Strategic capacity planning within the Erasmus MC

Final version

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Abstract

This thesis contains research within the area of strategic capacity planning in a hospital. The main approach is to analyze historic developments regarding patient demand and capacity consumption of Health Care resources and to draw the link with a planning of the resources in the future. The study is meant to contain a scientific as well as practical perspective as the research took place on behalf of the Erasmus MC in Rotterdam, the Netherlands.

It is important to notice that the Dutch Health Care system has undergone a transition in the last years. The consciousness of capacity planning has risen after the DBC (Diagnostic Treatment Groups) system has been introduced in the Netherlands in the year 2005. This had the effect that the Dutch Health Care system developed from a supply-focused to a demand driven system. Therefore, in our approach we focused on patient demand as the main factor of impact on capacity consumption. By analyzing historic information on patient demand, we could confirm general trends in the Netherlands as an increasing number of hospital admissions and a decreasing average duration of stay. Based on the data we constructed scenarios that forecast future demand. Our methodology represents a mathematical model that models linear relationships between the patient-related input parameters and the resource-related output parameters. As resources we selected beds, operation time and clinical workforce capacity. We also analyzed the possible impact of an internal reorganization (Theming) within the scenario analysis. Basically we found that if we follow the trend from the last years regarding the increase of the number of admissions, the future requirement of bed, operation time and workforce capacity will increase as well. This increase is expected especially in the area of GIC (digestion) and transplantation. The idea is that in the future the Erasmus MC makes increased usage of strategic capacity planning in order to overcome capacity shortages or the risk of excess.

Nederlandse samenvatting

Deze scriptie bevat onderzoek op het gebied van strategische capaciteitsplanning voor een ziekenhuis. Het hoofddoel van onze aanpak is om historische ontwikkelingen te analyseren van de vraag naar ziekenhuiszorg en de capaciteitsbenutting en daardoor de toekomstige behoefte naar capaciteit te voorspellen. Wij benaderen dit vraagstuk vanuit zowel een wetenschappelijk- als vanuit een praktisch perspectief, omdat het onderzoek in opdracht van het Erasmus MC in Rotterdam, Nederland uitgevoerd is.

In de laatste jaren is het Nederlandse zorgstelsel in transitie geweest. De aandacht voor capaciteitsplanning binnen de zorg heeft toegenomen. Sinds het nieuwe DBC systeem in 2005 is geïntroduceerd, is het zorgstelsel veranderd vanuit een aanbod-gericht naar een vraaggestuurd systeem. Daarom ligt binnen onze methode de focus op de vraag naar zorg als key-factor om de capaciteitsplanning te bepalen. Bij het analyseren van historische gegevens van de zorgvraag (binnen het Erasmus MC) konden wij algemene trends binnen Nederland bevestigen zoals een toename van ziekenhuisopnamen en een afname van de gemiddelde ligduur. Gebaseerd op de data uit het verleden hebben wij scenario's gemaakt om de toekomstige zorgvraag te voorspellen. Onze methode bevat een wiskundig model met een lineaire samenhang tussen de vraag gerelateerde input parameters en de resource-gerelateerde output parameters. Als resources hebben wij bedden, operatie tijd en personeels capaciteit gemodelleerd. Verder hebben wij de mogelijke impact van een interne reorganisatie (Thematisering) binnen de scenario analyse onderzocht. Als de trend van het stijgende aantal opnames van de laatste jaren verder doorzet betekent dit dat de toekomstige capaciteitsbehoefte ook verder zal stijgen. Deze stijging is in het bijzonder verwacht op gebied van GIC en transplantatie. Over het algemeen bevelen wij aan dat het Erasmus MC in de toekomst in sterkere mate gebruik maakt van strategische capaciteitsplanning, vooral om een capaciteitstekort of overschot te voorkomen.

Acknowledgement

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CONTENTS

1 INTRODUCTION

1.1BACKGROUND AND MOTIVATION: CAPACITY PLANNING

In recent years there has been a continuous rise of the health care expenditures in most countries across the world. This led to a greater need to economize the Health Care systems. Hospitals, such as the Erasmus MC in Rotterdam, face the challenge to operate in a more cost-efficient manner in order to remain competitive. Needless to say is that this transition should not occur on cost of the quality of care. Being successful within the new circumstances heavily depends on the existence of a sustainable strategy. Therefore hospitals such as the Erasmus MC strive to make good strategic choices for the future regarding their patient mixes and the capacity planning of their resources. However, this is a rather recent development. Strategic capacity planning of resources has its origin in the area of manufacturing and is a relatively new concept for hospitals. Within manufacturing, capacity planning is used to adjust the production capacity to the changing demands for products. As the Health Care system in the Netherlands has changed its focus from supply to demand (with the introduction of the DBC system in 2005), we can find more parallels between manufacturing and Health Care nowadays. This is why researchers and managers of hospitals aim to adopt successful capacity planning concepts from manufacturing.

1.2 BACKGROUND: DEVELOPMENTS WITHIN THE NETHERLANDS

The research takes place within the Erasmus MC, one of the largest medical centers within the Netherlands. In contrast to other countries, the Netherlands has to cope with an increasing number of hospital admissions over the last years. While in the year 1998 approximately 9% of the Dutch population had at least one clinical admission in a hospital, in 2008 this percentage increased to approximately 11%. (from the WHO report (2009)). In the same time the duration of stay decreased for almost all countries within the EU. However, remarkable for the Netherlands is the sharp decrease from 9,5 days in 1998 to 6 days in 2008.

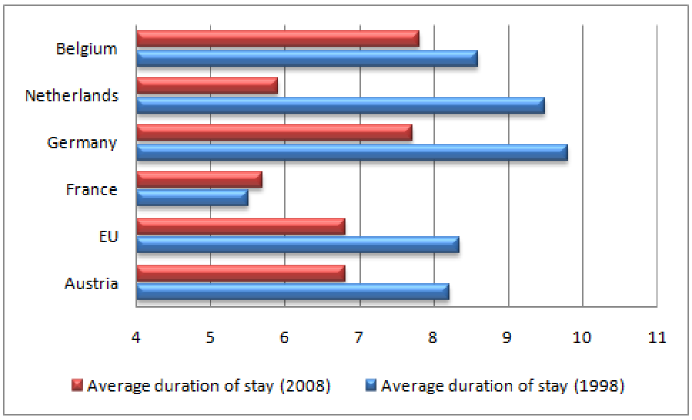


Figure 1.1 (From WHO report (2011): Cross country comparison and development in the duration of stay (in days) in hospitals

In the Roland Berger Study report (2007), the phenomenon of decreasing durations of stay is explained with the introduction of diagnosis related groups (as the DBC system in the Netherlands) and the development of technologic innovations.

In our research we focus on the impact of the change in demand on the resources beds, operation time and workforce (nurses). Bed occupancy rates are rather low in the Netherlands with 63,9 % in 2005 (Source: Roland Berger study report (2007). In comparison: Switzerland had a bed occupancy rate of 86,1% in 2005. It seems that the large Dutch hospitals cannot profit enough from the effect of scale which suggests plentiful room for improvement regarding capacity planning. Strategic planning of the workforce is probably most important due to the very high degree of labor intensity within hospitals. In this paper, we deal with questions on optimal formation sizes. In Figure 1.2 we can see that the Netherlands, in a cross-country comparison have comparatively many nurses per 100.000 inhabitants.

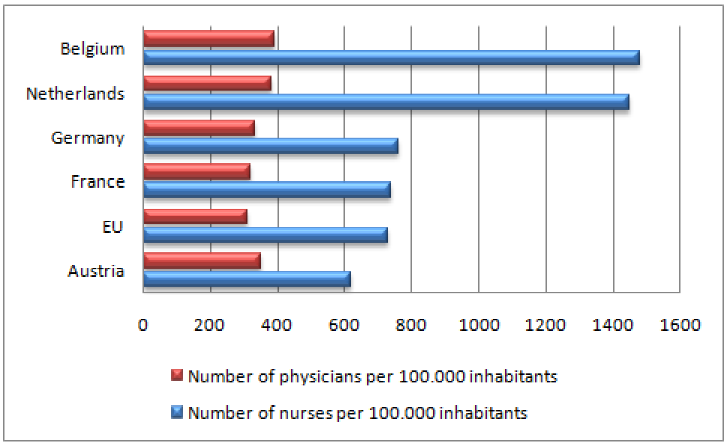


Figure 1.2 (From WHO (2009)): Physicians and nurses per 100.000 inhabitants

1.3 THEORETICAL FRAMEWORK AND CORE OF THE RESEARCH

Capacity planning for hospitals can be derived from Health Care demand which is described by the patient mix. The composition of the patient mix has a direct effect on qualities and quantities of the required capacity. In particular Van der Meer and School (2008) present a methodology on translating a patient mix into the capacity requirement. Within this methodology they multiply pre-determined DBC quantities with historical treatment times.

In this research, we are going to use a similar approach (similar to Van der Meer and School (2008)) for the Erasmus MC as we possess information on historical DBC quantities and treatment times as well. However, we have to be careful in using pre-determined DBC quantities due to the uncertainty in patient demand. Therefore we are proceeding with an approach similar to Ma and Demeulemeester (2010) by taking multiple scenarios regarding DBC quantities and treatment times into account. We plan to construct these scenarios similarly to Barros et al (2010) by forecasting the scenarios on basis of historical data. Finally we incorporate the data in a mathematical model. In Figure 1.1 we present a high-level scheme of the mathematical model we are using.

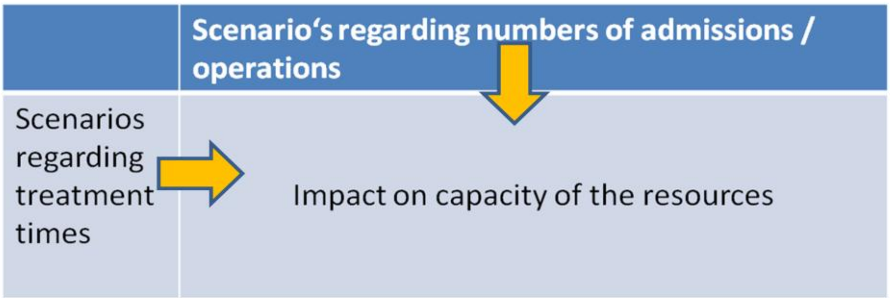


Figure 1.1: High level scheme capacity model

The capacity model has the purpose to translate input data namely numbers of admissions, average duration of stay, number of operation sessions and operation session times to the forecasted capacity consumption of selected resources.

In this research we examine the impact of the above-mentioned scenarios on the selected reseources: bed capacity, operation capacity and workforce capacity. To sum it up, the main research question is as follows:

What are historic developments regarding demand and capacity consumption of Health Care resources and what is the impact on a future capacity plan at the surgery department of the Erasmus MC?

1.4 METHODS

Due to the linear relationships of input and output data we make use of linear modeling. This linear relationship is rather straightforward for bed and operation time capacity. Basically there are upper limits of beds and operations time that should not be exceeded. The relationship between a patient mix and a workforce formation meanwhile is considered as a bit more tedious. In order to draw the link we basically have to know how much time a nurse spends on a patient. In practice this requires extensive measurements. Schouppe et al (2007) described a quantification of the workload for nursing in Belgium. After a precise identification of the activities of the nurses, they created standard times for these activities based on past measurements. These standard times require continuous updates as measurements vary over time and can show certain trends. Finally Schouppe et al (2007) created an instrument to reallocate the nurses on basis of the workload measurements. However, comparable data regarding the workload of nurses was not available within the Erasmus MC which is why we developed an alternative method.

