

For the first patient in line the availability of a therapist is checked. If the first patient is a new patient the availability of a therapist, specialized to perform the type of treatment, is checked. If the first patient is a recurring patient, the assigned therapist is checked. If there is no (appropriate) therapist available the patient is sent to the queue, and the queue is sorted based on the priority of the patients.

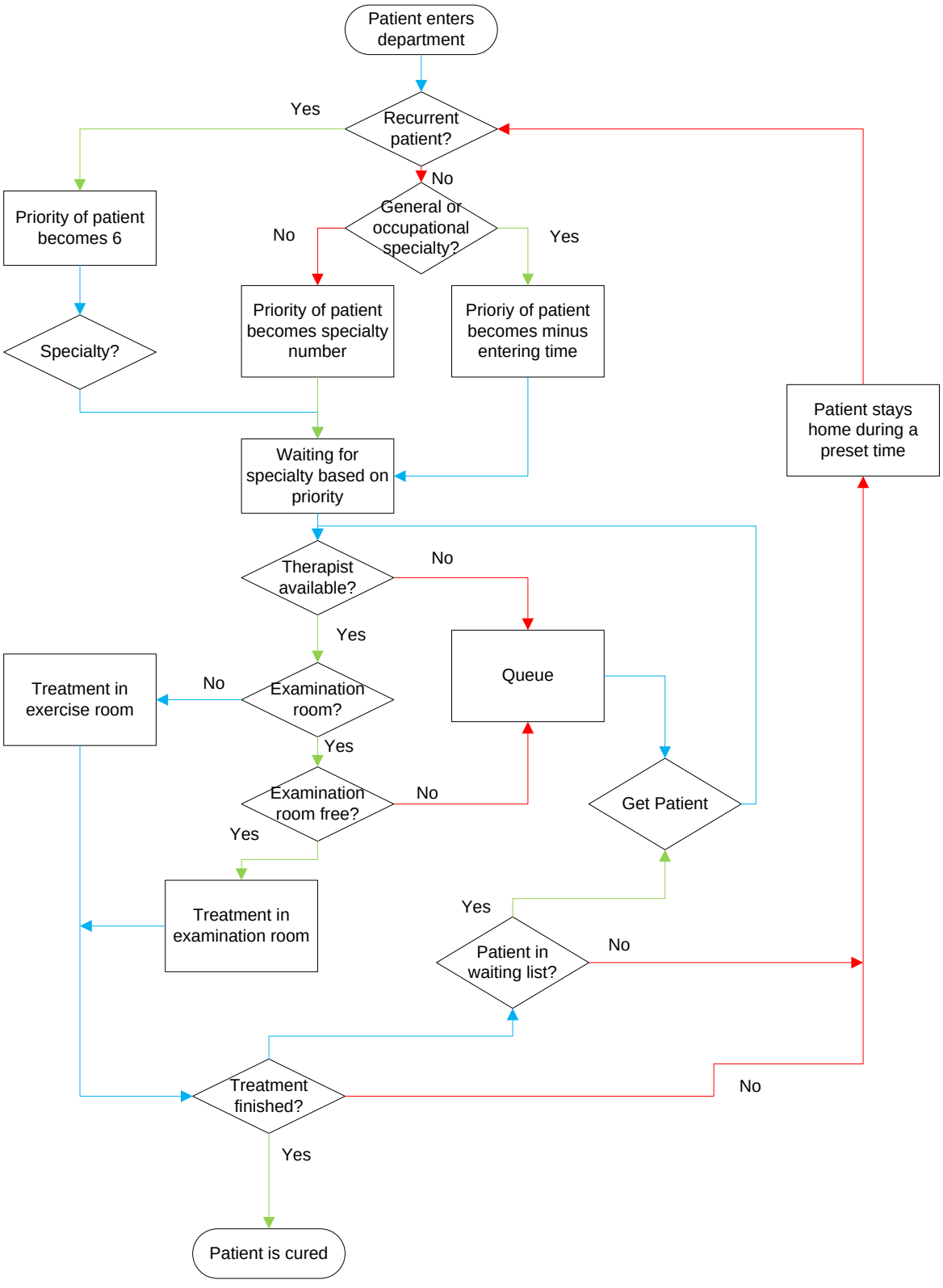

Figure 4.1: Structure of the model representing the physical therapy department

If the (appropriate) therapist is available, the next step is to determine whether the treatment should be performed in an examination room or exercise room. In case of exercise rooms there is no limit on the amount of patients. If the treatment should be performed in an examination room, an examination

room has to be available. If there is no examination room available, the patient is sent back to the queue. If the examination room is available the treatment is performed.
After the treatment is performed, we have to determine if the patient has to return for another treatment, or if the treatment plan is finished. When the patient has to return (recurring patient), the next treatment is performed after a preset time. When the treatment plan is finished, the patient leaves the system.

After a treatment is performed the therapist becomes available again. A patient is pulled out of the queue, which can receive treatment from this therapist. If such a patient is available the process is continued as described above. If there is no (matching) patient present in the queue, the therapist is idle until a new (or recurring) patient enters the system.

4.2.3 System characteristics

The following aspects of the physical therapy department should be represented in the model.

- The working times are between 8:00 a.m. and 5:00 p.m.;
- There are clinical treatments that have to be performed between 10:00-12:00 a.m. and 3:00-5:00 p.m.;
- There are at least 16 employees necessary each clinical time period, and on Tuesday afternoon and Friday afternoon at least 17;
- Some patients are treated in the examination rooms and others in the exercise rooms. In the examination rooms one patient can be treated each time and in the exercise rooms multiple patients can receive treatment at once;
- There are five different specialties that need a special trained therapist: children physical therapy, manual therapy, oedema therapy, pelvis therapy and occupational therapy;
- The duration of a treatment for general therapy takes 30 minutes, for the children, manual, oedema and pelvis therapy takes 45 minutes. For the occupational and rehabilitation therapy there are varying durations of the therapies;
- There are two large exercise rooms, five ordinary examination rooms, two children examination rooms and two pelvis examination rooms. Only the children and the pelvis therapies need specific examination rooms.

4.3 Technical design and verification

The computer program used to construct the model is Technomatix Plant Simulation v8.2. This program is relatively easy to use and extensive, but also has the ability to visualize what happens in the system during the simulation.

4.3.1. Construction of the computer model

Figure 4.2 presents an overview of the simulation model.

The model is organized into five different parts: Model Physical Therapy Department, Event Control, Simulation Settings, Experimental Factors and Performance Measurement as represented in Figure 4.2.

Model Physical Therapy Department

In the Model Physical Therapy Department part the actual simulation is presented. In the Entrance the different patients are generated according empirical distributions (The empirical distributions are based on the production data of 2008 from the Paranice system).

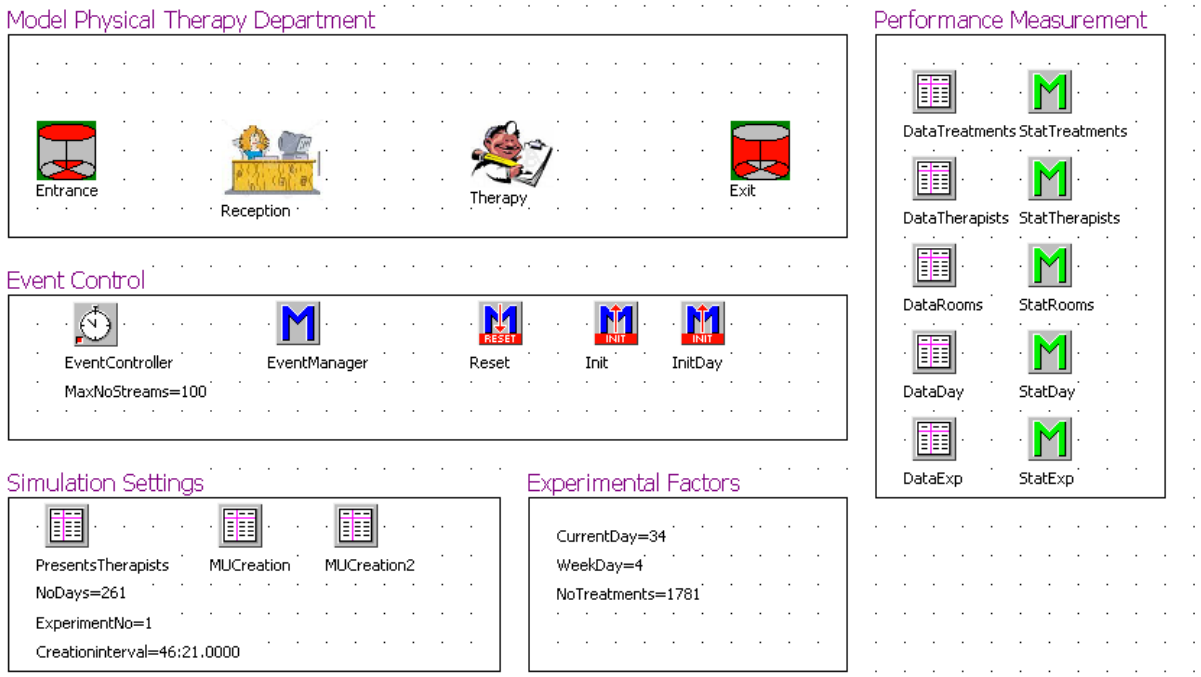

Figure 4.2: overview of the simulation model in Technomatix Plant Simulation v8.2

After the Entrance the patients go to the Reception. In the Reception they are sorted according to their priorities. The availability checks are performed next. When both a therapist and a room are available, the patient goes to the Therapy part. Otherwise the patient is set into a queue to wait until a therapist becomes available. The therapist is only allowed to perform therapy if the occupancy of the therapist is less than 50%.

In the Therapy part the patient receives treatment during the treatment time. After the treatment a check is performed to see if the patient has received all the treatments, or not. If there are treatments left to perform the patient returns after a preset time. If all the treatments are performed the patient goes to the Exit.

When the patient leaves the Therapy part, the therapist becomes available again (after checks) and a new patient can receive treatment from this therapist.

Event Control

In the Event Control, part the initialization, reset, initialization of the day and the event manager are represented.

In the initialization of the day the start and also the closure of the day is set. Besides this the initialization of the day makes sure that at 8:00 a.m. all the patients in the queue are walked through to find a matching therapist. This is also done at 12:00 p.m. because of the change of availability of the therapists at that point of the day.

The event manager takes care of ending and starting a new day at 5:00 p.m.

The last part is the Event Controller, which starts the simulation and controls the events during simulation

Simulation Settings
In the Simulation Settings part the number of days the simulation has to run and the creation interval are set. The creation interval is set based on an empirical distribution (the empirical distribution is based on the first appointments that are represented in the production data of 2008 from the Paranice system) and changes every day.

In the part Presence, Therapists the availability of therapists during different times a day and different days a week are stored. This table is loaded every day into the availability table of the specialists in the Reception of the Model Physical Therapy Department part.

Experimental Factors
The Experimental Factors are used during the simulation for calculation purposes in the performance measurement. The week day is the day of the week and is used for the setting of the availability of the therapists.

Performance Measurement
The performance of the model is kept in the performance measurement part, in order to be able to analyze the system. The data about the treatments are registered each time a patient completes his treatment. The data about the therapists and the rooms are also registered after each treatment. The data of the day is calculated and registered after each day. At the end of the experiment, the data about the experiment is calculated and registered.

Appendix D presents a more detailed description of the simulation model.