We basically calculated historical values regarding the “Nursing day per FTE” ratio and use them as a variable to predict the future workforce requirements. This ratio was different for the different units of the surgery department which can be due to the differences in their patient mix but also due to differences in efficiency. We also generated the so-called Theming-scenario that implied that the workforce (as well as bed) capacity of the units is pooled together and therefore has a less restrictive capacity limit. As we are considering future scenario’s regarding capacity planning it is essential to take all available information into account. The reorganization (theming) definitely will have impact on organization of the resources. We obtained some evidence that a unit or a theme has a fixed part of the formation (or a basis-formation) that has to exist irrespective of the number of admissions and a variable part that increases with an increasing number of admissions. Therefore we included this option in our alternative methodology as well.

1.5 PRACTICAL BACKGROUND

This research takes place in the Erasmus MC in Rotterdam and therefore basically can be seen as a case study. Principal for the study is the Cluster-office 4&5 (Clusterbureau 4 & 5). The research focuses on the capacity planning for the clinical units of the surgery department. Currently the surgery department of the Erasmus MC does not make use of strategic resource planning. However, some years ago, some internal advisors developed a capacity simulation model in Excel. The model had the purpose to simulate the *yearly* required capacity of beds and the operation time for the surgery department and makes use of so-called patient categories that are logical groups of DBCs (Diagnosis Treatment Combinations). As input, the model uses the numbers of admissions per patient category and the corresponding duration of stay. In case the patients undergo an operation, also an operation time is defined for them. This can be modeled for the current situation as well as possible future scenarios. Despite of the added value of the model, it is still not brought into operation and now the information in the model is outdated. As far, the old model does not take workforce capacity into account. In general, within the surgery department of the Erasmus MC the workforce capacity is not linked to the (number and type of) patients directly, but to the number of beds. Now the Cluster-office 4&5 is aiming to bring an updated capacity simulation model into operation. For this purpose they want to use the old Excel capacity model as a basis and adjust it to the current situation. Moreover, the wish is to incorporate the workforce capacity into the model as well. The idea is to continuously use the capacity model in the future in order to determine future scenarios of capacity consumption of selected resources. Furthermore the wish is to use the model in order to see the impact of the current reorganization (Theming) on the capacity.

1.6 VALIDITY AND GENERALISABILITY

One main limitation of our work is the explicit focus on the surgery department of the Erasmus MC. Within the case study we had to take care of the specifics of this department which are not necessarily in line with the literature. Moreover, according to the literature planning and control processes should ideally not be limited to small entities as departments of hospitals but rather be tackled more globally. This offers a larger range of possibilities in terms of redistribution of capacity and avoidance of bottlenecks. However, due to the fact that the research had to fit in the scope of a master thesis we chose this rather limited framework. However, we definitely recommend that in the future, the Erasmus MC should tackle capacity planning within a more global scope.

A second limitation of this research concerns our choice of modeling. Basically we chose to derive capacity consumption from predicted patient demand in order to generate future scenario's. In practice however, this choice of modeling might oversimplify reality. To give an example: Imagine a well-known specialist for liver surgery starts working at the Erasmus MC which represents a change in supply. The patient demand is likely to adjust to this adjustment in supply as patients tend to be sensitive for a good quality of the surgery. This makes supply the exogenous factor and patient demand endogenous which represents exactly the opposite to our choice of modeling. However, these events are very difficult to predict. In general we believe in the idea that similar to other industries supply should adjust to demand (and not vice versa) which is why we chose our approach.

A third limitation of this work is given by the fact that we did not possess data on the time use of the nurses working in the unit. One main concept of the thesis is to draw the link between patient demand and resource consumption which was difficult to draw to the lack of this data. During our research we were visiting the hospital in Leuven/Belgium (UZ Leuven). It turned out that they had an extensive time registration system in place that allows them to track the time use of nurses in detail which made it possible for them to make use of a well-proven planning system. Therefore we found out that generalizing and comparing the work at the Erasmus MC is rather limited. In order to improve capacity planning within the Erasmus MC we recommend the introduction of a time registration system in the Erasmus MC which would generalize data on the time use of the nurses. Moreover, due to the restrictions of data quality (see also Section 4.1.1) we have to observe results of the thesis with caution.

1.7 THESIS OUTLINE

We are going to answer the main research question by following a stepwise approach: In Chapter 2 of this thesis, we draw the theoretical framework. We describe the development of the Dutch Health Care system into a demand-driven system imposing an increased focus on capacity planning within Health Care. Then we provide general trends regarding demand and capacity consumption within the Netherlands that we later will compare to trends found within the surgery department of the Erasmus MC. Patient demand, often described by patient mix or case mix, plays a crucial role for the capacity consumption of the resources which we will further analyze. Basically, we aim to provide a literature review on capacity planning within hospitals and zoom in on promising sources. Thereafter we are aiming to answer the research question from a practical perspective. Firstly, we will outline the organizational context of the study more in detail in Chapter 3. This also includes a description of the patient flow and the description of the resources in scope. Then Chapter 4 will elaborate on historical developments regarding demand and capacity consumption of the resources in scope within the surgery department. Historical data forms a main ingredient regarding our methodology that determines scenarios of a future resource planning. Chapter 5 describes this methodology which is based on mathematical modeling. We basically construct a methodology that predicts the capacity requirements of the future on basis of historical information. A similar approach is used by other authors as for example Barros et al (2010) who estimate future capacity consumption of resources for hospitals in Chile. The results in

Chapter 6 are presented in form of a scenario analysis. By considering the historical data, we can still envision different developments for the future. It still remains to be seen whether the constructed scenarios prove realistic. Basically they should help an organization in obtaining a better insight into the capacity consumption of resources which allows making an improved future capacity planning. We will finish the thesis with a discussion part in Chapter 7.

2 THEORETICAL FRAMEWORK

2.1 INTRODUCTION AND OUTLINE

Recall that we are analyzing historic developments regarding demand and capacity consumption of Health Care resources (input) and its impact on a future capacity planning (output). The research is performed as a case study within the Erasmus MC which is further described in Chapters 3 to 6. This chapter is meant to provide the theoretical framework for the main research question. By means of a literature review we aim to make a selection of the most relevant sources for our case study. Finally we are aiming to check whether our findings for the Erasmus MC are in line with the general developments in the Netherlands and the findings from the literature.

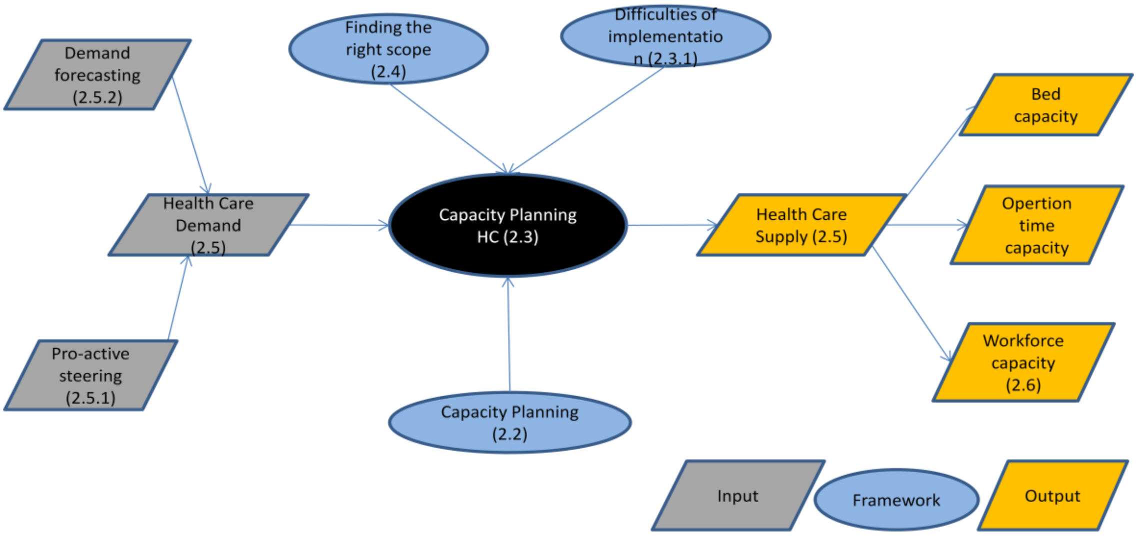


Figure 2.1: Conceptual model Theoretical framework

This chapter is structured as follows: Firstly we outline general developments regarding capacity planning in general in Section 2.2. In Section 2.3 we elaborate on the application of capacity planning within the Health Care industry. In Section 2.4 we zoom in on the question on how to find the right scope for the planning process. Sections 2.2 – 2.4 have the purpose to clarify the framework of Capacity Planning within Health Care. Section 2.5 will explain the main concepts of Health Care supply and demand in order to elaborate on the input and output of capacity planning. Section 2.6 covers the translation of the patient mix to a planning regarding a workforce formation. Here we zoom in on one of the main output variables within capacity planning. We conclude the chapter with Section 2.7 which elaborates on the interaction of our research and the literature. A sketch on the conceptual model which this theoretical framework is based on is given in Figure 2.1

2.2 CAPACITY PLANNING

The following sections (2.2 – 2.4) have the purpose to clarify the framework of Capacity Planning within Health Care. Capacity planning has its origin in the area of manufacturing. The basic idea is to determine the production capacity needed by a (manufacturing) organization in order to meet changing demands for its products (according to the Definitions of supply chain management (2006)). This implies that demand from customers is central and planning processes are derived or endogenous. Van der Meer and School (2008) point out that it is crucial to make a capacity planning process an integrated business process which also contains a constant update and improvement of historical data. This also continuously improves the quality of the resource planning.

Authors as Hans et al (2006) distinguish between three different levels of capacity planning: strategic, tactical and operational. Capacity planning should ideally be done at any of the three levels. Strategic capacity planning involves making long-term decisions, whereas in tactical or operational planning, resources are planned for shorter planning horizons. In tactical as well as operational planning quantities of resources are fixed to a greater extend which leaves the challenge to utilize the available resources as efficient as possible. On a tactical and strategic level we can configure or redistribute the present resources in such a way that some restrictions are removed or relaxed. Van der Meer and School (2008) stress the importance of focusing on the bottlenecks within tactical or strategic planning as this will yield less problems during the daily execution.

In this thesis we focus on the strategic planning of the resources as we analyze historic (long-term) developments in order to analyze the long-term impact on a future capacity plan. Within strategic planning, quantities of the resources can be considered as variable. But how do we determine a good long term strategic planning of the resources?

2.3 CAPACITY PLANNING WITHIN HEALTH CARE

Now we zoom in on capacity planning within Health Care in order to clarify the framework for the problem. According to Van de Ketterij et al. (2002) the Dutch Health Care system was characterized by its focus on the supply rather than on the demand prior to 2005 which is contrary to the idea of capacity planning within manufacturing. In this system patient demand had to adjust to the supply. Supply can be described by health care resources as for example physicians, nurses, beds or operation rooms. In 2005, the introduction of the Diagnosis Treatment Combination (DBC) system changed the system from supply control to demand control. Van de Ketterij et al. (2002) find that as the DBC system puts the patient demand at a centre stage, capacity can be allocated such that demand is met. Therefore capacity planning began to receive enhanced attention within health care. However, according to Hans et al (2006), capacity planning within health care is still lagging far behind in comparison with manufacturing. Therefore authors such as Roth and van Dierdonck (1995) suggest implementing manufacturing capacity planning systems within health care organizations.

While manufacturing often involves capital intensive production techniques, health care is known for its high degree of labor. In spite of this various sources that treat capacity planning in hospitals deal with bed capacity as the main hospital resource. In the year 1988 Smith-Daniels et al. (1988) presented an extensive literature review on capacity management in hospitals and indicate that most admission scheduling systems often restrict themselves to bed capacity. This focus often yields sub-optimization for the utilization of the other resources. In more recent years we found more literature that identified operation time and medical staff as critical resources. Examples are the studies of Van Berkel and Blake (2007) or Harper (2002). Beds and medical staff are allocated to so-called nursing units within a hospital. The size of the nursing unit depends on the quantities of their resources.

2.3.1 DIFFICULTIES OF IMPLEMENTING CAPACITY PLANNING IN HEALTH CARE

In this section we deal with difficulties that can arise by implementing capacity planning concepts in Health Care. The problem is that concepts within manufacturing often cannot be copied directly to hospitals, due to the unique nature of health care delivery (Hans et al. 2006). The authors state that within health care, the focus on hospitals or single managerial areas is too narrow in order to obtain a good planning and suggest an integrated framework for the whole supply chain.

Kulijs et al (2007) analyze whether the Health Care industry is able to benefit from experiences from manufacturing in the field of modeling and simulation. In manufacturing modeling and simulation is often applied to obtain better insights in capacity planning processes. However, the authors find seven axes of differentiation between manufacturing and Health Care that make it more difficult to implement these concepts in Health Care. These axes include a comparatively higher degree of irrationality (for example caused by the fear of death of patients) and a higher importance and complexity of politics as Health Care is very labor intensive and therefore involves many different people.

In our research we have found that data often was of limited quality. In case the quality of the input is inferior, it is rather problematic to construct a model that generates suitable output for a reliable capacity planning. It might be that the quality was limited due to irrationality and the higher degree of politics. However, given that the need for capacity planning in Health Care increases and furthermore we could find a considerable amount of literature we were still motivated to deal with this topic.

2.4 FINDING THE RIGHT SCOPE FOR CAPACITY PLANNING

According to Hans et al (2006), planning and control processes should ideally not be limited to small entities as departments of hospitals but rather be tackled more globally. However, to a great extend, literature often focuses on smaller entities which is also criticized by Van Berkel et al (2009). They point out that the focus on a single department within a hospital ignores complex relationships between departments. This also forms a limitation to our case study as we are focusing on the surgery department of the Erasmus MC and ignore relationships to other departments.

De Bruin et al (2010) analyzed in their research the sizes of different nursing units and came to the conclusion that the distribution of the resources of the different nursing units is to a great extend based on historically obtained rights and often lack well-founded quantitative approaches. They demonstrate the efficiency of merging rather small nursing units. We will later on analyze the effect of theming within the Erasmus MC, which has characteristics of a merger. De Bruin et al (2010) also mentioned that due to possible far-reaching of specialization, the scope of merging has a limit.

2.5 HEALTH CARE SUPPLY AND DEMAND

The conceptual model given in Figure 2.1 outlines that we are going to determine the long-term Health-Care supply by making use of Health Care demand as input. This section has the purpose to explain and define supply and demand within Health Care. Health care supply is characterized by the resources available as bed capacity, workforce capacity or operation time. Health care demand is generated by the patients and ultimately leads to the requirement of the resources. The insurance companies in the Netherlands are supposed to act as prudent purchasers of care on behalf of their customers. This basically implies that they are agents for the patients and negotiate with hospitals on the quality and prices of health care.

Basically the demand within a hospital is diverse. We have already seen that in the year 2005, in the Netherlands the DBC system was introduced. This system (per definition) differentiates between the patients by the allocation of their exact required treatment. The total population of patients with the different diagnoses in a hospital is defined as patient mix or case mix. Hatcher and Connelly (1988) stress the financial implications of the case mix for the hospital. They suggest creating meaningful diagnosis groups as a basis in order to make appropriate managerial decisions for a hospital.

As mentioned, the case mix has a direct impact on the utilization of the different resources. We have found many simulation studies (eg Van Berkel and Blake (2007), Vermeulen et al (2009)) that take a case mix as given and try to find an optimal resource allocation. On the other hand there are also studies that consider the resources as given and try to find an optimal case mix that corresponds to them. However, these studies correspond more to tactical or operational resource planning. In strategic planning, neither, the amount of the resources nor the composition of the case case-mix is fixed. This leads us to focus on studies regarding flexible future case mixes. We have found two basic approaches on the assessment of future case mixes: Proactive steering of the case-mix by the hospital or demand forecasting which assumes a more reactive hospital. We will describe these approaches more in detail in the following two sub-sections. The way, how we consider demand is crucial as this has a direct impact on how we define the input for our model.

2.5.1 PRO-ACTIVE STEERING OF HEALTH CARE DEMAND

Nowadays hospitals in the Netherlands strive to make strategic decisions regarding their case mix. Van der Meer and School (2008) find that often hospitals are aiming to specialize in certain patient groups which provides them with a more stable demand. They present a methodology on how the Onze Lieve Vrouwe Gasthuis (OLVG) in Amsterdam translates a fixed scenario regarding a patient mix to the required capacity. The selected scenario is based on the production agreement between the hospital and the health insurance. On basis of historical data, the OLVG knows much time and effort a certain DBC profile requires per department. By multiplying the agreed DBC quantities by the corresponding historical times, the OLVG obtains a capacity utilization scenario per capacity sort.

Dowling (1976) as well as Ma et al (2009) compare the decision problem regarding the case mix in the health care sector with the product mix decision problem within manufacturing. Similar to products, some patients are more profitable for a hospital than others depending on their diagnosis. Ma et al (2009) as well as Ma and Demeulemeester (2010) develop an approach to produce the optimal case mix pattern together with its associated resource allocation scheme. However, they claim the existence of a trade-off between an optimal resource allocation and an optimal financial impact. Only focusing on maximizing the financial contribution can lead to over or underuse of certain existing resources. An example could be a physician with a certain specialism that treats patients that are not profitable.

2.5.2 DEMAND FORECASTING

Authors as Kuntz et al (2009) suggest that capacity should be endogenously assigned according to the forecast of future demand. The problem lies in the uncertainty regarding the future: We simply cannot say for sure exactly how the demand will behave for a society or a hospital. According to Vermeulen et al (2009) due to uncertainty and fluctuations in demand it is important that resources be flexible allocated. The authors study the impact of different case mixes on computer tomography scans (CT-scans) at the radiology department within the Academic Medical Centre Amsterdam (AMC). Ma and Demeulemeester (2010) find that due to the uncertainty of the future a simulation analysis should take multiple scenarios regarding case mixes into account in order to cope with the present uncertainty. However, the question arises on what we can accept as realistic scenario. Often researchers as Van der Meer and School (2008) make use of average figures from the past regarding the capacity consumption of resources in order to forecast the future. Barros et al (2010) made use of historical data from 2001 until 2009 in order to forecast future case-mixes for three hospitals in Chile. They point out that demand forecasting on basis of historical data is a concept that has worked well within manufacturing.

2.6 WORKFORCE PLANNING

In Section 2.5 we described the possible impact of a patient mix on the capacity consumption of the resources. We consider the relationship between a patient mix on the one hand and beds and operation time on the other hand as relatively straightforward and will explain our approach more in detail in Chapter 5. The relationship between a patient mix and a workforce formation meanwhile is considered as a bit more tedious and elaborate. In this section we explain this further.

Sermeus et al (2007) performed a study on whether it is feasible to allocate nursing resources in an accurate manner among hospitals in Belgium. Belgium in contrast to the Netherlands also uses diagnosis related patient groups in order to be able to make changes in the distribution of the nursing resources. Therefore the authors research whether differences in diagnosis related groups (that correspond to DBCs in the Netherlands) justify differences in quantities of nursing resources. They conclude that differences in the patient mix only have a relatively small effect on differences in nursing resources (20-40% according to Sermeus et al). Furthermore, an accurate allocation of the nursing resources depends heavily on completeness and correctness of information on the workload of the nurses. Schouppe et al (2007) wrote a paper regarding Workload Indication for Nursing (WIN). In order to quantify the workload for nursing they firstly indentified the activities that are executed by nurses of the surgery, internal medicine and geriatrics departments. Thereafter they created standard times for these activities based on past measurements. These standard times require continuous updates as measurements vary over time and can show certain trends. Finally Schouppe et al (2007) created an instrument to reallocate the nurses on basis of the workload measurements. Myny et al (2010) criticize the fact the there are insufficient registration possibilities within some Belgian hospitals in order to allow a good reallocation of resources based on high-quality data regarding the workload. Furthermore they strive to improve the methodology from Schouppe et al (2007) by an in-depth analysis of the factors that have an influence on the workload.

2.6.1 OTHER APPROACHES REGARDING WORKFORCE PLANNING

Hurst (2003) wrote a review on different approaches on strategic planning of nurses. They label the approach of Schouppe et al (2007) a time-activity approach. The advantage of this approach is that type and frequency of nursing interventions form a good predictor of the nursing workload. Furthermore it can take admission numbers and case mixes of patients into account. However, the implementation of this approach is rather costly. Elkhuizen et al (2007) point out the fact that these approaches are difficult to apply in practice because they require a great deal of data and clerical work.

More traditional approaches are for example the Professional Judgement approach which simply transforms duty rotas into whole time equivalents (FTE). This approach is quick, simple and inexpensive to use. However, it does not take admission number and case mixes into account, therefore disregards patients demand. The Nurse per occupied bed method is a bit more advanced as this method takes care of admission numbers. In case more beds are occupied by patients, this approach suggests to make use of more nurses. Elkhuizen et al (2007) made use of this method in order to determine the required nursing capacity in the Amsterdam Medical Centre (AMC).

According to Hurst (2003), the Acuity –quality method (in contrast to Professional Judgement and Nurse per Occupied bed) can take fluctuations of patient mixes into consideration. Patients in this method are divided into categories that simulate dependency on the nurses. However, according to Hurst (2003) type and frequency of nursing interventions required by patients (as used in the time-activity approach) are felt to be a better predictor than the patient dependency categories. The last approach analyzed by Hurst is the regression-based approach, which is less costly than the time-activity approach. Moreover, this method is useful in case predictions (i.e. on numbers of admissions) are possible

2.7 CONTRIBUTION OF THIS THESIS TO THE LITERATURE

This chapter was written to provide the reader with the theoretical framework for the case study performed in the Erasmus MC in Rotterdam. This section will summarize on how the research performed within the case study connects with the theory. Furthermore the contribution of our research from a scientific perspective is highlighted.

Firstly we have explained the origins of capacity planning and outlined the difficulties of implementing capacity planning principles in hospitals. Also in the Erasmus MC there is currently limited attention regarding capacity planning. But times have changes with the introduction of the dbc system in 2005. Next to changing from a supply-focused to a demand-oriented system, due to the introduction of the dbc system in 2005, there is now data available to better identify the Health Care demand by means of a case mix. With the case study we are aiming to verify whether in practice it is feasible in order to implement capacity planning or whether indeed the difficulties of implementation outweigh the benefits of capacity planning.

There are various sources from academic literature available regarding capacity planning in hospitals. However, a lot of sources refer to tactical or operational planning. In this short term planning parameters as quantities and qualities of resources is fixed. In our research we focus on strategic planning which leaves supply and demand parameters variable. We found two methodologies that are suitable for strategic resource planning namely pro-active steering of the demand and demand forecasting. Pro-active steering of demand can be applied in case the hospital has a clear strategy on patient focus groups. Demand forecasting could be more appropriate in case the hospital is aiming to react on the changing demand. In our research we will analyze the historic developments in the demand by analyzing the historic patient mixes. Similar to the available literature we are aiming to make predictions on future patient mixes based on the past data. Moreover we analyze the interaction of demand and the resources. The resources we identified in the literature are bed capacity, operation time and workforce capacity which we also used in our research.

While bed as well as operation time capacity is rather straightforward to model, the relationship between patients on the one hand and an appropriate workforce formation is more cumbersome. To draw this relationship we basically have to know how much time a nurse spends on a patient. In practice this requires extensive measurements. Schouppe et al (2007) described a quantification of the workload for nursing in Belgium. After a precise identification of the activities of the nurses, they created standard times for these activities based on past measurements. These standard times require continuous updates as measurements vary over time and can show certain trends. Finally Schouppe et al (2007) created an instrument to reallocate the nurses on basis of the workload measurements.