4.3.2 Verification of the model

After the first construction of the model using the empirical distributions for the creation of patients per specialty and the number of treatments per patient per specialty, there are 2027 patients created by the simulation model. This number is in comparison to the real number of unique patients that received treatment at the physical therapy department in 2008 (based on the production figures of 2008 from the Paranice system).

The model performed a total of 14820 treatments. The real number of treatments performed in 2008 is 17430 treatments (based on the production figures of 2008 from the Paranice system). This is a deviation of 15%. The reason for this deviation is the use of the empirical distribution of the number of treatments per patient. In the actual situation the patients with a lot of treatments are seen from the beginning of the year until the end of the year. Because of the random assignment of the number of treatments to the patients, in the model this is not necessarily the case. This means not all the assigned treatments are performed in the model.

To resolve this problem the empirical distribution of the number of treatments assigned to the patient is adjusted. This in order to make sure that the performed treatments in the model are in comparison to the performed treatments in the actual situation, and not the assigned treatments are in comparison.

4.4 Validation of the program

According to Law (2007, p. 259) the most definitive test of a simulation study's validity is to establish that its output data closely resembles the output data that is expected from the actual (proposed) system.

For the validation the following specifics of the performance indicators described in section 4.2.1 are used: the number of patients per specialty, the number of treatments for each specialty, and the occupancy of the examination room.

The simulation model is based on the new planning approach where double booking of examination rooms is not possible. The actual data is based on the old planning approach; however the data is comparable to the new planning approach. Because, if a patient cannot receive his treatment for reasons of no availability of an examination room, the treatment is cancelled and not billed. However the data used is based on billing.

Table 4.2 presents a comparison of the real data and the data from the simulation study regarding the number of patients and the number of treatments.

	actual # patients	sim # patients	deviation	actual # treatments	sim # treatments	deviation
General	686	672	2.0%	5604	5611	-0.1%
Manual	42	41	2.4%	206	199	3.4%
Oedema	65	66	-1.5%	919	964	-4.9%
Children	270	275	-1.9%	1412	1385	1.9%
Pelvis	279	268	3.9%	1736	1762	-1.5%
Rehabilitation	262	265	-1.1%	4545	4398	3.2%
Occupational	445	440	1.1%	3008	3009	0.0%
Totaal	2049	2027	1.1%	17430	17328	0.6%

Table 4.2: Comparison of actual data (based on the production figures of 2008 from the Paranice system) and the simulation data of the treatments and the number of patients

The deviation of the number of treated patients in the actual system, and simulation model is less than 5%. This means the simulation model compares to the actual situation regarding the number of treated patients.

The deviation of the number of treatments that are performed in the actual system and simulation model is less than 5%. This means that the simulation model compares to the actual situation regarding the number of treatments per specialty that are performed.

Table 4.3 presents the comparison of the simulation data and the actual data regarding the occupancy of the examination rooms during the day.

	Occupancy simulation	Occupancy actual	Deviation
8:00 a.m-10:00 a.m.	61,6%	55,6%	10,7%
10:00 a.m. -12:00 p.m.	26,5%	21,7%	22%
12:00 p.m.-3:00 p.m.	28,3%	42,6%	-33,6%
3:00 p.m. -5:00 p.m.	4,7%	16,6%	-71,9%
Average occupancy	30,0%	33,7%	-10,9%

Table 4.3: Comparison of actual data (based on the production figures of 2008 from the Paranice system) and the simulation data of the occupancy of the examination rooms

The deviation of the occupancy is very large during some parts of the day. This is due to a limitation of the simulation model, considering the 50% of the occupancy of the therapists, further explained in section 4.6. Eliminating this limitation by using the occupancy of 50% of the therapists over parts of the day does not result in a more accurate representation of the reality.

The overall occupancy has a deviation of almost 11%, keeping in mind the short registration period of the use of examination room as described in section 2.3.5, this is not a large deviation. Therefore, the

performance of the simulation model for the overall occupancy of the examination rooms is in correspondence with the actual situation.

4.5 Design of experiments

The design of experiments consists of three parts, first the warm up period should be defined, second the run length should be defined and third, the different experiments that should be performed.

4.5.2 Warm up period

The amount of new patients in first two weeks of a new year is relatively high due to administrative reasons. The difference is 50 new patients per day in the first two weeks against 10 per day in the rest of the year. It is therefore impossible to use a warm up period. Instead of a warm up period, there is a different creation interval used in the first two weeks than during the rest of the year.

4.5.3 Run length

The simulation program execution time is within 60 seconds for an entire year of 261 days. This is a short time, so there is no reason to shorten the run length.

4.5.4 Experiments

The experiments are divided into two scenarios. Scenario A concerns what will happen if the number of patients increases. Scenario B concerns the decrease in the number of examination rooms.

Scenario A

Scenario A concerns the increase of the number of patients. The initial experiment is to determine how many patients are minimally necessary to reach an occupancy of the nine examination rooms of 57%. This is done by increasing the number of therapists present by 20 whom are able to treat all the specialties. This in order to know all the patients can receive treatment. Table 4.4 presents the result of this experiment.

# patients	increase	avg occupancy of examination room
2161	0%	30%
3242	50%	53%
3458	60%	54%
3674	70%	59%
3565	65%	57%

Table 4.4: Experiments in first scenario about increase In the number of patients to reach an occupancy of 57%

The results of Table 4.4 show that an increase of 65% is needed to achieve an occupancy of the examination rooms of 57%. Remark that the results in Table 4.4 are obtained by not taking special therapists into account.

Table 4.5 describes the experiments in scenario A.

The first three experiments in Table 4.5 are used to determine the number of FTE that is necessary in the initial situation with 2161 patient, given the 50% occupancy of therapists. The occupancy of the examination rooms needs to be increased to 57%. Therefore, an increase of 65% in the number of patients is needed. Experiment 4, 5, and 6 shows the description of the experiment. However, an increase of 65% is not achievable. It is more likely, based on the experience of the head of the department, that increase will be 15%. The last three experiments concern the number of FTE necessary for the expected increase of 15% in the number of patients.

	# pat	# general therapist	# manual therapist	# oedema therapist	# children therapist	# pelvis therapist	# rehab therapist	# occup therapist	# total
Exp 1	2161	15	1	1	2	3	2	1	25
Exp 2	2161	16	1	1	2	2	2	1	25
Exp 3	2161	17	1	1	2	2	2	1	26
Exp 4	3565	20	1	2	3	3	3	2	34
Exp 5	3565	20	1	2	3	3	2	2	33
Exp 6	3565	20	1	2	3	3	2	1	32
Exp 7	2493	17	1	1	2	2	2	1	26
Exp 8	2493	18	1	1	2	3	2	1	28
Exp 9	2493	18	1	1	2	3	2	2	29

Table 4.5: Experimental settings in scenario A

Amongst the experiments the number of (specialized) therapists is varied. These variations are based on the occupancy of the (specialized) therapists.

Scenario B

Scenario B concerns the decrease of the number of examination rooms. The initial experiment is to determine how many rooms are minimally necessary to perform the number of treatments. This is done by making no exceptions between rooms, so all the treatments can be performed in all the examination rooms. Table 4.6 presents the result of this experiment. The first line in Table 4.6 represents the initial situation with five general, two pelvis and two children examination rooms.

# room	# treatment	Avg occ therapists	Avg occ room 8-10	Avg occ room 10-12	Avg occ room 12-15	Avg occ room 15-17	Avg occ rooms
init	17328	34.6%	61.6%	26.5%	28.3%	4.7%	30.0%
9	17492	34.7%	62.4%	26.8%	28.8%	4.9%	30.5%
8	17335	34.5%	68.1%	29.6%	33.0%	4.9%	33.8%
7	17205	34.4%	73.6%	35.6%	36.8%	6.8%	38.0%
6	16871	34.0%	81.2%	43.2%	40.2%	7.6%	42.7%
5	16530	33.6%	85.7%	50.2%	49.2%	11.8%	49.2%
4	15832	32.8%	90.9%	60.4%	56.8%	17.8%	56.5%
3	14980	31.9%	95.9%	71.8%	71.7%	29.5%	67.7%

Table 4.6: Experiments in second scenario about decrease number of examination rooms to reach an occupancy of 57%

The results of Table 4.6 show that between four and six examination rooms are needed. Remark that the results in Table 4.6 are obtained by not taking special rooms into account.

Table 4.7 presents the description of the experiments needed to determine the number of (specialized) examination rooms.

The first five experiments are based on six examination rooms. Experiments six through ten are based on five examination rooms. And the last three experiments are based on four examination rooms.

	Number of general rooms	number of children rooms	number of pelvis rooms	Total
Exp 1	2	2	2	6
Exp 2	4	0	2	6
Exp 3	3	1	2	6
Exp 4	3	0	3	6
Exp 5	2	1	3	6
Exp 6	1	2	2	5
Exp 7	0	2	3	5
Exp 8	3	0	2	5
Exp 9	2	1	2	5
Exp 10	2	0	3	5
Exp 11	1	0	3	4
Exp 12	1	1	2	4
Exp 13	2	0	2	4

Table 4.7: Experimental settings in scenario B

Amongst the experiments the number of specialized rooms is varied. These variations are based on the occupancy of the (specialized) examination rooms. The number of therapists is set to the default situation as described in section 2.3.4 (20.8 FTE) and the number of patients is 2161.

4.6 Limitations of the model

Due to the fact a simulation model is a representation of the reality; there are some limitations of the model.

The first limitation concerns the use of registered data from billing instead real data about the duration of the treatments and number of treatments performed. For example two patients can receive rehabilitation treatment at the same time in the exercise room by one therapist, but this is registered as two different treatments, at different times. The treatment time for a treatment is registered to be 25 minutes, while the actual treatment was less, for example 15 minutes. This results in a less accurate described of reality, because of the reduction in variability. But on average the treatment times are correct.

The second limitation concerns the unavailability of data about the arrival process. The arrival process in the simulation is modeled based on the first appointments of the patients. This can result in a deviation from the actual situation.

The third limitation concerns the clinical patients and the group patients. These patients are not directly taken into account in the model.

The fourth and last limitation of the model concerns the distribution of time of the therapists. The model assumes that all the other activities, besides the direct patient related activities are performed at the end of the day. This is the result of the programming of the model, because the occupancy of a therapist cannot exceed the 50%. This results in a deviation between the actual situation and the modeled situation of the occupancy of the examination rooms during the day. This means the actual occupancy will be about 10% larger than presented in this research.

4.7 Conclusion

The simulation described is valid to calculate the number of FTE necessary and the number of examination rooms.

5 Computational results

In this chapter the simulation model described in the previous chapter is used to answer research question 6 and 7, which concern the number of patients and the number of examination rooms needed. The computational results have an overall error of 5% and for the occupancy an error of 10% based on the results of the validation of the simulation model in Chapter 4.

Section 5.1 presents the results concerning the increase in the number of patients. Section 5.2 presents the results concerning the decrease in the number of examination rooms. The conclusion of this chapter is presented in section 5.3.

5.1 Scenario A: increasing number of patients

This section provides an answer to research question 6: How many patients are necessary to increase the occupancy with the given amount of examination rooms?

5.1.1 Description of scenario A

Based on the data of previous years there is growth expected in the rehabilitation patients and treatments. In order to make the decision to recruit more patients it has to be clear how many patients need to be recruited to reach the average occupancy of 57% of the examination rooms.

In this scenario the decision variables number of patients and number of (specialized) therapists are used. In this way the number of treatments that need to be performed to reach the occupancy of 70% during outpatient time and 40% during clinical time (so an average occupancy of about 57%) of the examination rooms can be calculated.

In this scenario one children's therapist, the general therapists, and to complete the number therapists one or two rehabilitation therapists are assigned to clinical work.

5.1.2 Performance of scenario A

The performance of scenario A consists of three parts. First, the number of FTE is calculated based on the current number of patients. Second, the number of FTE is calculated based on the increase of 65% in patients. Third, the number of FTE is calculated based on the increase of 15% in patients.

Current situation: 2161 patients

Table 5.1 presents the results of the number of therapists necessary to treat the number of patients in the current situation, so with 2161 patients per year.

	experiment 1	experiment 2	experiment 3
# FTE	25	25	26
# treatments	16328	18304	18335
avg occupancy manual therapist	11.5%	11.5%	11.3%
avg occupancy pelvis therapist	30.1%	43.7%	43.3%
avg occupancy children therapist	46.5%	46.0%	46.2%
avg occupancy oedema therapist	47.7%	47.3%	46.4%
avg occupancy general therapist	53.3%	52.7%	49.8%
avg occupancy occupational therapist	42.3%	42.8%	42.6%
avg occupancy rehabilitation therapist	56.7%	48.4%	48.1%
avg occupancy therapists	47.9%	48.9%	47.0%
avg occupancy rooms	32.7%	33.6%	33.6%

Table 5.1: the results of the experiments about the number of therapists necessary to perform the treatments with 2161 patients, based on the simulation study

The difference between the first two and the third experiment is the number of FTE. The difference between the first and second experiment is in the first experiment 15 general therapists and three pelvis therapists are available and in the second experiment, 16 general therapists and two pelvis therapists.

The results show that an increase in FTE without an increase in patients in not desired, the increase is 30 treatments. In experiment 1 the occupancy of the rehabilitation therapists is too high. The best distribution of therapists is as in experiment 2. Where 2161 patients are treated by 16 full time general therapists, one manual, one oedema, two children, two pelvis, two rehabilitation, and one occupational FTE. At the moment there is a total of 24.5 FTE present, which in total is in comparison to result from the simulation study. There is a difference however in the amount of FTE of the occupational therapy, where according to the simulation model 1 FTE should be sufficient, at the moment there are 3.7 FTE present. The reason for this might be that indirect patient related time for occupational therapists is larger than for physical therapists. However, this does not clarify the total difference.

The distribution between different specialties cannot be compared with the actual situation. For reasons that no information of the actual situation is available.

Increase of 65%: 3565 patients

Table 5.2 presents the number of therapists necessary to treat the number of patients increased by 65%, so with 3565 patients per year.

	Experiment 4	Experiment 5	Experiment 6
# FTE	34	33	32
# treatments	30261	30136	28623
avg occupancy manual	14.6%	14.7%	14.9%
avg occupancy pelvis	48.2%	47.6%	47.2%
avg occupancy children	40.8%	41.3%	40.8%
avg occupancy oedema	44.3%	44.3%	44.8%
avg occupancy general	48.0%	48.1%	48.1%
avg occupancy occupational	36.5%	36.4%	54.0%
avg occupancy rehabilitation	34.2%	49.4%	49.4%
avg occupancy therapists	44.3%	45.6%	46.3%
avg occupancy rooms	56.0%	55.8%	54.8%

Table 5.2: the results of the experiments about the number of therapists necessary to perform the treatments with 3565 patients, based on the simulation study

The difference in the experiments is the number of FTE. In experiment 4, amongst others, there are three rehabilitation therapists and two occupational therapists. In experiment 5 there are two rehabilitation therapists and two occupational therapists. In experiment 6 there are two rehabilitation therapists and one occupational therapist.

There are not enough treatments performed in experiment 6. The difference in the number of treatments between experiment 4 and 5 are not significant. Though, experiment 4 uses more FTE. Therefore, the results of experiment 5 are preferable.

The best distribution of therapists is as in experiment 5. Where 3565 patients are treated by 20 full time general therapists; one manual, two oedema, three children, three pelvis, two rehabilitation, and two occupational therapists.

The occupancy of the examination rooms is 55.8%. This is lower than the 57% as formulated in section 2.3.5, but is the best approximation that can be made with the simulation model.

Increase of 15%: 2493 patients
Table 5.3 presents the number of therapists necessary to treat the number of patients increased by 15%, so with 2493 patients.

	experiment 7	experiment 8	experiment 9
# FTE	26	28	29
# treatments	20727	20794	20802
avg occupancy manual	12.0%	11.2%	11.3%
avg occupancy pelvis	52.0%	34.4%	34.1%
avg occupancy children	50.0%	50.0%	49.5%
avg occupancy oedema	47.6%	46.8%	46.3%
avg occupancy general	52.4%	49.5%	49.5%
avg occupancy occupational	52.3%	52.6%	27.2%
avg occupancy rehabilitation	37.2%	37.2%	36.7%
avg occupancy therapists	49.3%	45.7%	44.0%
avg occupancy rooms	37.9%	38.0%	37.9%

Table 5.3: the results of the experiments about the number of therapists necessary to perform the treatments with 2493 patients, based on the simulation study

The difference in the experiments is the number of FTE. In experiment 7, amongst others, there are 17 general therapists, two pelvis therapists and one occupational therapist. In experiment 8 there are 18 general therapists, three pelvis therapists and one occupational therapist. In experiment 9 there are 18 general therapists, three pelvis therapists and two occupational therapists.

The difference in the number of treatments between experiment 7, 8 and 9 are not significant. Though, experiment 7 uses less FTE. Therefore, the results of experiment 7 are preferable.

The best distribution of therapists is as in experiment 7. Where 2493 patients are treated by 17 full time general therapists, one manual, one oedema, two children, two pelvis, two rehabilitation, and one occupational therapist.

The occupancy of the examination rooms is 37.9%, this means the number of examination rooms can still be decreased in this scenario.

5.1.3 Conclusion of scenario A

An increase of 65% to 3565 patients leads to the desired occupancy of examination rooms. In this case there is 33 FTE needed to perform the treatments with the following distribution: 20 full time general therapists, one manual, two oedema, three children, three pelvis, two rehabilitation, and two occupational therapists.

An increase of 65% is not likely to be obtained; more likely is an increase of 15% to 2493 patients. In this case there is 26 FTE needed to perform the treatment with the following distribution: 17 full time general therapists, one manual, one oedema, two children, two pelvis, two rehabilitation, and one occupational therapist. With this number of patients and FTEs an occupancy of 37.9% of the nine examination rooms can be achieved.

5.2 Scenario B: decrease in number of rooms

This section provides an answer to research question 7: How many examination rooms are necessary to perform the current mix and volume of the patients with an increased occupancy?

5.2.1 Description of scenario B

In this scenario the decision variables the number of examination rooms and number of patients is used. In this way the number of examination rooms that need to be performed to reach occupancy of the examination rooms of 57% can be calculated.

Based on the initial experiments performed in section 4.5.4 a minimum of four examination rooms and a maximum of six examination rooms are needed.

5.2.2 Performance of scenario B

The performance of scenario B consists of two parts. First, the number of examination rooms is calculated based on the current number of patient and the current distribution of therapists. Second, the number of examination rooms is calculated based on the increase of 15% in patients, and with the earlier distribution of therapists in section 5.1.2.

Current situation: 2161 patients

Table 5.4 presents the different experiments with different number of total rooms, pelvis, children and general rooms.

Exp no	# treat-ments	# general room	# children rooms	# pelvis room	Occ rooms 8-10	Occ rooms 10-12	Occ rooms 12-3	Occ rooms 3-5	Average occupancy rooms
1	16733	2	2	2	0.78	0.41	0.41	0.09	0.42
2	16898	4	0	2	0.78	0.42	0.43	0.09	0.43
3	16654	3	1	2	0.77	0.41	0.41	0.08	0.42
4	16821	3	0	3	0.77	0.41	0.42	0.09	0.42
5	16497	2	1	3	0.78	0.40	0.38	0.08	0.41
6	16514	1	2	2	0.85	0.48	0.48	0.13	0.49
7	16295	0	2	3	0.83	0.48	0.47	0.12	0.48
8	16417	3	0	2	0.85	0.49	0.49	0.12	0.49
9	16215	2	1	2	0.83	0.48	0.46	0.11	0.47
10	16295	2	0	3	0.83	0.48	0.47	0.12	0.48
11	15303	1	0	3	0.87	0.56	0.50	0.15	0.52
12	15437	1	1	2	0.89	0.57	0.54	0.16	0.54
13	15677	2	0	2	0.89	0.57	0.57	0.16	0.55

Table 5.4: the results of the experiments about the number of rooms necessary to perform the treatments with 2161 patients, based on the simulation study

The difference amongst the experiments is the number examination rooms. In experiments 1-5 the total number of examination rooms is six. In experiments 6-10 the total number of examination rooms is five. In experiments 11-13 the total number of examination rooms is four.

Based on Table 5.4 an interesting remark can be made. When the number of children rooms is 0 the overall system performs better than when the children treatments have to be performed in a specific room, provided that the number of pelvis rooms is sufficient. This can be explained because the system becomes more flexible when using rooms with multiple functions.

A second remark is that the number of treatments decreases when the number of rooms is decreased. However, this effect is not caused by simply the decrease in examination rooms, but due to the decrease in planning flexibility.

Based on the results in Table 5.4 we can conclude that the number of examination rooms should be four or five. Although, Table 5.4 shows a reduction in the number treatments compared to the actual situation. However, the number of treatments can be reestablished by introducing a better planning method.

The best results are shown by experiment 13 (occupancy of 55%). However, by decreasing the number of examination rooms to four, the flexibility is narrowed too much (an occupancy of the examination rooms of 89% between 8-10 am). By decreasing the number of examination rooms to five, the flexibility is still narrowed (an occupancy of the examination rooms of 85% between 8-10 am), but still sufficient. The best distribution of examination rooms is as in experiment 8 (occupancy of the examination rooms of 49%) based on five examination rooms and the average occupancy, where 2161 patients are treated in two pelvis rooms and three multifunctional rooms.

Increase of 15%: 2493 patients

The results in Table 5.4 have shown that not using separate children rooms perform the best and at least two pelvis rooms are needed. Moreover, a minimum of five rooms is needed. These configurations are tested in this scenario.

Table 5.5 presents the different experiments and results with different number of total rooms, pelvis and general rooms for 2493 patients per year.

Exp no	# treat-ments	# room	# pelvis room	# general room	Occ rooms 8-10	Occ rooms 10-12	Occ rooms 12-3	Occ rooms 3-5	Average occ rooms
1	20844	8	2	6	63.8%	46.5%	45.8%	14.2%	42.9%
2	20755	8	3	5	61.3%	45.3%	47.1%	14.6%	42.6%
3	20761	7	2	5	67.6%	53.4%	53.8%	17.4%	48.7%
4	20723	7	3	4	67.4%	50.8%	54.3%	18.6%	48.5%
5	20627	6	2	4	77.6%	62.5%	60.7%	21.0%	56.0%
6	20587	6	3	3	77.3%	60.6%	60.2%	23.3%	55.9%
7	20256	5	3	2	88.0%	70.0%	70.4%	29.4%	65.1%
8	20000	5	2	3	88.3%	67.7%	67.9%	28.7%	63.7%

Table 5.5: the results of the experiments about the number of rooms necessary to perform the treatments with 2493 patients, based on the simulation study

The difference amongst the experiments is the number examination rooms. In experiments 1 and 2 the total number of examination rooms is eight. In experiments 3 and 4 the total number of examination rooms is seven. In experiments 5 and 6 the total number of examination rooms is six. In experiments 7 and 8 the total number of examination rooms is five.