3 CONTEXT OF THE CASE WITHIN THE ERASMUS MC

3.1 INTRODUCTION

In Chapter 2 we provided the reader with a general literature review regarding capacity planning in Health Care. As our research takes place in the Erasmus MC in Rotterdam, the next two chapters elaborate more on the concrete case. Basically, this current phase of the study concerns the surgery department of the Erasmus MC. While Chapter 3 deals with the organizational context of the study and is meant to give a broader overview, Chapter 4 will zoom in on analyzing historical data and therefore give a more detailed overview over the processes in scope.

Chapter 3 is structured as follows: Section 3.2 is supposed to provide the reader with a broad idea of the organizational context. Section 3.3 deals with a schematic description of the patient flow within the surgery department and Section 3.4 zooms in on the resources that are in scope.

3.2 ORGANIZATIONAL CONTEXT

Principal for the study is the Cluster-office 4&5 (Clusterbureau 4 & 5) within the Erasmus MC. The mission of the Cluster office is to provide customer-oriented and effective advice and support to primary customers. Primary customers are the managers of the departments of cluster 4 and 5 (department heads, division heads, medical coordinators, unit managers, key users, laboratory heads and project leaders). The corresponding departments of the Cluster 4 are: Internal Medicine / Diet Studies, MDL (stomach, intestine, liver), Pulmonology, Rheumatology and Dermatology. Cluster 5 deals with Surgery, Trauma and SEH (Emergency). In total about 1,500 people are employed in the clusters (source doc: visie_clusterbureau). Currently the Erasmus MC is planning to perform a reorganization which is called “Thematisering” (Theming). The purpose of the theming is that capacity is organized and (re)allocated efficiently. The aim is to put patients into a central position and organize the capacity in such a way that patients can benefit from it optimally. This has not always been the case in the past. Rechel et al (2010) claim that traditionally, hospitals were designed around specialties and departments rather than around the needs of patients. This often results in a poor patient flow and long waiting times. Clusters 4, 5 and 8 are planned to be combined into one theme (Theme Dijkzigt).

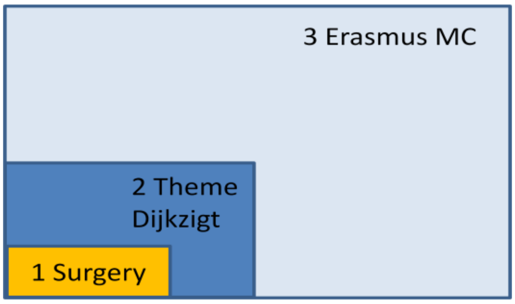


Figure 3.1: Scheme scope Erasmus MC

This research focuses on the capacity simulation of the clinical units of the surgery department (within Cluster 5). However, a second phase research could extent the scope to the other departments within the new theme Dijkzigt. The final aim is to allocate capacity efficiently within the entire Erasmus MC. Consider Figure 3.1 for a schematic overview of the scope.

3.3 DESCRIPTION OF THE SURGERY PATIENT FLOWS

As mentioned in Section 3.2, this phase of the study focuses on the clinical units of the surgery department. In this section we are aiming to provide the reader with an overview of the patient flow within the surgery department. Having a good understanding of the patient flow is of crucial importance for an optimal allocation of capacity. The surgery department distinguishes between two different *sorts* of patients: operative patients and conservative patients. In the remainder of this thesis we index the different sorts with *s*. As operative patients usually undergo an operation, while conservative patients don't, their flow is different

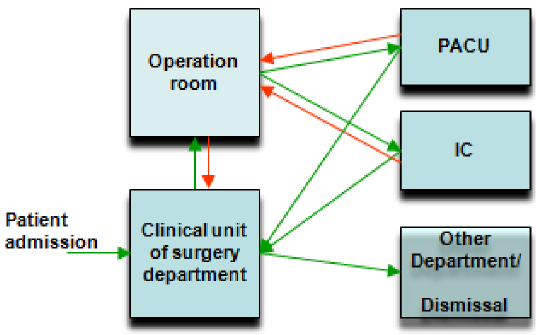


Figure 3.2a: Patient flow operative patients

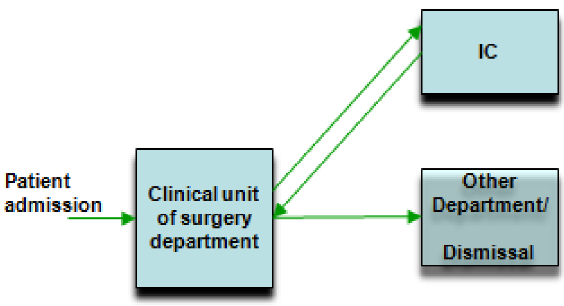


Figure 3.2b: Patient flow conservative patients

Consider Figure 3.2. Figure 3.2a depicts the process flow for operative patients while Figure 3.2b depicts the process flow for conservative patients. After admission has taken place, operative patients are transferred from the corresponding clinical unit to the operation room where they undergo the operation. In some cases patients have to remain in the operation room for multiple operation sessions. When the procedure is finished, patients are either transferred back to the clinical unit, to the PACU (Post-Anesthesia-Care-Unit) or the IC (Intensive Care). The IC is usually used in case patients have undergone rather severe operations and require more intensive care in order to recover. The PACU contains patients with lower severities, which still require postoperative, hemodynamic or respiratory care, 24 until 48 hours after the operation. After the initial recovery has taken place, patients are transferred back to the corresponding clinical unit for further observance and recovery. Finally either dismissal takes place or a transfer to another department in case the patients deal with any additional problem not related to the surgery department. Conservative patients do not undergo an operation (by definition). However, they might be transferred from the corresponding clinical unit to the Intensive Care unit, in case this is necessary. Finally also conservative patients are either dismissed or transferred to another department.

Next to the difference in sort, patients have another criterion that distinguishes them from another: the specific case mix or diagnosis of the patient. In the year 2005, a new case mix system was introduced in the Netherlands, which was meant to better register and pay the delivered care, the so-called DBC system. DBC stands for Diagnose (Diagnosis) Behandeling (Treatment) Combination (Combinatie). A DBC can be regarded as a predefined average treatment, which is applied when a specific diagnosis occurs. The surgery department of the Erasmus MC uses approximately 1000 DBCs. In our study we grouped the DBCs into a restricted number of categories that are summarized in Figure 3.3. The grouping is in line with the categorization from the old Excel model from 2006. In the remainder of this thesis patient categories are indexed with *c*. Basically the patient flow is virtually the same for each patient category. The difference only lies in the fact that the different clinical units have different specializations and have preferences regarding the patient categories. A patient of category Trauma for example is most likely to be treated in Unit 9 Center. However, we elaborate more in depth on this in Chapter 4

Dutch name	English name	Average age	% male
ALGEMEEN	General patients	53	47,06%
ENDO	Endo	54	35,26%
GIC	GIC - digestion	59	55,79%
LEVER-TX	Liver Transplant	50	63,74%
ONCO	Onco	56	30,76%
TRAUMA	Trauma patients	45	66,22%
TX-niertransplantatie	Kidney Transplant	52	57,28%
VAAT	Vascular patients	65	65,50%

Figure 3.3: Names and statistics of patient categories

3.4 SCOPING OF THE RESOURCES

This research has the purpose to elaborate on an optimal strategic resource allocation. The study is zooming in on the surgery department of the Erasmus MC. Although this focus is rather specific, we study rather general resources. On a high level speaking, the resources in scope are beds, operation time and the workforce. In the following, we describe our motivation for selecting these resources and explain their scope and relevance within the Erasmus MC.

1) Resource: Beds

Already in the year 1988 Smith-Daniels et al. (1988) present an extensive literature review on capacity management at hospitals and indicate that most admission scheduling systems focus on bed capacity. Also within the Erasmus MC allocation of bed capacity is of crucial importance. The question is how beds will be allocated within the buildings of the Erasmus MC in the scope of the reorganization (theming). Corresponding to the patient flow in Figure 3.2, within the surgery department, the clinical units, the Intensive Care (IC) unit and the PACU require bed capacity. Before 2010 the surgery department mainly made use of three clinical units: Unit 8 North, Unit 9 Center and Unit 9 South. From 2010 onwards a forth unit is taken into operation for the surgery department: Unit 9 North. The required bed capacity is rather straightforward to measure which is simply the product of the number of admissions of the patients and their corresponding duration of stay. We will elaborate further on this in Chapter 4.

2) Resource: Operation time

With operation time we basically mean the product of all operative admissions and their corresponding durations of the operative sessions within the operation room. Operation time is basically limited by two main resources namely the (Chirurgic) workforce and availability of the actual operation room. However, within this study we limit ourselves to operation time. There is one maximum amount of yearly operation time negotiated regarding elective patients. In case this maximum is exceeded, patients are put on a waiting list and operated in a later time. Operation time as well as bed capacity has already been modeled in the existing Excel capacity model.

3) Resource: Workforce capacity

As mentioned in Chapter 2, the Health Care industry is known to be very labor intensive with labor costs up to 80% of the total costs. This also means that there is a high cost pressure on efficiently allocating these resources. Moreover, allocating the labor resources efficiently and optimally is usually in the interest of the patient as he requires sufficient attention. However, modeling workforce capacity is rather difficult. How many patients can a nurse treat per day? This heavily depends on the patient as well as on the employee. Therefore we require information on both. Basically, within a clinical unit we speak of one workforce formation that corresponds to it. In this research we are dealing with the formations of the clinical units Unit 8 North, Unit 9 Center, Unit 9 South and Unit 9 North. A formation consists of different functions. The functions corresponding to the above-mentioned clinical units are summarized in Figure 3.4. Note: the largest share of the group in terms of FTE is usually formed by the nurses.

Dutch name	English name
Regieverpleegkundige	Nurse Director
Seniorverpleegkundige	Senior Nurse
Verpleegkundige	Nurse
Leerling	Apprentice
Voedingsassistent	Nutrition Assistant
Afdeling Assistant	Department Assistant
Medisch Student	Medical Student
Unithoofd	Unit Head
Verzorgende	Care giver
Senior Verzorgende	Senior Care Giver
Zorgassistent	Care Assistant
Teamleider Medische studenten	Team Leader Medical Students
Praktijk begleider	Practice companion
Polikliniekassistent	Outpatient Clinic Assistant

Figure 3.4: Functions of formation in scope

4 DATA ANALYSIS SURGERY DEPARTMENT/ERASMUS MC

4.1 INTRODUCTION

In Chapter 3 we provided the reader with the organizational context of the study. We also drew a high-level scheme of the patient flow within the surgery department and gave an overview over the resources in scope. Chapter 4 is meant to analyze the patient flow and the capacity usage of the resources in more detail. Basically we do this by analyzing historical data. The aim is to analyze whether we can find certain trends in the development of the parameters. While Chapter 5 elaborates on the methodology of strategic capacity planning, Chapter 4 is meant to provide important ingredients for this methodology in terms of realistic parameters. In Chapter 3 we have motivated that the resources under consideration within our study are beds, operation time and workforce. There are several factors that have an impact on the capacity consumption of these resources. We have seen in Chapter 2 that historical data concerning the number of hospital admissions and the average duration of stay per admission are crucial regarding capacity consumption of the clinical resources beds and workforce. The number of admissions in the operation room and the operation session times determine the operation time capacity. In this chapter, we analyze both: the development of the above-mentioned parameters as well as their impact on the capacity consumption on the selected resources.