Based on the results in Table 5.5 we can conclude that the number of examination rooms should be six. The best distribution of examination rooms is as in experiment 5 (occupancy of 56%), where 2493 patients are treated in two pelvis rooms and four multi-functional rooms.

5.2.3 Conclusion of scenario B

In the current situation the number of five examination rooms (two pelvis and three multi usable rooms) are needed to perform the treatments (occupancy of 49%). With increase of 15% in the

number of patients, six examination rooms (two pelvis and four multi usable rooms) are needed to perform the treatments (occupancy of 56%).

5.3 Conclusion

An increase of 65% to 3565 patients leads to an occupancy of 55.8% of the actual number of examination rooms (nine). In this case there is 33 FTE needed to perform the treatments with the following distribution: 20 full time general therapists, one manual, two oedema, three children, three pelvis, two rehabilitation, and two occupational therapists.

An increase of 15% to 2493 patients leads to an occupancy of 37.9% of the actual number of examination rooms (nine). In this case there is 26 FTE needed to perform the treatment with the following distribution: 17 full time general therapists, one manual, one oedema, two children, two pelvis, two rehabilitation, and one occupational therapist.

With the reduction of the number of examination rooms the following can be concluded. In the current situation with 2161 patients five examination rooms (two pelvis and three multi usable rooms) are needed to perform the treatments (occupancy of 49%). With increase of 15% in the number of patients, six examination rooms (two pelvis and four multi usable rooms) are needed to perform the treatments (occupancy of 56%).

6 Implementation of the new planning approach

Based on the new planning approach described in Chapter 3 and the results from the simulation study described in Chapter 5, some changes should be made in order to increase the efficiency of the physical therapy department.

This chapter provides insight in the difficulties about change and some guidelines how to overcome these difficulties, which is an answer to research questions 8 and 9. In section 6.1 an introduction is given to organizational change. Section 6.2 describes the causes of resistance to change in theory. Section 6.3 describes the way to overcome the resistance to change in theory. Section 6.4 describes the implication for the physical therapy department. Section 6.5 gives the conclusions of the chapter.

6.1 Organizational change

Change in organizations is inevitable to be able to grow and stay competitive. This is not different for health care organizations in the Netherlands, where a population that grows older will make more and more use of the health care facilities. This means that the costs of health care will grow, if the organizations will not change. This already happens where costs of square meters will be an issue and also by improving the effectiveness of the department. These organizational changes are significant because they impact activities performed within organizations as well as individual staff and clients on a personal level (Thompson, 2010).

6.1.1 Definition

In order to be able to understand the process of organizational change a clear definition is needed. There are many definitions of organizational change as:

Organization change is the movement of an organization away from its present state and toward some desired future state to increase its effectiveness (George & Jones, 2008, p. 603)

Organizational change is considered the adoption of a new idea or behavior by an organization (Daft, 2001, p. 357)

Organizational change is defined as a modification in goals, structures, or operations of an organization (Thompson, 2010).

Organizational change at an operational level or process level requires simple changes to day-to-day tasks, thus incrementally improving performance. However, change can also be at a strategic level, impacting on the direction of a company and the people it employs, thus requiring step changes at operational or process levels (Price & Chahal, 2006)

Even though the definitions differ from each other, the principle is the same: the movement of the organization by changing (one of) its elements.

6.1.2 Change process

Changing an organization is not just introducing the change and wait. Kurt Lewin (George & Jones, 2008, pp. 620-621) designed a three-step process to implement change. The first step is to unfreeze the organization from its present state, the second step is to make the change and last to refreeze the organization in the new state so that the members of the organization do not revert to their previous work attitudes and behaviors.

To perform this three step process the following steps could be performed according to George & Jones (2008, pp. 621-623):

- Diagnosis of the organization: recognize the existence of a problem and the need for change (unfreezing the organization)
- Determining the desired future state: to identify and plan where the organization needs to be
- Implementing action: identification of resistance to change and deciding who will be responsible (making the change)
- Evaluating action: asses the degree to which the change have accomplished its objectives
- Institutionalizing the action: to make it the norm in the organization (refreezing the system).

The first step in the action research is one of the most important ones. If the need for change is not clear to the employees involved, the implementation of the change will most likely fail (Williams (1989) in: A Strategic Framework for Change Management (Price & Chahal, 2006)).

6.1.3 Triggers for change

The triggers for change fall into two categories: external and internal triggers. External triggers are for example the market competition or the demand from stakeholders and internal triggers are the improvement of operational efficiency or the need to improve the quality.

Oakland & Tanner (2007) argue that, even though the first impression is that are two triggers, all the triggers are a manifestation of external drivers for change. For example the need to improve the quality of the product is most likely the result of the demand from the customer, or the stakeholders.

The key drivers for the change should be communicated and understood by the stakeholders involved to make the change a success.

6.1.4 Types of change

Besides the difference in trigger of change, there is also a difference in the way the change affects the organization. Krovi (1993) distinguishes three types of organizational change:

- Evolutionary vs revolutionary changes: where evolutionary change is about modest adjustments and revolutionary change is about serious upheavals.
- First vs second order change: first order change involves a variation that occurs within a given system which itself remains unchanged. Second order change involves a variation whose occurrence changes the system itself
- Alpha and gamma change: alpha change involves variation in the level of some existential state. Gamma change involves a redefinition or reconceptualization

The distinguished three types are consistent with the difference between transitional change and transformational change as described by Price & Chahal (2006). Transitional change is the implementation of a new desired state requiring dismantling existing ways and transformational change is implementing an evolutionary new state, requiring major and ongoing shifts in organizational strategy and vision.

6.2 Resistance to change

This section gives an answer to research question 8: What difficulties can arise by changing to the new planning approach?

With the implementation of a change an amount of resistance will always be present. Huczynski and Buchanan (2001: in A Strategic Framework for Change Management (Price & Chahal, 2006)) defined resistance to change as an inability or an unwillingness to discuss or to accept organizational changes that are perceived in some way damaging or threatening to the individual.

According to Kurt Lewin a wide variety of forces make organizations resistant to change, and a wide variety of push forces organizations toward change. According to the force-field theory these two sets of forces are always in opposition in an organization. Figure 6.1 represents this. When the forces are evenly balanced, the organization is in a state of inertia and does not change. To get an organization to change, managers must find a way to increase the forces to change, reduce the resistance to change or both simultaneously (George & Jones, 2008).

Figure 6.1: When push and pull forces are equal, the organization will not change

These forces to change can be allocated to three areas in the organization, the individual resistance, the group resistance and the organizational resistance. The resistance on individual level is the most important resistance for the physical therapy department.

6.2.1 Individual resistance

George & Jones (2008, pp. 609-610) describe the following variables that cause the resistance of change on individual level:

- Uncertainty and insecurity: people resist change because they are uncertain and insecure about the outcome
- Selective perception and retention: there is a general tendency for people to selectively perceive information that is consistent with their existing views
- Habit: people's preference for familiar actions and events. People also have the tendency to maintain the status quo

In line with the selective perception and retention is the use of a multidimensional definition towards attitudes as described by Piderit (2000). One key benefit of using the multidimensional definition to describe employees' attitude towards change is conceptualizing each dimension as a separate continuum. This allows the possibility of different reactions along the different dimensions.

There are two dimensions distinguished: the cognitive and emotional dimension. Cognitive dimension of an attitude refers to an individual's beliefs about the attitude object. Emotional dimension of an attitude refers to an individual's feelings in response to the attitude object. The simplest case of ambivalence to imagine is the case in which an individual's cognitive response to a proposed change is in conflict with his or her emotional response to the proposal.

The above goes for all organizations, including health care organizations, but the professionals working in health care are different from other employees. Callaly & Arya (2005) describe medical staff

as being particularly resistant to change, because of personal factors such as fear of loss of power, autonomy or change of role, skepticism about the political and organizational imperatives for change that are often seen as transient and being imposed by government without sufficient opportunity for input by clinical staff.

6.3 Overcoming the resistance

That resistance is inevitable is made clear above, but there are some tactics to reduce the resistance. This section gives an answer to research question 7: What are the solutions to these difficulties?

George & Jones (2008, pp. 625-626) describe the following tactics to reduce the resistance:

- Education and communication: the most important to change is uncertainty about what is going to happen. Through education and communication, the members of the organization can be informed about the change and how it will affect them
- Participation and empowerment: Participation complements empowerment by increasing employees' involvement in decision making and giving them greater autonomy to change their work procedures
- Facilitation: both managers and employees find change stressful because established task and role relationships alter as it takes place.
- Bargaining and negotiation
- Manipulation: when it is clear that change will help some individuals and groups at the expense of others, senior managers need to intervene in the bargaining process and manipulate the situation to secure the agreement or at least the acceptance, of various people or groups to the results of the change process
- Coercion: the ultimate way to eliminate resistance to change is to coerce the key players into accepting change and threaten consequences if they choose to resist.

Besides the established ways of overcoming resistance like described above, another way is gaining more interest. It is about turning resistance into attraction, so not focusing on the resistance, but focusing on how the resistance can become an attraction (Plsek & Kilo, 1999). This can be done in two ways, first by talking to the person who resists the change. During this personal talk it should be made clear what the person currently likes and dislike on the way of working. Most of the times some of the dislikes can be taken away by the change, which makes the change much more attractive than before the open and honest conversation.

Second, according to Plsek & Kilo (1999) ideas spread more rapidly when they can be easily observed or tried out before investing in full adoption. While the technical soundness of the idea can create attractive pull, the perceived risk of making the change can distort the pulling force. The ability to observe someone trying the change, and to be able to try it out themselves, increases the attraction to the change. So the start of the change in a small and controlled situation is the second way to bend the resistance to attraction.

6.4 Implications for the physical therapy department

For each organization the change process differs, because of the type of change that needs to be implemented, but also because of the type of resistance that is expected regarding the change.

6.4.1 Description of the change

The change that needs to be carried through is a transformational change. The working methods of the therapists need to be adjusted. Not only the planning part of the treatments is important but also, when the number of examination rooms will decrease, a more punctual treatment schedule is needed.

The treatment schedule will be less flexible because fewer rooms are available. This means that therapists have to make sure that they will not originate from their time frame. Originating will not only influence their schedule, but also the schedule of their colleagues and other patients.

The moment treatments are planned centrally, all other activities of therapists at fixed times need to be registered in digital agendas to prevent double booking. This asks for a change in routine and mindset for the therapists.

One of the ingredients to make the department perform better is a better distribution of the number of therapists present during the week. This means that some therapists have to work at their free Friday afternoon, after 20 years of Friday-afternoon-leave.

The final step of change is not only the adaption of the therapists to the new working methods, but also the change in the way of working by receptionists. Their jobs will change; they will get more responsibility by planning patients for the therapists.

The trigger for the overall change is internal: it is the opinion of the board of the hospital that the amount the square meters that are in use by the department are too large in correspondence with their contribution to the hospital.

However, when taking a closer look, the change is external. Because of the increase in the number of patients more hospital space is needed to treat all patients. So the real trigger for change is the changes in the demographical area which influences the internal triggers, just like stated by Price & Chahal (2006).

6.4.2 Problems with the change

Therapists at the physical therapy department are resistant to the change. There are some who think it is a good idea to change the working methods, but do not agree to decreasing the number of examination rooms, or vice versa. The resistance comes forth out of insecurity: the therapists do not really know what changes in working methods will be made, and how this change will influence their current working methods.

Furthermore, the resistance concerns selective perception. Many of the therapists witness the shortage of examination rooms at times of the day. This shortage indicates, according to the therapists, that the number of examination rooms cannot be decreased but should be increased.

When changing the working times of therapists build on rights come to play. There is resistance when leave application is rejected or leave should be consumed a different day during the week. Their habits and build on rights makes it hard to accept the change.

Finally, the physical therapists are health care professionals, so also the personal factors described by Callaly & Arya (2005) are of influence to their resistance to change. They fear a loss of power and autonomy: with the new working method therapists are not fully in charge of their agenda anymore.

This leads to a change of role for the receptionists, and a change in the relationships between the receptionists and the therapists. The personal factor of the political and organizational change is also of influence. The therapists question why financial reasons should be leading in making a decision about the service delivered to patients.

6.4.3 Overcoming the problems

Overcoming the resistance to change is done by making clear to the therapists why the change is needed and how the change will influence them. If this is not clear, the implementation of the change

is likely to fail. Thus, the first step in overcoming the problems to change is to educate the therapists and communicate with them.

After this first step the resistance to change has not disappeared for all therapists. To convince all therapists of the need for change a personal talk might help. Try to make them see the advantages of the change and how this will (positively) influence their jobs.

The third step is to make the therapists participate in the change process. It might be a good idea to select someone who is positive about the changes suggested and can help convince colleagues. Also, it might be a good idea to include the therapists in designing the new working method in order to make sure the changes will align with their demands.

The fourth step is to start a pilot of the new working method. Some therapists let their appointments be planned by the receptionists. This way they can see how things will be work and whether the resistance they perceive is justified in practice. Also, their colleagues can see how the new method works and share experiences.

If all this does not work, the final step is to manipulate or coerce the person that is stopping or negatively influences the change. This is the final option to make sure the change will be realized, however not the preferred one and it is only possible when only a small number of therapists are still against the change.

6.5 Conclusion

The change of working method is a transformational change for the physical therapy department. It needs to be totally clear to the therapists what the change will be, why it is necessary and how it will influence their own performance.

Because the therapists, in the new working method, do not directly plan their own patients, the therapists might encounter the loss of power and autonomy. This makes them resistance to the change. Also the habit of being free at certain days a week makes it difficult to change this instance.

To overcome the resistance to change the therapists need to know what the change is about and how it will influence them. This can be executed through education and communication, participation, and by starting a pilot. This pilot enables the therapists to experience how the change works and what it will bring them. If this does not help they can be manipulated or coerced as a last resort.

7 Conclusion and Recommendations

Based on the description of the new planning system and the results of the simulation study conclusions and recommendations can be made. This chapter provides an answer to the central research question: *"How can the productivity at the physical therapy department of The hospital be increased?"*

7.1 Conclusion

Before the research question can be answered a solution to the most important problem areas of the physical therapy department need to be found. Ideally this will lead to a better productivity of the department. The first problem concerns the availability of therapists. The availability of the therapists is not evenly spread during the week. The second problem concerns the occupancy of the examination rooms which is too low. The third problem there are patients rejected due to unavailability of examination rooms.

These problems can be solved at the operational level or tactical level or both. At the operational the introduction of a new planning method will solve the problem of a unevenly distribution of availability of therapists during the week. By central planning the double booking of examination rooms can be avoided.

At the tactical level a change in the number of examination rooms or the increase in the number of patients can solve the problem about the occupancy of the examination rooms. There is an increase 65% (to 3565 patients) needed to reach an occupancy of 57% of the examination rooms. To be able to treat all these patients a total of 33 FTE are necessary according to the simulation study.

However an increase of 65% is not likely to be obtained. An increase of 15% to 2493 patients will be more likely when the extra effort is made to recruit more patients. In this case an occupancy of 37.9% of the examination rooms can be achieved, with 26 FTE.

The number of examination rooms can be decreased by four in the current situation, resulting in an overall occupancy of the examination rooms of 49%, according to the simulation study. However, with the use of a good planning method a higher occupancy can be obtained. The examination rooms need to be used more flexible, there should be two pelvis rooms (where also other patients can receive treatment, except children) and three multi usable rooms (where all patients can receive treatment except pelvis patients).

With an increased number of patients by 15% the number of examination rooms can be decreased by three. In this case four general and two pelvis rooms are needed.

For these kinds of changes it is important that the therapists need to understand the need for the change and the implications it has for them. Also an effort should be made to avoid the resistance to the change to make sure the implementation will be successful.

We can conclude that the answer to the research question *"How can the productivity at the physical therapy department of The hospital be increased?"* is to introduce a new planning method, increase the number of patients (15%) and give up at least three examination rooms.

7.2 Recommendations

In this part recommendations are made for the physical therapy department. Some of these recommendations are of practical use and others are for further research

7.2.1 Practical recommendations

The first recommendation to the physical therapy department is as quickly as possible start with the implementation of the new planning method. The advises concerning implementation of change, as described in chapter 6, should be kept mind. The new therapists that are hired should at least work on the Friday afternoon.

The second recommendation concerns the reduction of the number of examination rooms. The department should reduce the number of examination rooms by three. In this situation there is still the possibility to grow. The general rooms need to be prepared to perform all the treatments, except pelvis treatments. This way the planning of examination rooms becomes more flexible. One of the examination rooms needs to be a large room for the intake of children patients.

The third recommendation concerns the use of a proper waiting list. Currently, there is no registration of the waiting time the patients. When the waiting time is clear, it might be easier to manage the department.

The fourth recommendation concerns start hiring new therapists. It takes about five years to train an inexperienced therapist. Combined with the fact that within five years a few experienced therapists will retire, they need to hire new therapists right now.

7.2.2 Recommendations for further research

There are some recommendations for further research. The number of effective FTE decreases in the coming years. This is due to the aging of the therapists currently working. The consequence is that the efficiency of the therapists needs to be increased. Research can shows where the therapists lose time and where they can gain time to improve the productivity.

For research purposes and for effectively controlling the department an administrative system should be used that registers the actual time spent on different tasks.

Before starting to hire therapists to treat more patients, a good and solid research needs to be done about the amount of patients the department can recruit.

To develop a planning system that does not use a waiting list. In this way the department can provide a more patient friendly service.

A study needs to be performed to see if the new planning approach improves the productivity of the department. During this study a calculation can be made about the benefits of the new planning method and the costs of the current method.

To perform a benchmark study to see how other physical therapy departments perform and what planning approaches they use.

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Appendix A: Calculation of number of employees necessary

In this Appendix the calculation of the minimum number of employees that should be present each day. This is based on the time that should be used to perform the clinical work.

Dept	Direct treatment time in min	Indirect treatment time in min	Total treatment time in min	# of days a year	Treatment time a day	Available time a day in min	# at depart ment
SCU	16030	6668	22698	240	95	180	0,53
A0	18160	7555	25715	245	105	180	0,58
G2	35885	14928	50813	260	195	180	1,09
G0	43470	18084	61554	260	237	180	1,32
D1	23665	9845	33510	260	129	180	0,72
D0	5350	2226	7576	245	31	180	0,17
C1	85020	35368	120388	225	535	180	2,97
C0	14280	5940	20220	245	83	180	0,46
B1b	29410	12235	41645	250	167	180	0,93
B1a	22650	9422	32072	250	128	180	0,71
G1	48350	20114	68464	230	298	180	1,65
B0	2430	1011	3441	260	13	180	0,07
Zotel	6425	2673	9098	260	35	180	0,19
overig	260	108	368	260	1	180	0,01

Table B: The calculation of the number of employees necessary a day based on the clinical patients

The number of therapists that should at least be present each part of the day has been calculated based on the production figures of 2008. All the treatments that were performed by the physical therapists on the clinical departments were divided over the different departments. Based on the distribution used on the physical therapy department, for example the Intensive Care and the Cardiology department is seen as one department, the total time to treat the patient has been calculated. Also the indirect patient related time was calculated in order to make sure all the time necessary by patient is taken into account. Based on the report of Hoeksma, Homans & Menting (IJland, Droeven, Vierke, & Bijlsma, 2006) the indirect patient related time is 41,6% of the direct patient related time for clinical patients. Also the amount of days the departments are closed or not working in full capacity (like the summer and Christmas holidays and some religious free days) are taken into account. Than based on clinical time of two times 90 minutes a day (because they don't spend the 2 hours each time period that stands for it, so the 90 minutes are more in line with reality), the number of therapists necessary to perform the clinical work is presented. Because there should be whole therapists present for each cluster the amounts are add together for the clusters and rounded above. This means there have to be 16 therapists present each day.

According to the therapists on Tuesday and Friday afternoon there is a top in the workload on the orthopedic department because of the discharge of a lot of people and the administration that goes with it, so there should be one person extra on these moments.

Appendix B: Occupancy

In this Appendix the occupancy of the examination rooms are presented in more detail

2008	Occupancy PT	Occupancy OT	Occupancy Pelvis	Occupancy Children	Total Occupancy
January	33,7%	6,4%	28,0%	30,6%	35,3%
February	33,3%	6,5%	26,1%	25,3%	33,6%
March	37,9%	7,2%	35,1%	35,0%	40,6%
April	33,1%	7,7%	27,6%	28,8%	35,2%
May	30,7%	8,0%	26,2%	22,9%	32,4%
June	24,4%	7,3%	21,1%	23,1%	27,5%
July	22,7%	4,8%	24,2%	20,3%	25,2%
August	26,5%	7,9%	26,7%	19,2%	29,3%
September	29,7%	5,9%	26,9%	28,6%	32,2%
October	35,0%	10,0%	33,5%	24,1%	37,8%
November	38,9%	9,9%	31,6%	26,4%	40,0%
December	37,7%	6,7%	29,1%	20,1%	35,6%
Average	**32,0%**	**7,4%**	**28,0%**	**25,4%**	**33,7%**

Table C.1: Occupancy of the treatment category during the year

2008	Occupancy PT	Occupancy OT	Occupancy Pelvis	Occupancy Children	Total Occupancy
Monday	36,7%	5,3%	39,6%	22,4%	37,1%
Tuesday	33,8%	5,5%	22,1%	29,1%	33,2%
Wednesday	31,2%	9,4%	37,0%	34,5%	38,5%
Thursday	35,7%	10,0%	19,2%	20,9%	34,3%
Friday	23,9%	5,5%	23,2%	19,6%	25,8%

Table C.2: Occupancy of different days of the week

2008	Occupancy PT	Occupancy OT	Occupancy Pelvis	Occupancy Children	Total Occupancy
8.00 a.m - 10.00 a.m	56,0%	10,5%	41,5%	42,5%	55,6%
10.00 a.m - 12.00 p.m	18,1%	5,5%	21,5%	17,4%	21,7%
12.00 p.m - 15.00 p.m	42,8%	9,0%	40,7%	21,7%	42,6%
15.00 p.m - 17.00 p.m	13,0%	4,1%	6,8%	25,4%	16,6%

Table C.3: Occupancy during different parts of the day

Appendix C: Selection of Distributions

In this appendix the selection of the distributions of the time necessary for the treatments for the rehabilitation and occupational therapy and the distributions of the number of treatments per patient per category is described. In the simulation program used to simulate the activities of the physical therapy department is Technomatix Plant Simulation. This simulation program has a limited number of distribution that can be used to fit the real data. So only the distribution available in the program are analyzed to come up with the best distribution fit.

Selection of the distribution for treatment time

Rehabilitation

The minimum time spent per rehabilitation patient is 15 minutes. So the distribution should take this into account. The easiest way to do this is to use the distribution for the remaining minutes. So the distribution function should look like 15 + the distribution function.

Table C.1 presents the summary statistics of the registered data of the rehabilitation patients.