This chapter is organized as follows: The introduction is supplemented with a note on th data used for our research in Section 4.1.1. Thereafter, Section 4.2 deals with the analysis of the above-mentioned parameters: Section 4.2.1 deals with the number of hospital admissions, 4.2.2 covers the average duration of stay, and Section 4.2.3 the operation times. Section 4.3 treats the analysis of the past resource consumption of the resources.

4.1.1. A NOTE ON THE DATA USED FOR THE RESEARCH

The data stems from internal sources within the Erasmus MC. At the moment the research was performed, data was extracted from two different IT systems that run parallel (BO and BO XI). BO XI mainly contains data regarding operation time capacity while BO contains the remaining data. In an optimal case we would have preferred one single source of data as this would have overcome some problems due to differences in the structure of the data. For example operation time capacity data was registered from 2007 onwards while data that originates from BO is available from 2006 onwards. Unfortunately, prior to 2006 there is no data available which has to do with the fact that the DBC system was firstly introduced in 2005. Therefore the period under consideration for the analysis is 2006 – 2010 (5 years). Needless to say: The data analysis could increase in value in case more years of data are available.

The data quality unfortunately also has its limitations. Within the Erasmus MC, the employees had to get used to the DBC registration process. Especially in the beginning of the DBC registration, often registration errors occurred. Sometimes we found in the data for some diagnoses that the number of clinical admissions is greater than the number of the nursing days which is virtually impossible. However, this phenomenon seems to diminish over the years: more recent years deliver more reliable data.

4.2 PARAMETER ANALYSIS (FOR 2006 – 2010)

4.2.1 NUMBER OF ADMISSIONS

We should not make the mistake to confound the number of admissions with the number of patients, as a patient could be granted admission several times. Firstly we were interested in the total number of clinical hospital admissions that were registered in the surgery department between 2006 and 2010. Clinical admissions refer to patients that stay at least one night in the clinic. In Figure 4.1 we can observe that the number was increasing during this time interval. After a decrease from 2634 admissions in 2006 to 2378 admissions in 2007 (due to the temporary shutdown of several clinical beds), there was a continuous increase in the number which peaked in 2010 with 3305 admissions in 2010.

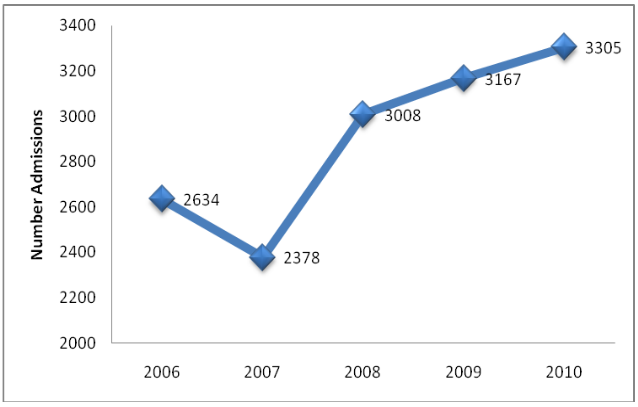
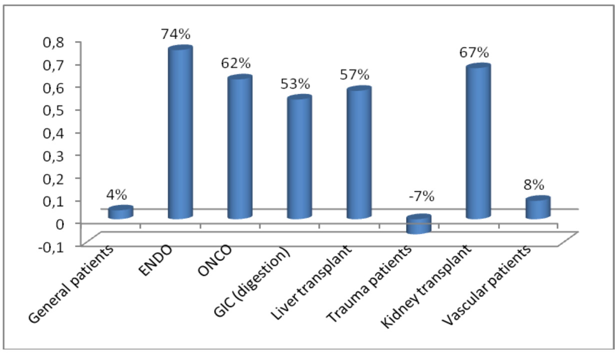


Figure 4.1: Development Nr. clinical admissions

In Chapter 3 we have introduced the so-called patient categories. We are also interested in the number of admissions per patient category in order to obtain a better understanding of the general trend from Figure 4.1. Consider Figure 4.2 which represents an analysis of the different patient categories. Figure 4.2a displays a pie chart that represents the total number and the % out of the total number of the admissions per category. We can basically see that GIC(digestion) patients form the largest chunk with 27% of the total number, but also Vascular patients(22%), Trauma patients(21%), General patients(14%) and Kidney patients(11%) represent numerous groups. Figure 4.2b represents the % change of the number of the admissions per category between 2006 and 2010. We can observe that the number of admissions has increased within the above-mentioned time interval for all categories except Trauma (- 7%). The number of general patients (+4%) and Vascular patients (+8%) has only increased slightly, while all other categories show remarkable growth figures (53% - 74%).



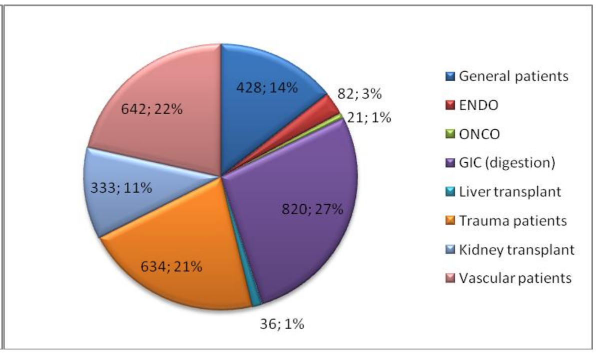


Figure 4.2a: (Nr;%) Admissions in 2010

Figure 4.2b: % Change Nr. Admissions 2006 ➔2010

The greatest impact has the growth of the number of GIC admissions with a growth rate of 53%. While in 2006 there were 537 yearly admissions- this increased to 820 admissions per year. In Chapter 3 we have already mentioned that before the year 2010 the surgery department has made use of three clinical units: Unit 8 North, Unit 9 Center and Unit 9 South. In the remainder of Section 4.2.1 we analyze how the admissions were divided among the above-mentioned clinical units between 2006 and 2010. Consider Figure 4.3. The number of admissions has increased for all units within the time interval under consideration.

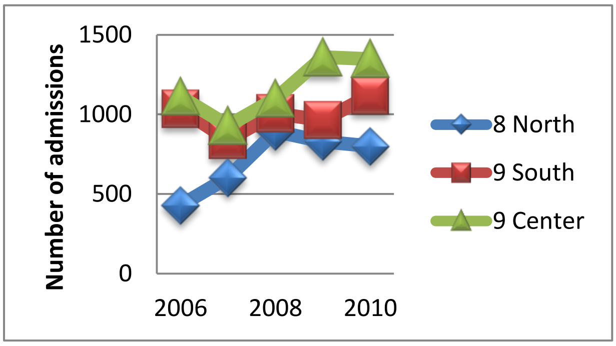


Figure 4.3: Nr Admissions per Unit (2006-2010)

Moreover it is apparent that Unit 9 Center continuously had the highest number of admissions, while Unit 8 North continuously had the lowest number. Basically the three units used to deal with different patient mixes as they all have a different specialism. In Figure 4.4 we summarize the distribution of the different patient categories over the units with the help of pie charts. In order to show the development in time, we plot the distributions for the year 2006 and 2010, respectively.

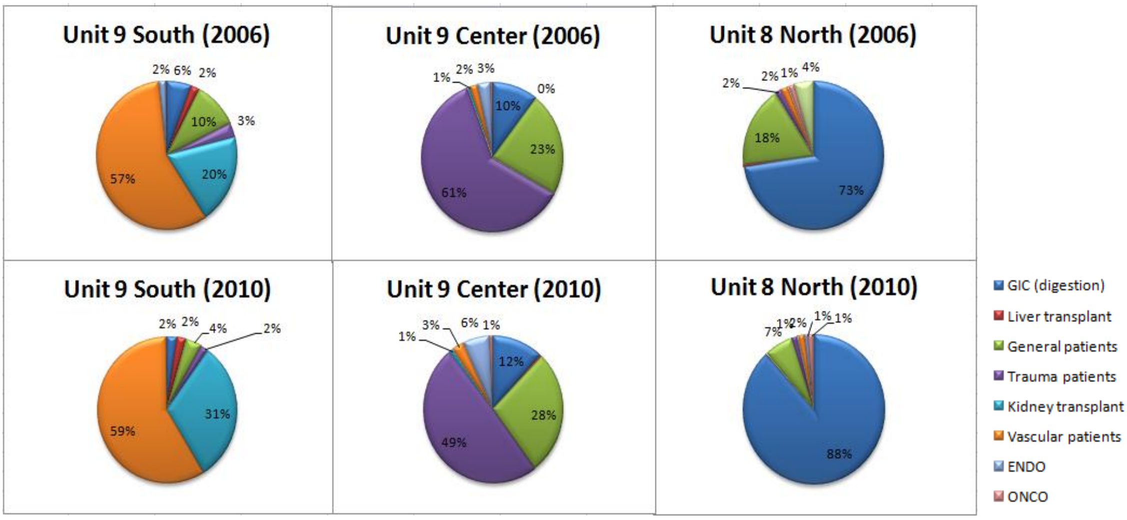


Figure 4.4: Distribution categories per Unit (2006;2010)

We can see that Unit 8 North is mainly treating GIC (digestion) patients. It is interesting to see that this unit seems to increase the focus on this specialism over time. While in the year 2006, only 73% of the total patients in Unit 8 North were of category GIC, in 2010 the share amounts 88%. A similar development occurred in Unit 9 South. Unit 9 South has two main pillars of patients categories: Vascular and Kidney patients. While in 2006 those two categories together had a share of 77% (57% for Vascular patients and 20% for Kidney patients), the share increased to 90% in 2010 (59% for Vascular patients and 31% for Kidney patients). The development of Unit 9 Center was different during the time interval under consideration. Although we can state that the specialism of this unit is the treatment of Trauma patients, this share decreased from 61% in 2006 to 49% in 2010, which also has to do with the fact that there is an overall decrease in the number of admissions of Trauma patients. Concluding, we observe the existence and development of rather specialized units (Unit 9 South and 8 North) as well as a rather generalized unit (Unit 9 Center).

4.2.2 AVERAGE DURATION OF STAY OF THE PATIENTS

This section contains an analysis of the average duration of stay of the patients within the clinical units which also has a major impact on the capacity consumption of the resources. Firstly we graph the development of the average duration of stay over the time interval 2006 – 2010 by taking patients of all categories into consideration.

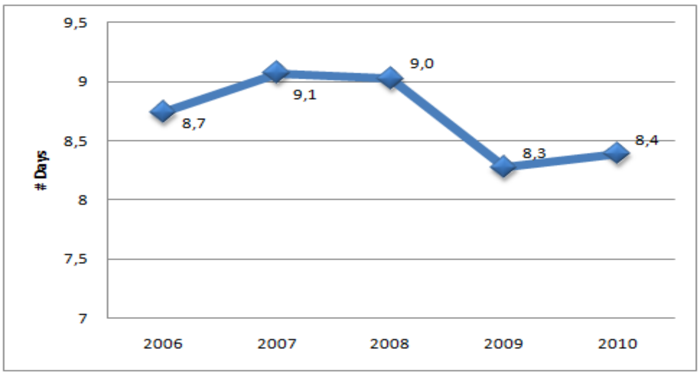


Figure 4.5: Development total average duration of stay

Consider Figure 4.5. We can see that the average duration of stay slightly declined over the last years from 8,74 days in 2006 to 8,39 in 2010. In Figure 4.5b we graph the development of the duration of stay per sort. The total average duration of stay decomposes into the into individual durations of stay per (sub)category and on the different sorts. In general the data regarding the average duration of stay per subcategory will be an important ingredient for the capacity planning methodology which we will describe further in Chapter 5. However, we leave a further detailed analysis of these parameters out of scope in this thesis. In Section 4.2.1 we aggregated the number of admissions per unit and concluded that Unit 8 North had the lowest number of admissions while Unit 9 Center had the highest number. In Figure 4.6 we display the average duration of stay per unit for the time interval under consideration. We can see that patients located in Unit 8 North through the years have the longest duration of stay of about 11 days, while patients located in Unit 9 Center have the shortest duration of stay of on average 7 days. What is also remarkable is that the duration of stay especially decreased in Unit 9 Center over the especially between 2008 and 2009.