Statistic	
Mean	18,0
standard deviation	8,2
variance	66,8
coefficient of variation	0,5
skewness	3,1
kurtosis	10,1
Max	60,0
Min	15,0
Median	15,0

Table C.1: summary statistics for the rehabilitation patients

The data used to find the best distribution is presented in Table C.2. The registered data is adjusted to be able to use it correctly in the simulation program. So first the 15 minutes that are by definition necessary for a treatment are subtracted.

Value (minutes)	# present (total sample size = 4560)
0	3921
15	437
30	145
45	57

Table C.2: data used to find the best distribution fit for rehabilitation, based on production figures of 2008 from the Paranice system

Based on the registered data of the rehabilitation patients it is expected that a Poisson distribution might be the best fit. However, the gamma and normal distributions score the best on the Chi square test and the Kolmogorov-Smirnov tests.

In Figure C.1a-C.1d the different tests of the goodness of fit are presented for the normal distribution with the parameters δ=8,172 and μ= 2,954.

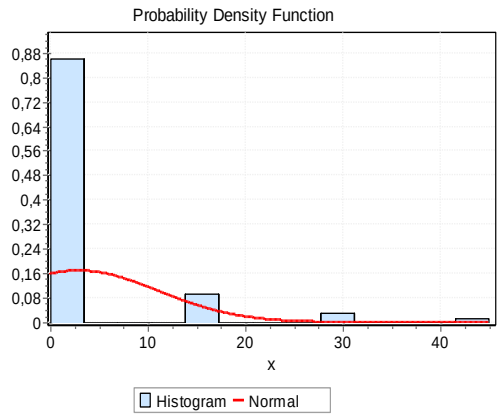

Figure C.1a: Normal probability density function with δ=8,172 and μ=2,954

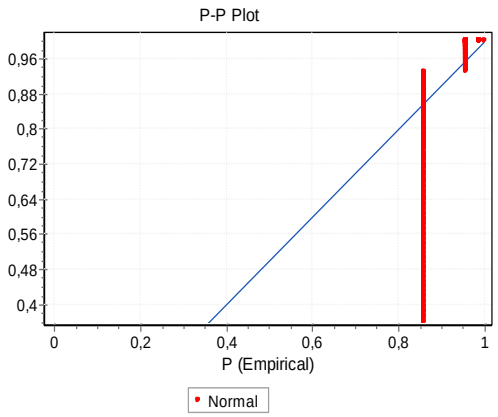

Figure C.1b: PP-plot for the normal distribution function with δ=8,172 and μ=2,954

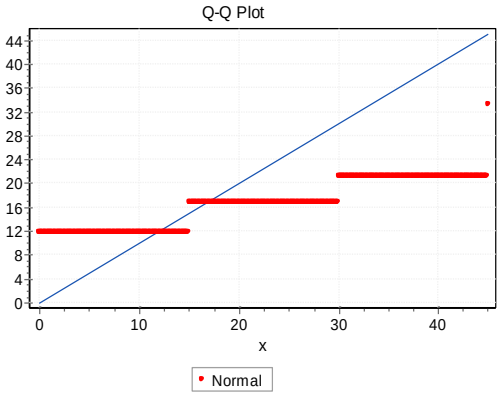

Figure C.1c: QQ-plot for the normal distribution function with δ=8,172 and μ=2,954

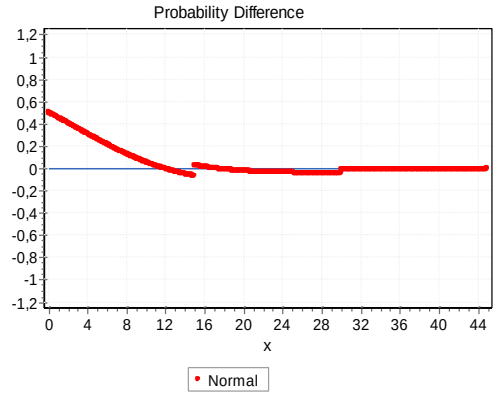

Figure C.1d: Probability difference for the normal distribution function with δ=8,172 and μ=2,954

In Figure C.2a-C.2d the different tests of the goodness of fit are presented for the gamma distribution with the parameters α=0,131 and β= 22,608.

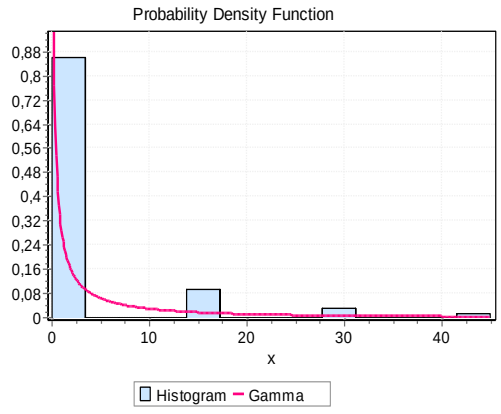

Figure C.2a: Gamma probability density function with α=0,131 and β=22,608

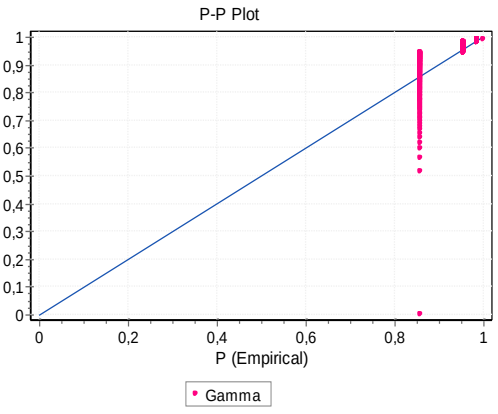

Figure C.2b: PP-plot for the gamma distribution function with α=0,131 and β=22,608

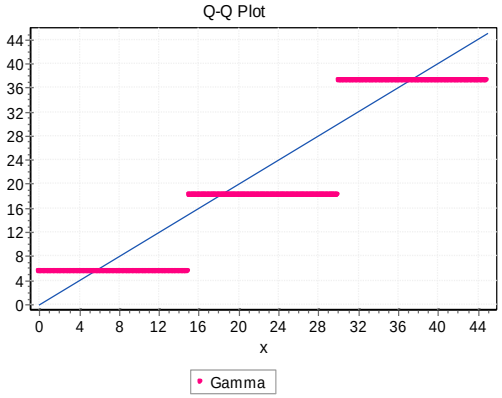

Figure C.2c: QQ-plot for the gamma distribution function with α=0,131 and β=22,608

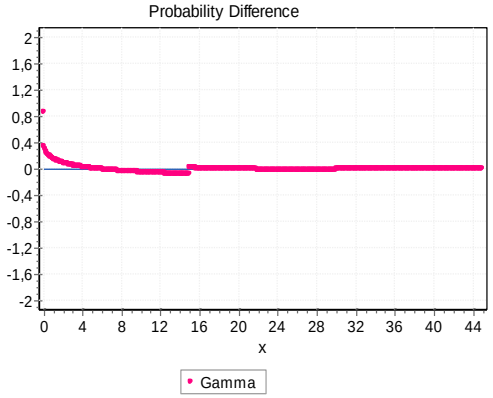

Figure C.2d: Probability difference for the gamma distribution function with α=0,131 and β=22,608

Even though the normal and gamma distributions are the best fit, they both do not pass the Chi square test and the Kolmogorov-Smirnov tests. This means that the distributions do not represent the data in the correct way. So the use of the empirical distribution is the best way to continue.

Appendix D: Detail description simulation model

In this appendix the simulation model, as Figure E.1 presents, is described in detail.

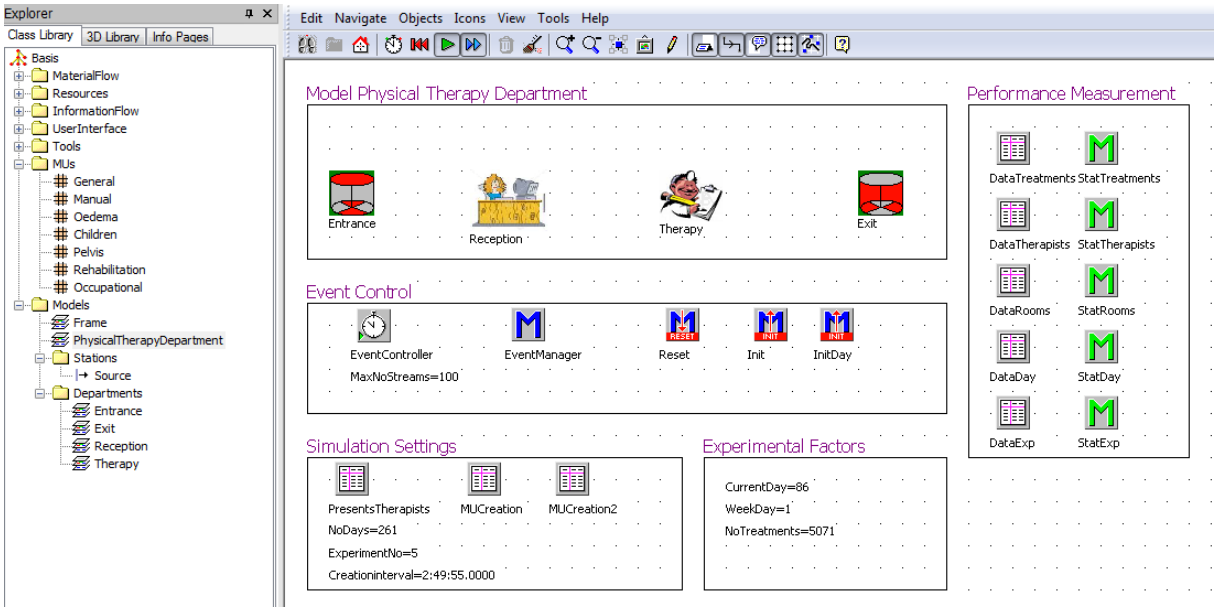

Figure E.1: The simulation model of the Physical therapy Department

Movable Units (MUs)

The movable units (MUs) in the system are the patients. On the left side of the overview of the model as Figure E.1 presents are the MUs represented. The patient groups present at the physical therapy department each represent another MU, this means there are 7 different MUs: General, Manual, Oedema, Children, Pelvis, Rehabilitation, and Occupational. All the MUs have custom attributes which are used during the simulation to set for example treatments times, number of treatments and are also used to guide the MU through the system in the right way. Table E.1 shows the different custom attributes used during the simulation. The usage of the different custom attributes are described in the sections below.

Name	Type
ArrivalTime	real
CheckRoom	boolean
ExaminationRoom	boolean
FirstTreatment	boolean
IdNo	integer
In	real
LastAppointment	integer
NextTreatment	integer
NumberOfTreatments	integer
PatientType	integer
Priority	real
Recurring	real
RoomNo	integer
ServiceTime	real
StartTherapy	real
Therapist	integer
Treatment	boolean
TreatmentNo	integer

Table E.1: custom attributes of the MUs in the simulation model

The departments

The simulation model consists of the departments entrance, reception, therapy and exit.

Entrance

Figure E.2 shows the overview of the entrance part of the simulation model.

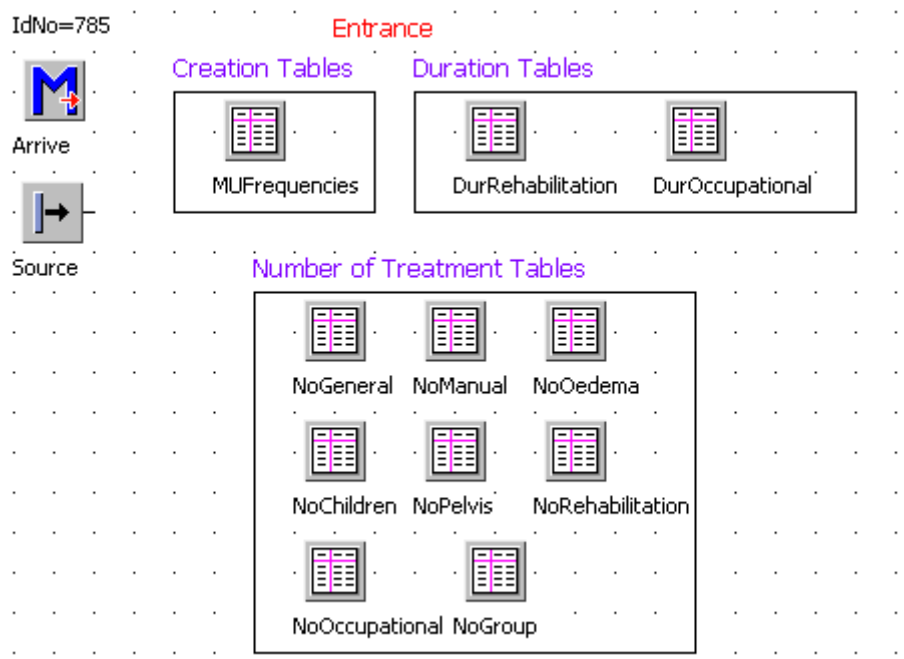

Figure E.2: Overview of the Entrance in the simulation model

The source is the object that takes care of the production of MUs. The creation interval (shown in the simulation settings part of the model) is used to determine when a new MU should be created in the source. The number of MU of the different patient types that should be created are based on an

empirical distribution with the use of creation table. In the MUFrequencies table the distribution of the different MUs are described. The data in this table is based on the production data of 2008 from the Paranice system of the physical therapy department. In order to guide the production of the patients the source uses also an failure moment. This is between 16:30 p.m. and 8:00 a.m., in this time interval there are no patients created.

Each time a MU is created by the source the arrive method is called. The arrive method present in the entrance is used to fill in a part of the custom attributes presented in able E.1 above. The first custom attribute, PatientType, is already set with the creation of the MUs. In the arrive method this custom attribute is used to set other custom attributes different for each patient type. The first thing that is done is to set the IdNo (the variable above the arrive method), this IdNo is used to set the custom attribute IdNo of the MU, in order to be able to differentiate between the patients in a later stage. The next attribute that is set is the ArrivalTime, this attribute is later used to set the priority of the patient. After that the attribute ServiceTime is set, the service time for the most MUs are fixed, but for the rehabilitation and occupational patient again an empirical distribution, with the use of the duration tables, is used to set the service time. Also the attribute NumberOfTreatments is by an empirical distribution using the number of treatment tables. After this the attribute ExaminationRoom for each patient type is set, to represent if the patient should receive treatment in an examination room or in the exercise room. The method also sets the variable Creationinterval in the Simulation Setttings part of the model each day.

Reception

Figure E.3 shows the overview of the reception part of the simulation model.

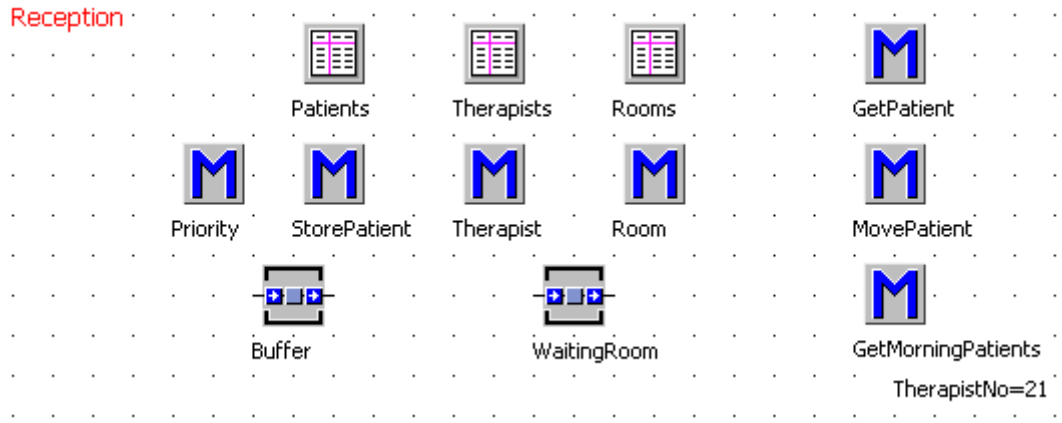

Figure E.3: Overview of the Reception in the simulation model

When the MUs arrive from the entrance they first go to the Buffer. Also patients that finished their therapy but are not finished their entire treatment are send to Buffer. At the entrance of Buffer the method Priority is called. First the custom attribute In is set to tell the waiting time of a MU before receiving treatment later, this in only done if the attribute In is 0, so when it is a new patient or a patient that already received treatment and after that returns to the Buffer part. In this method the recurring patients (when the custom attribute Recurring is set true in the therapy part) should receive treatment before the new patients, so the custom attribute Priority is set to 6. After that the specialized patients, children, pelvis, oedema, manual and rehabilitation, get priority in the order described. At last the other patients receive a priority number that is negative to the attribute ArrivalTime.

The StorePatients is called at the moment the MU wants to leave Buffer. In this method the patients are set in the table Patients, with the custom attributes Priority, PatientType and Therapist. After this the method sorts the Table so the patient with the highest priority is set on the top of the table. And at last the MU moves to the WaitingRoom.

At the entrance of the WaitingRoom the method Therapist is called. In this method a check is done, based on the table therapists, if there is a therapist available to perform the therapy of the patient. First a check is performed to see whether the treatment can be performed before 17:00 p.m. after that the custom attribute CheckRoom is set false. Also a help variable is used to check whether the therapist is already over the allowed amount of direct patient tied work (because the therapist has to perform other activities like administration as well), if this is the case, the therapist cannot perform another treatment at that moment. The first check is if the MU already as an assigned therapist (which is the case if it is a recurrent patient). When the MU has no assigned therapist all the therapists present in the therapists table are walked through. The first check for the therapist is if it is allowed to perform therapy of the patient type (also set in the therapists table) and if the therapist is not busy (set in the therapist table). When the therapist is allowed to perform the therapy a check is done if the therapist is present (set in the therapists table), this is dependent on the time. If the therapist is available, it will be checked whether the therapist is not yet over its amount of direct patient tied work, if this is the case the custom attribute Therapist will be set to the number which therapist is checked, the attribute CheckRoom will be set on true and in the column “busy?” in the therapists table the value will be set to true. The same goes for the recurring MUs, but only the therapist assigned to the MU is checked. When the custom attribute CheckRoom is set to true, the method Room is called.

In the method Room a check is done, based on the table Rooms, if there is a room available to perform the therapy of the patient in. First the custom attribute Treatment is set false, because this attribute is used to check whether a MU can go to the therapy part of the model, or has to stay in the waiting room. The first check is if the therapy has to be performed in an examination room, so if the custom attribute ExaminationRoom is true. If it is, all the rooms in the table Rooms are walked through. The first check is whether the room is available (set in the Rooms table), after that it is checked whether the therapy of the attribute PatientType can be performed in the room (also set in the Rooms table). When this is the case, the custom attribute RoomNo is set, also the attribute Treatment will be set to true and the column “available” in the rooms table is set to false. If there is no room available the next room will be checked. If the therapy does not have to be performed in an examination room, the custom attribute Treatment will be set to true and the rooms do not have to be checked. The next step is to set the column “available?” of the room number to false, the column “Time busy” in the therapists table will be set by adding the time by the attribute ServiceTime of the MU, and the time the room is busy is set in the column “Time busy” in the Rooms table. After that the method MovePatient is called. If there is no room available the patient will stay in the WaitingRoom and in the table Patients.

In the method MovePatient the MU will be removed from the table Patients and the WaitingRoom and moved to the Therapy part of the model. So the information about the MU is deleted from the table so that the next MU in line moves up one place.

The method GetMorningPatient is called at the beginning of the morning (at 8 a.m.) and at the beginning of the afternoon (at 12 p.m.) to make sure the therapists get to work. The method is called in the InitDay method in the EventControl part of the model. This method is a combination of the methods Therapist and Room and walks through all the MUs in the table Patients.

The method GetPatient is called at the moment the MU leaves the therapy part of the simulation model. The therapist is available at that moment and a check is done if there is a patient present for that therapist in the WaitingRoom and Patients table. The method walks through all the MUs present in the Patients table, the custom attributes CheckRoom and Treatment are set to false and after that a check is performed if there is already a therapist assigned, if this is the case a check is performed to see whether the therapist that came available, and is addressed in the Reception part of the model with the variable Therapist, equals the therapist that is assigned to the MU. If this is the case, the

custom attribute CheckRoom is set to true and the column “busy?” in the Therapists table is set to true. If the MU does not have a therapist assigned a check is performed to see if the therapist can perform the treatment based on the attribute PatientType of the MU, as is set in the Therapists table. If this is the case the custom attribute CheckRoom is set to true and the column “busy?” in the Therapists table is set to true. After that a similar method like the Room method is performed. If the custom attribute Treatment is true (if there is a room available) the MU is deleted from the table Patients and moved to the Therapy part of the simulation model.

Therapy

Figure E.4 shows the therapy part of the simulation model.

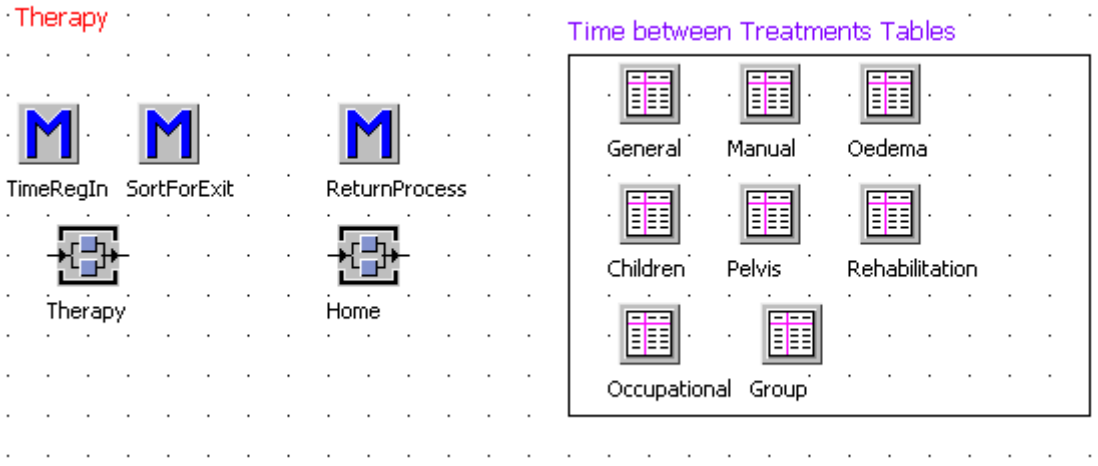

Figure E.4: The therapy part of the simulation model

The method TimeRegIn is called at the entrance of the Therapy. In this method the custom attribute StartTherapy is set, in order to calculate the waiting time of the patient later and the attribute TreatmentNo is added by 1. The therapy takes the time of the custom attribute ServiceTime. At the exit of the Therapy the SortForExit is called. This method makes sure the column “busy?” in the therapists table is set to false, and the column “available?” in the rooms table is set to true. Also the custom attribute LastAppointment is set to the number of the variable of the current day in the experimental factors part of the model. This attribute is used for checking purposes at the end of the simulation. After that a check is performed regarding the treatment numbers, if the attribute TreatmentNo is equal to the attribute NumberOfTreatments, so all the treatments that need to be performed per MU are performed, then the MU moves to the Exit part of the model. If this is not the case the attribute recurring will be set to true, the attribute FirstTreatment will be set to false and the attribute of NextTreatment is set based on the empirical distributions presented in the Time between Treatment Tables. After that the MU moves to the Home part of the simulation model. This means that the therapist becomes available again and should be able to treat another patient, if the occupancy of the therapist of that does not exceed the maximum occupancy. So first a check is performed about the occupancy of the therapist, if this does not exceed the maximum occupancy the method GetPatient in the Reception part of the model is called. At the end of the method the methods StatTreatments, StatTherapists and StatRooms are called.