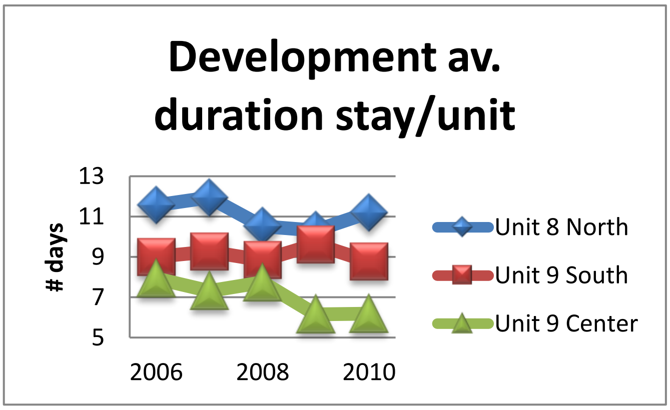


Figure 4.6: Duration of stay per unit

4.2.3 OPERATION (SESSION) TIMES/NUMBERS

We have seen that there are different sorts of patients: operative and conservative. In this section we analyze operation statistics and therefore only refer to patients that are operative. Finally, our aim is to measure operation time capacity. Similar to the parameters analyzed above in order to see the impact on the clinical resources, we require numbers of admission and duration times. In this section we analyze the admissions of patients for the operation room and operation session times.

1) Number of operative sessions

Firstly, it is important to note that admissions for the operation room are crucially different from the number of clinical admission which we analyzed in Section 4.2.1. To give an example: There are patients with one clinical admission but up to 10 admissions for the operation room (which is an exception of course). We computed average figures per (sub) category, which will be crucial for our methodology described in Chapter 5. In our analysis we have found that these parameters behave relatively stable over time.

2) Operation session times

On average, operative session times range between 183 minutes in 2007 and 196 minutes in 2010. (data from 2006 was unfortunately not available) The standard deviation is comparatively high (approximately 120 minutes) as we are dealing with aggregated figures averaged over all categories. Also regarding operative session times, we made a further breakdown for the different categories. While session times for Liver patients on average have a duration of 368 minutes (approximately 6 hours), mild vascular patients, mild Trauma patients and mild general patients only require about 100 minutes for operative sessions on average. Furthermore, we distinguish between elective (planned/scheduled) and emergency (unplanned) patients. While elective patients have an average duration of 214 minutes per session,, unplanned patients only require 151 minutes.

4.3 CAPACITY CONSUMPTION OF THE RESOURCES

In Section 4.2, we have analyzed admission numbers as well as duration figures. This Section is meant to provide the reader with information on the capacity consumption of the selected resources beds, operation time and workforce. However, note that we are still dealing with historical data.

4.3.1 CAPACITY CONSUMPTION OF BEDS (CLINICAL UNITS)

Capacity consumption of beds is simply measured in terms of nursing days. Nursing days are derived from the number of admissions and the average duration of stay. Let *Nd* be the parameter for nursing days, *P* be the parameter for the number of admissions and *Ad* be the parameter for the average duration of stay. *C* is the index for patient categories while *SC* is the index for the patient sub-categories. Then we calculate the nursing days by the following formulas: $Nd_c = P_c * Ad_c$ or $Nd_{sc} = P_{sc} * Ad_{sc}$ respectively

So far we have found that the total number of admissions increased during the previous years, while the average duration of stay had a nonincreasing pattern. In Figure 4.7a we can see that similar to the number of admissions, the number of nursing days shows an increasing pattern over the time from 2006 to 2010.

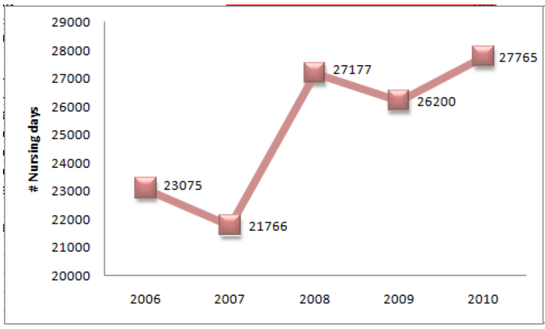


Figure 4.7a: Development total number nursing days

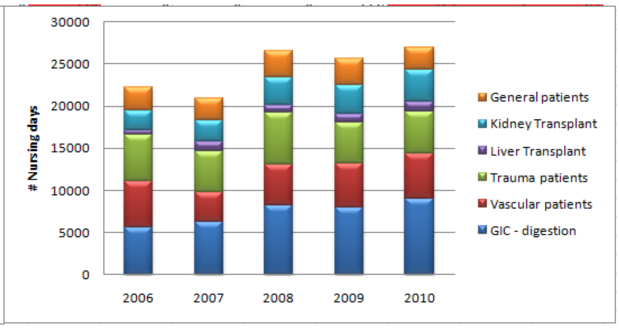


Figure 4.7b: Development number nursing days/category

Splitting the total number of nursing days into the categories (as shown in Figure 4.7b) yields that especially the nursing days for GIC/digestion patients and kidney patients have increased over the last years while the nursing days corresponding to patients of other categories stayed rather constant. By anlyzing the nursing days per unit (Figure

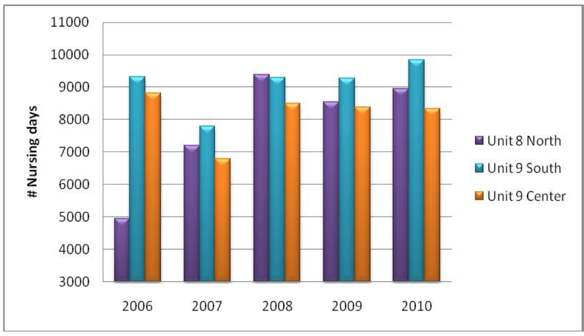


Figure 4.8a: Development number nursing days per unit

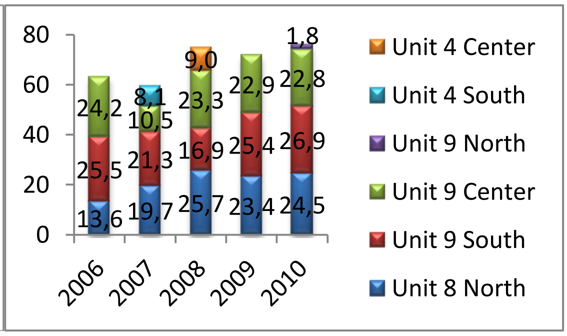


Figure 4.8b: Average usage of beds per unit

4.8a) we can see that Unit 9 South continuously realized the highest number of nursing days while Unit 9 Center realized the lowest number of nursing days over time. The low average stay of the patients seems to offsets the high number of patients in this unit. Figure 4.8b displays the average bed consumption per unit (by dividing the nursing days by 365). Note that in the year 2007 part of the bed capacity of 9 Center was redistributed to Unit 4 South, while in 2008 part of the bed capacity of Unit 9 South was redistributed to Unit 4 Center.

4.3.2 CAPACITY CONSUMPTION OF OPERATION TIME

If *SC* is the index for the patient subcategories, let *OC* be the total operation time capacity, P_{SC} the number of clinical admissions of (sub) category *SC*, O_{SC} the number of operative sessions per admission and OT_{SC} the average operation session time for category *SC*.Then the total operation capacity is calculated as follows: $OC = \sum_{SC} P_{SC} * O_{SC} * OT_{SC}$

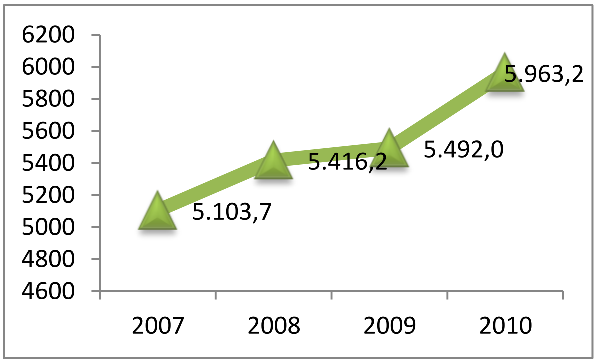


Figure 4.9: Development Total number of operation time (in hours)

In Figure 4.9 we depict the development of the total yearly operation capacity used. Clearly we can observe an increasing pattern. In 2010 the total time of all operation sessions amounted to 5963,2 hours

4.3.3 CAPACITY CONSUMPTION OF WORKFORCE CAPACITY

Calculation of bed as well as operation time capacity was rather straightforward as it directly relates to the number of admissions and the corresponding durations. However, regarding workforce capacity we can not directly draw this link. This link requires further modelling which we describe further in Chapter 5. However, in this section we provide the reader with an overview regarding historical data of the workforce. In the year 2006 it was determined that each of the three clinical units receives a fixed yearly budget of 36,8 FTE. In Figure 4.10 we display the decomposition of the budget on the different functions. Recall Chapter 3 for an overview of the different functions with the clinical units. Workforce capacity is measured in terms of FTE (Number of Full-Time emplyees). Within the Erasmus MC, apprentices have a yearly net working time of 1066,8 hours per FTE while emplyees of other functions have a yearly net working time of 1526,3 hours per FTE. Net working time, is calculated by subracting holidays, special leave, other absent, courses, seminars and illness from the gross working time.

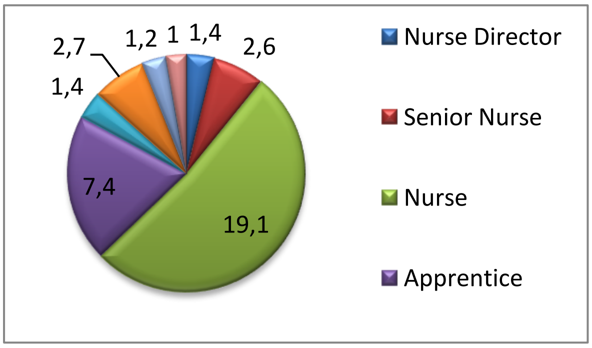


Figure 4.10: Budget per unit (workforce)

Next to the budget, we were interested in the actually realized number of yearly FTEs. In Figure 4.11 we depict the development of the realized number of FTEs per unit. We can see that there are differences across units but also across time. In Chapter 5 we are going to relate this information to the nursing days.

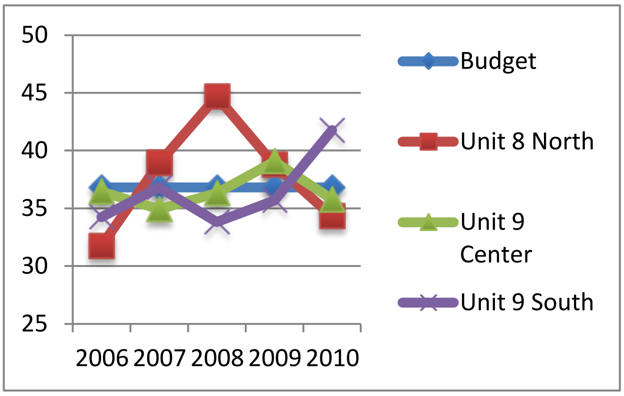


Figure 4.11: Development realized FTE per unit (versus budget)

5 METHODOLOGY REGARDING CAPACITY PLANNING

5.1 INTRODUCTION AND MOTIVATION OF THE APPROACH

The previous two chapters dealt with an analysis of the capacity consumption of selected resources of the surgery department of the Erasmus MC. In particular: Chapter 4 contained an analysis regarding historical data related to the demand of Health Care (surgery) and capacity consumption. The historical data will be used in order to construct future scenarios which we further describe in Chapter 6. In this chapter we focus on the methodology that helps to strategically plan the resources for the future. Recall that in Figure 1.1 we provided a high-level scheme of the mathematical model. The model translates input data namely numbers of admissions, average duration of stay, number of operation sessions and operation session times to the forecasted capacity consumption of selected resources (bed capacity, operation capacity and workforce capacity). Due to the linear relationships of input and output data we make use of linear modeling. This approach is motivated by the observation that capacity planning within hospitals should be derived from Health Care demand which is described by the patient mix (see Chapter 2). In particular Van der Meer and School (2008) present a methodology on translating a patient mix into the capacity requirement. Within this methodology they multiply pre-determined DBC quantities with historical treatment times. We were aiming to use a similar approach for the Erasmus MC as we possess information on historical DBC quantities and treatment times as well. Another important pillar of our study is the analysis of the impact of theming. Theming implies that the past and current circumstances regarding the organizational structure are fundamentally changed. This chapter also describes how we model this.