The MU stay is Home part as long as the custom attribute NextTreatment, after that the MU goes back to the Buffer part in the Reception part of the model. The ReturnProcess method takes care of this and also sets the attribute In to 0 again.

Exit

Figure E.5 shows the Exit part of the simulation model

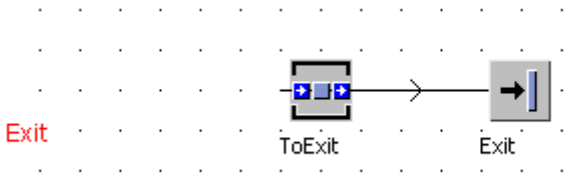

Figure E.5: the Exit part of the simulation model

The MUs are deleted from the system by the Exit after all the treatments are performed.

Event Control

Figure E.6 presents the Event control part of the simulation model. This part makes sure the model actually performs the tasks like moving the MUs and setting the right initial settings.

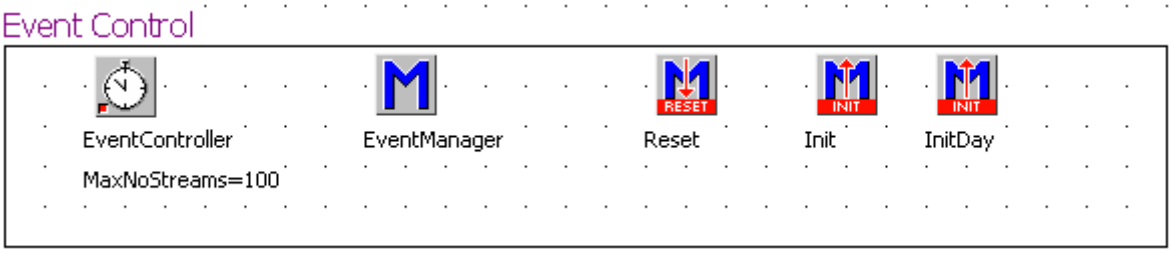

Figure E.6: Event Control part of the simulation model

The EventController runs the entire simulation model, with the use of simulation time and an event list the tasks are performed as programmed in the Physical Therapy Department part of the model. In the event list the moving of MUs through the system is taken care of and the simulation time determines when this should happen. The simulation time is used in the Physical Therapy Department part to let the patient stay in the Buffer part of the reception, the Therapy part of the therapy and the Home part of the therapy. Further the simulation time is used to find out if the day has ended and to check whether a therapist is present at certain parts of the day. With the use of the EventController the methods Reset and Init are called at the start of the simulation.

The Reset method takes care of the deletion of the movable units left in the system by the last experiment. And the method deletes all the information in the tables DataTreatments, DataTherapists, DataRooms and DataDay. The last function of the Reset method is to set the number of random streams with the use of the variable MaxNoStreams in the Event Control part, to make sure enough random streams are present to execute the simulation in the right way.

The Init method is used to initialize the simulation. The collection of data of the MUs and the departments is set. And also the variables in the Experimental Factors part of the model are set to 0, and also the IdNo variable in the Entrance part of the model is set to 0.

The EventManager is a method called in the InitDay method at 17:30 p.m. in advance. The EventManager first activates the registration of the statistics per day, so it calls the StatDay method in the Performance Measurement part of the model. Then it checks if the number of days the simulation runs equal is to the number of days the simulation should run, with the help of the variable CurrentDay in the Experimental Factors part of the model and the variable NoDays in the Simulation Settings part of the model. If this is the case the simulation is stopped, else the method InitDay is called to initialize a new day.

The InitDay method is called by the EventManager to initialize a new day. Here the variables CurrentDay and WeekDay of the Experimental Factors part of the model are set each day. The WeekDay represents the day of the week that is necessary to find out if a therapist is present on that part of the week. After that the presence of employees are set using the PresentTherapists table in the Simulation Settings part of the model in the Therapists table in the Reception part of the model. This is done for the different parts of the day. Also the busy and available column of the Therapists and Rooms table in the Reception part are set to false/true and the time busy columns are set to 0. After that the initial setting of the variable Creationinterval in the Simulation Settings part of the model is set, to makes sure the first new patient enters the system at 8:00 a.m. to activate the system. At last the data in the tables DataRooms and DataTherapists in the Performance Measurement part of the simulation setting are set to 0. The method InitDay also initializes the start of the day by calling the method GetMorningPatients at 8 a.m. to "fill" the system for that day. This method is called again at 12 p.m. because of the change in availability of the therapists. The GetMorningPatients is called in advance with the use of the method MethCall, which uses the simulation time to determine when another method should be called. Also the end of the day is set by the InitDay method, again with the use of the method MethCall

Simulation Settings

Figure E.7 presents the simulation settings part of the simulation model. In this part different settings are set in order to vary with some settings, like the number of therapists present and their specialties, the creation interval and the number of days the simulation should run.

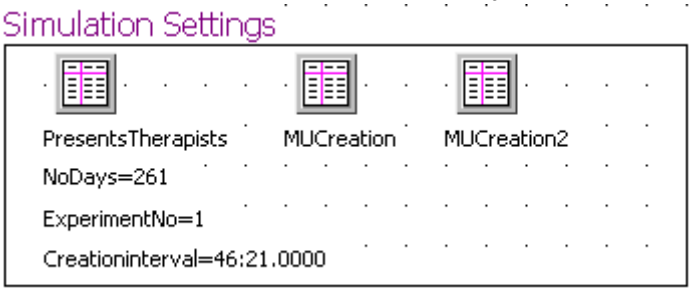

Figure E.7: The Simulation Settings part of the simulation model

In the table PresentsTherapists the number of therapists present on the different parts of the day are set.

The variable NoDays sets the total number of days the simulation should run. The EventManger in the EventControl part of the simulation model uses this variable to check whether the simulation should stop or continue with a new day.

The variable ExperimentNo is used for administrative purposes in the Peformance Measurement part of the simulation model.

The variable Creationinterval is set by the method InitDay in the EventControl part of the simulation model. The Creationinterval is set by using an empirical distribution based on the production data of 2008 from the Paranice system. Because the registration of the starting of registration on the 1st of January, the first two weeks there are much more new patients than in the rest of the year. The difference is that large that it couldn't be taken care of by running the simulation longer. So to solve the problem of the number of patient created in the model, the first two weeks the creation interval is smaller and for the empirical distribution the table MUCreation is used. After the first two weeks the creation interval is larger and the empirical distribution uses the data from the MUCreation2 table, the change the use of tables is takes care of in the InitDay part of the simulation model.

Experimental Factors

Figure E.8 presents the experimental factors in the simulation model.

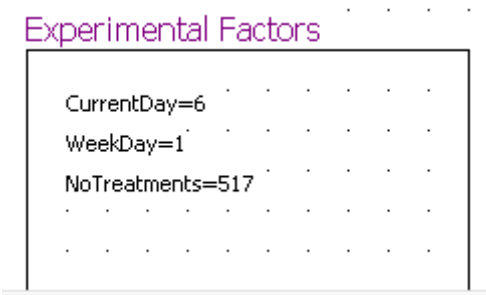

Figure E.8: The Experimental Factors of the simulation model

The variable CurrentDay is used to check whether the simulation should stop, this is the case when the variable CurrentDay is equal to the variable NoDays of the Simulation Settings part of the simulation model. The variable is also used for calculation purpose of the time of the day in the different methods in the Physical Therapy Department part of the model.

The variable WeekDay is used to see which data of the table PresentsTherapists of the Simulation Settings part of the model should be loaded into the table Therapists in the Reception part of the Physical Therapy Department part of the simulation model. The presence of the therapists is dependent of the day of the week.

The variable NoTreatments refers to the number of treatments performed during the simulation and is used in the method StatExp of the Performance Measurement part of the model.

Performance measurement

Figure E.9 presents the Performance measurement part of the simulation model, in this part the registration of the performance of the model takes place.

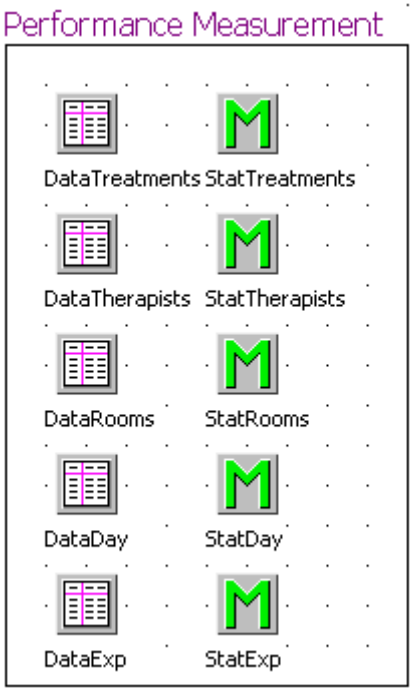

Figure E.9: The Performance Measurement part of the simulation model.

The StatTreatments method is called at the end of the therapy in the Therapy part of the model. The information registered by the StatTreatments method in the DataTreatments table is the patient ID, patient type, last appointment day, number of treatments that need to be performed, treatment number, if the treatment has to be performed in the examination room, when the next treatment can take place, the time the treatment should take, and waiting time. All these data are gathered with the use of the custom attributes assigned to the MUs. At the end a check is performed to see whether it is past 17:00 p.m. and the EventManager should be called.

The StatTherapists method is called at the Therapy part of the model to set the information in the DataTherapists table. This table is used to determine if a therapist is still allowed to perform treatments, so if they are not over the 50% time they spend on direct patient tied activities. The same goes for the StatRooms method with the DataRooms table. Accept the check if there can be another treatment performed in the examination room is not performed, because there cannot be more than one person at a time in the examination room. It can happen that the occupancy of a room at het certain part of the day is larger than 1.00 because the treatments starts in that time interval, but can be continued in another. In that case the treatment is registered in the beginning interval.

The StatDay method is called by the EventManager at the end of the day. The method registers data in the DataDay table, so check how the simulation performs day to day. The DataDay table gathers the following information on each day: day number, week day number, number of treatments performed that day, occupancy of specialized therapists and overall occupancy of the therapists, occupancy of specialized rooms, occupancy at different parts of the day and the overall occupancy of the rooms, average waiting time for each patient type and the overall average waiting time. The data is gathered from the other tables in the Performance Measurement part of the model.

The last method in the Performance Measurement part is the StatExp. The StatExp registers the information about the entire experiment, so the average of the information present in the DataDay table. The information present in the DataExp table is: experiment number, total number of treatments, average waiting time, average occupancy of specialized therapists and overall the occupancy of the therapists, the average occupancy of the examination rooms, at different parts of the day and to specialty and last the overall occupancy of the rooms. In this table the performance of the different experiments can be easily overlooked.