The structure of this chapter is as follows: Section 5.2 covers the mathematical modeling of bed and operation time capacity. Section 5.3 is devoted to the modeling of workforce capacity. In Section 5.4 we describe the mathematical modeling of Theming. The results corresponding to this methodology are presented in Chapter 6.

5.2 MATHEMATICAL MODELING (BED AND OPERATION TIME CAPACITY)

Bed and operation time capacity are modeled by linear relations. We basically model so-called capacity constraints where the left hand side represents the capacity consumption and the right hand side the capacity limit. Firstly in Section 5.2.1, we mathematically define modeling of the bed capacity, Section 5.2.2 deals with operation time capacity.

5.2.1 MODELING OF BED CAPACITY

In order to model bed capacity in the form of capacity constraints, we firstly define the following indices as well as parameters.

Indices

U	Units [Unit 8 North; Unit 9 Center; Unit 9 South; Unit 9 North]
SC	Patient subcategory [General severe, General mild, Endo…]
S	Patient sort [operative, conservative]

Parameters

B_U	Number of beds of Unit *U*
$B_{IC}; B_{PACU}$	Number of beds of IC; PACU
Min_U	Minimum % of occupancy of the beds of Unit *U*
Max_U	Maximum % of occupancy of the beds of Unit *U*
$Ad_{SC,S}$	Average duration of stay for patients with subcategory *SC* and sort *S*
$P_{SC,S}$	Number of admissions for patients of subcategory *SC* and Sort *S*
$P_{SC,S,U}$	Number of admissions for patients of subcategory *SC*, sort *S* treated in Unit *U*

Currently the clinical units (as well as the IC and PACU) have a certain number of beds available. In the short term the number of beds B_U and $B_{IC}; B_{PACU}$ is fixed. On a yearly basis each clinical unit strives to achieve an occupancy rate which lies within the interval

$[Min_U; Max_U]$. However, in the scope of theming, we treat these figures as deterministic variables. In the following we provide the bed capacity constraints:

(1) $$\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \leq Max_U * B_U * 365 \qquad \forall U$$

(2) $$\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \geq Min_U * B_U * 365 \qquad \forall U$$

(3) $$P_{SC,S} = \sum_{U} P_{SC,S,U} \qquad \forall SC, S$$

Constraints (1) and (2) describe the fact that bed occupancy should lie within the interval $[Min_U; Max_U]$, while constraint (3) implies that all patients of each subcategory and sort are treated by all units U under consideration. However, the question also remains which figures we use for $P_{SC,S,U}$ and $Ad_{SC,S}$ for the model. The scenarios corresponding to the modeling of bed capacity are presented in Chapter 6

5.1.2 MODELING OF OPERATION TIME CAPACITY

In order to model operation time we will have to define additional parameters. Now we do not distinguish anymore between different sorts of patients as done within the bed capacity. Instead we divide patients into elective (Index *el*) and emergency (Index *em*) patients. This classification is done according to medical reasons (rather than organizational reasons). We have seen in Chapter 4 that elective patients and emergency patients have differences in their operation times. Moreover, there is an operation time capacity limit which only yields for elective patients.

Parameters

$OELMax$ Maximum of operation time available for elective patients

$P_{SC,el}$ Number of admissions for patients of subcategory *SC* which are elective

$P_{SC,em}$ Number of admissions for patients of subcategory *SC* which are emergency patients

O_{SC} Number of operative sessions per admission of category *SC*

$OT_{SC,el}$ Average operation session time for category *SC for elective patients*

This yields the following capacity constraint regarding operation time capacity:

(4) $$\sum_{SC} P_{SC,el} * O_{SC} * OT_{SC,el} \leq OELMax$$

Constraint (4) implies that the actually consumed elective operation time capacity (on the LHS of the equation) should not exceed the maximum capacity limit which is predefined for elective patients (on RHS of the equation). Emergency patients are not included in this capacity limit. Basically there is no arrangement regarding a maximum capacity limit for emergency patients which is why the total operation time spent on emergency patients is unconstrained in our model. Also regarding operation times and number of operative sessions, we will analyze the corresponding scenarios in Chapter 6.

5.3 MATHEMATICAL MODELING OF WORKFORCE CAPACITY

Mathematical modeling of bed as well as operation time capacity is rather straightforward whereas workforce capacity is more tedious to model. However, also regarding workforce capacity, questions we ask are: "How many extra admissions justify one additional FTE per year?" or "What is the impact of the development of the average duration of stay on the workforce formation?".The problem is that there is no direct link between the main parameters as the number of admissions ($P_{SC,S,U}$) and the average duration of stay ($Ad_{SC,S}$) on the one hand and the workforce formation on the other hand. We have seen in the literature review in Chapter 2 that the UZ Leuven (Belgium) is making use of data regarding the time, nurses are spending on average on patients from different categories. However, this data is not available within the Erasmus MC. Therefore we constructed a methodology based on nursing days/FTE ratios.

In this section we present three different approaches. Section 5.3.1 analyses the relationship between the total number of nursing days per unit and the corresponding formation. In Section 5.3.2 we refine this approach by dividing the formation into a fixed and a variable part. In Section 5.3.3 we further refine this approach by taking a patient-intensity factor into account.

5.3.1 WORKFORCE CAPACITY ACCORDING TO A "NURSING DAY PER FTE FACTOR"

Recall from Chapter 3 that a workforce formation corresponds to the clinical units under consideration. Let *f* be the index for the different functions within the workforce formation. (Recall that all available functions are listed in Figure 3.4). In Chapter 4 (Section 4.3.4) we gave an overview over the development of the total number of FTEs aggregated over all functions per unit. Moreover in Section 4.3.1 we gave an overview over the development of the nursing days per unit. In this section we are combining both above-mentioned datasets by constructing Nursing days (per unit)/FTE (per unit) ratios.

Nursing days per FTE				
	Unit 8 North	Unit 9 Cente	Unit 9 South	Average
Last ratio (2010)	220,53	214,38	265,25	233,39
Average ratio	206,51	223,46	254,72	228,23
Worst case	155,97	194,30	212,58	187,62
Best case	279,54	241,80	260,82	260,72

Figure 5.2: Nursing days/FTE ratios

We can make use of a restricted number of Nursing days/FTE ratios (15- corresponding to 3 units in 5 years). In Figure 5.2 we display the main statistics that correspond to these values. The ratios are calculated per unit but also presented as a unit-average in the last column of Figure 5.2. Not surprisingly the ratio is changing each year which means that the performance of an average FTE within the unit varies over time. The row with the title "Best case" displays the highest ratios which have been realized since the year 2006, while "Worst case" corresponds to the lowest performance in the same time-interval. Within this approach we assume that each FTE within a unit is realizing the same amount of nursing days. (which is not true in practice) Consider Figure 5.3. Here we plot the combinations of FTE per unit per year and Nursing days per unit per year and model the relationship by means of a linear function that crosses the origin. (FTE/Unit/year is the dependent variable while the number of nursing days/unit/year is independent).

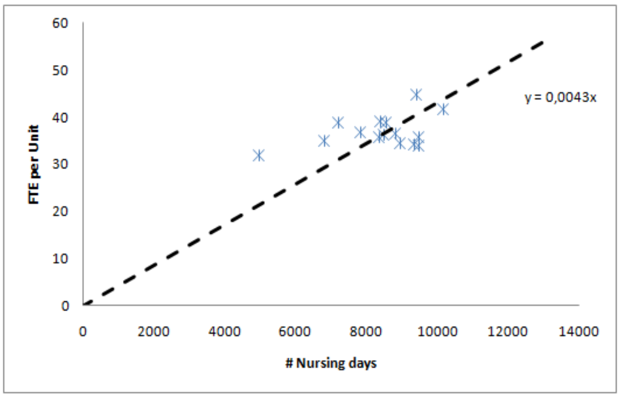


Figure 5.3: Nursing days/FTE ratios in a x/y plane

Now, let NF_U be the parameter for the nursing days that can possibly be realized per FTE in a unit maximally. Then the capacity constraint regarding workforce capacity per unit becomes:

(5) $$\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \leq W_U * NF_U \qquad \forall U$$

Here W_U represents the total workforce of a unit in terms of FTE aggregated over all functions $(W_U = \sum_f FTE_{U,f})$, $FTE_{U,f}$ is the number of FTE, unit U employs for a certain function f.

5.3.2 INCORPORATION OF A FIXED SHARE OF THE FORMATION

In Section 5.3.1 we made a rather strong assumption, namely that each FTE is realizing the same number of nursing days. In this section we find that it is more appropriate to assume that there is a fixed fraction of the formation of a unit that exists irrespective of the number of realized nursing days. Consider again Figure 5.3. We plot historical data regarding combinations of nursing days and FTE (both per unit). Now we perform an OLS regression corresponding to these data points with the number of FTE per unit as dependent variable and the number of nursing days per unit as the independent variable. We summarize the outcome of the regression in Figure 5.4.

	Coefficients	*Standard error*	*t Stat*	*P-value*
Intercept	27,573	5,353	5,15	0,00
X Variable 1	0,001	0,001	1,76	0,10

Figure 5.4: Regression results (R Square= 0,1923)

This test would imply that we obtain some evidence regarding a non-zero intercept (significant, even within a 99% confidence interval). According to this test, approximately 27,57 FTE are not directly related to the number of nursing says, while any additional Nursing day requires approximately 0,0011 FTE. However, due to the low value of R square and the low number of observations (15 = 5 years * 3 units), this result has to be treated with great caution. The added value of the test more lies in substantiating the following:

In the year 2006, within the Erasmus MC a time use study was performed with the aim to obtain more insight into more insight into the care processes. In the study it was found that out of the net working time of the workforce of a unit, a fraction is directly spent on the patients ("direct care"), while another fraction is rather spent indirectly ("indirect care") or preparatory ("preparatory care"). These fractions differ per function. While a nurse spends a relatively high fraction of time on "direct care", a unit head spends most of her time in "preparatory care". We aggregated the available information and calculated that Unit 8 North as well as Unit 9 Center spent 20,61 FTE (Unit 8 North:67 %, Unit 9 Center: 58,4%) and Unit 9 South 22,60 FTE (62,2%) on indirect and preparatory care (average value = 21,27 FTE). This value is slightly lower than the intercept found in the regression above. Recall that W_U represents the total yearly workforce of a unit *U*, Nd_U represents the yearly amount of nursing days per unit and NF_U a factor corresponding to the maximum number of nursing days per FTE. Now we let W_U be a function of Nd_U and a non-zero intercept which we name *Const.* Now, $W_U = Const + ND_U * (1/NF_U)$.

Consider Figure 5.5. Here we plot three estimated trend lines through the data points assuming a non-zero intercept. (Here we took the value for the intercept from the "Ruimte voor Nieuw" study) The orange line corresponds to the most pessimistic Nursing days/FTE ratio ($NF_U = 400$) while the green line corresponds to the most optimistic Nursing days/FTE ratio ($NF_U = 769{,}23$) . The black line corresponds to an estimated average ($NF_U = 555{,}56$)

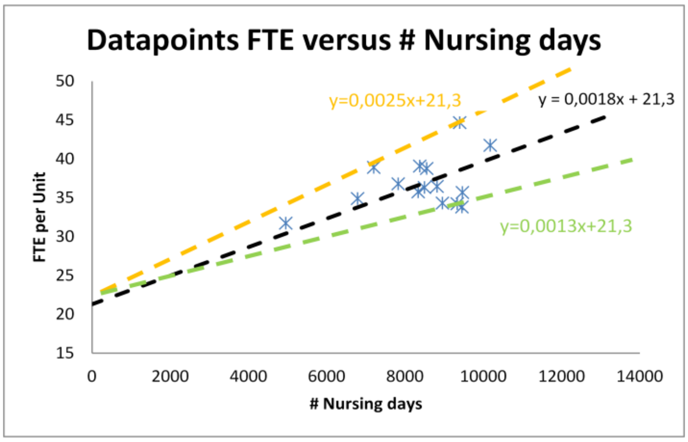


Figure 5.5: Nursing days per FTE in a x/y plane with a non-zero

Intuitively one might argue that nursing days are resulting from the number of FTE and therefore should be the dependent variable (while the number of FTE should be independent). However, in our analysis we aim to explain the formation size by the amount of workload which is carried out.

The outcome of this section is an adjustment of the workforce capacity constraint (5) into (6) with the adjustment of a non-zero intercept, which corresponds to a fixed part of the formation that is present irrespective of the number of nursing days.

(6) $$\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \leq (-Const + W_U) * NF_U \qquad \forall U$$

In Chapter 6 we present the results regarding different parameters for the workforce capacity.

5.3.3 INCORPORATING A PATIENT INTENSITY FACTOR

Basically so far we have assumed the homogeneity of a nursing day. In practice a patient might require a lot of time effort from a nurse, but also very little, which depends on the patients but also the time. From our basic understanding, we would estimate that a patient with a more severe disease requires "more" care than a patient with a "mild" disease. In Chapter 2 we have already seen that the UZ Leuven has quantified the time effort that nurses spend on different patient categories. However, unfortunately, we do not have data for our study corresponding to the Erasmus MC. In this section we only provide the method on how we would incorporate an intensity factor into the capacity constraint. As data is lacking, we will not incorporate this in our results.

As far the capacity constraint was comparing nursing days on the LHS with a maximum capacity on the RHS. We were comparing days with days. Now we rewrite the capacity constraint in terms of hours by performing the following transformation: $WH_U = \sum_f FTE_{U,f} * NH_f$, where NH_f is the yearly number of nursing hours an FTE of function *f* can supply per year. Basically all employees work 1526,3 net hours per year except apprentices which work 1066,8 hours per year. Furthermore, let $IF_{SC,S}$ be the so-called intensity factor for patients of subcategory SC and sort S. These are the number of hours a patient of subcategory *SC* and sort *S* requires care from a nurse on average per day. Then the capacity constraint becomes

$$(7) \qquad \sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} * IF_{SC,S} \leq (-Const + WH_U) * NF_U \qquad \forall U$$

5.4 THE IMPACT OF THEMING (THEMATISERING)

Theming means that basically the current structure regarding the clinical units is not fixed any more. As far, we modeled bed capacity (Equation (1) and (2)) as well as workforce capacity (Equation (5) or (6)) per unit. However, in the case of Theming we assume that all capacity is shared and we have the following aggregated capacity constraints

$$(1') \qquad \sum_{U}\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \leq \sum_{U} Max_U * B_U * 365$$

$$(2') \qquad \sum_{U}\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \geq \sum_{U} Min_U * B_U * 365$$

$$(6') \qquad \sum_{U}\sum_{SC}\sum_{S} P_{SC,S,U} * Ad_{SC,S} \leq (-Const_T + \sum_{U} W_U) * NF$$

We have chosen to transform the workforce capacity constraint with the fixed share of the formation (6) to a constraint on theme-level (6') . Here $Const_T$ represents the fixed share of the formation which is not related to "direct care". We believe that $Const_T < 3 * Const$ which means that there would be synergy in terms of the indirect and preparatory care for the units. We will construct different scenarios which we will further describe in Chapter 6. Then we combine this with different factors regarding NF , which we have found in Section 5.3.2. Next to the fixed share for the formation, theming also implies that bed and workforce capacity is jointly used. We will compare this to the current situation where we have a preference distribution regarding patients of the different subcategories. For the description of the scenarios as well as the results we refer the reader to Chapter 6.

6 SCENARIO ANALYSIS AND RESULTS

6.1 INTRODUCTION

In Chapter 5 we have described the methodology on how we aim to construct a strategic capacity planning for the future. This chapter presents the results that correspond to this methodology in form of a scenario analysis. Scenarios corresponding to different parameters are constructed. Thereafter we analyze the corresponding impact for the capacity consumption of the selected resources beds, operation time and workforce. Moreover, one major part of this chapter will be devoted to the impact of theming on the resources. Theming has no effect on operation time as operation time historically has been a jointly used resource by the entire surgery department.

We start by presenting a general approach regarding scenarios in Section 6.2 before we tackle scenarios regarding future operation time in Section 6.3. Section 6.4 deals with future scenarios regarding bed capacity and the impact of theming on this. In Section 6.5 we describe the future capacity requirement of workforce (nursing) capacity. This also includes theming scenarios as well the incorporation of a fixed share of the formation as described previously in Chapter 5 (Section 5.3.2)

6.2 CONSTRUCTION OF SCENARIO'S

This section deals with the general approach on how we construct scenarios. We basically make use of three sets of scenarios: average values, values 2010 (last values) and trend values. Regarding operation times we only possess data from 2007 until 2010 (see also Section 4.1.1) while for numbers of admissions and average duration of stay we possess data from 2006 - 2010. Therefore the scenarios corresponding to operation time contain less historical information. Consider Figure 6.1 for a schematic overview of the scenarios. Average values assume that each year in the past receives the same weight for the estimation of the future scenario. This scenario is more robust or outliers than the other sets of scenario's due to the averaging effect. However, it disregards trends and the fact that the last year has more predictive power than previous years. The values 2010 might be a better indicator for estimation of the future. However, it might be that for example due to measurement errors some values of 2010 are not reliable. Moreover this set of scenarios ignores trends as well. Therefore we also included trend values as a scenario set. In Chapter 4 we have basically observed that numbers of admissions have increased during the last years while the average duration of stay has decreased. The trend scenarios assume that these developments will continue in the future.

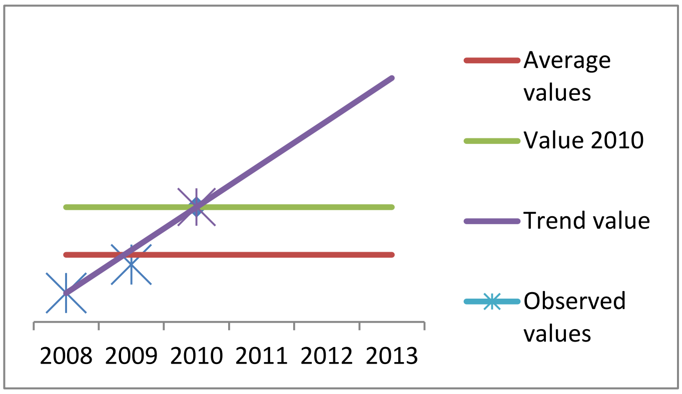


Figure 6.1: Schematic visualization of three sets of scenarios (average values, Values 2010 and trend values) constructed on basis of observed values

6.3 RESULTS OPERATION TIME CAPACITY

Recall from Chapter 5 that the factors of influence on operation time capacity are the number of admissions ($P_{SC,el}$ and $P_{SC,em}$ respectively) as well as the average operation session time per category *SC* ($OT_{SC,el}$ *and* $OT_{SC,em}$ respectively) and the number of operative sessions per admission of category *SC* (O_{SC}). In this section we will describe the different scenarios we constructed regarding operation time and present the results. In Chapter 4 (Section 4.2.3) we have concluded that O_{SC} behaved rather steady over the last years. Therefore we basically used the values of 2010 for our calculation. Regarding the remaining parameters we generated 9 scenarios: For both, P_{SC} as well as OT_{SC}, we made use of values from 2010, average values from 2008 until 2010 and trend values calculated between 2008 and 2010. This yields 3 x 3 = 9 scenarios. The outcome is measured in totally required yearly operation time and is presented in Figure 6.2.

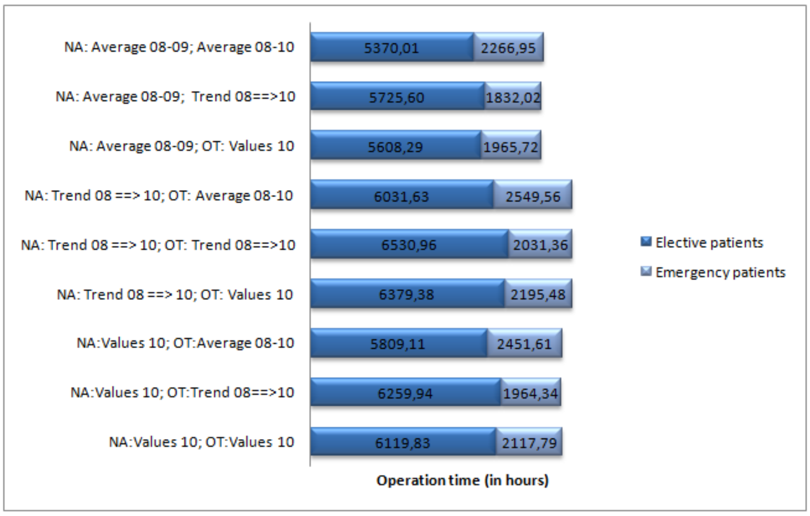


Figure 6.2: Future scenarios Total operation time (in hours) – NA= Number of admissions, OT = Operation Time

We can basically observe that the number of admission seems to have a greater impact on total operation time than the individual operation times per subcategory. The scenarios that incorporate the trend regarding the increasing number of the operative admissions yield the highest values regarding totally required yearly operation time. Scenarios that predict an average number of operative admissions (over the years 2008 – 2010) for the future yield relatively low total required operation time. However, due to the continuous past increase in the number of admissions we find these scenarios less realistic. When a new capacity limit regarding operation time capacity for elective patients ($OELMax$) is agreed upon, these scenarios might be taken into account.

6.4 RESULTS BED CAPACITY

In the past beds were divided over the different clinical units which meant that each unit had a certain capacity restriction. Theming implies existing of one pool of beds that can be used for any surgery patient. This situation is less restrictive as individual units will reach their maximum much quicker than a pooled Theme does. As explained in Chapter 5, we model the capacity requirement of beds within a Theme as the sum of the individual bed capacity requirements of the units. Regarding bed capacity we constructed a set of 5 scenarios that imply different scenarios regarding beds. We have already described that the determinants of bed capacity are the number of admissions for patients of subcategory *SC* and Sort *S,* denoted by $P_{SC,S}$ and the average duration of stay $Ad_{SC,S}$. In contrast to the approach regarding operation time capacity this also includes conservative patients. We make use of the following scenarios regarding the above-mentioned parameters: Values of 2010; the trend between 2008 and 2010; Average values averaged over 2008 – 2010; the trend between 2006 and 2010 and average values, averaged over 2006 – 2010 (we can make use of a larger interval as we possess more years of data- see Section 6.2) . Here we use the scenarios jointly for all parameters under consideration. The results are presented in Figure 6.3.

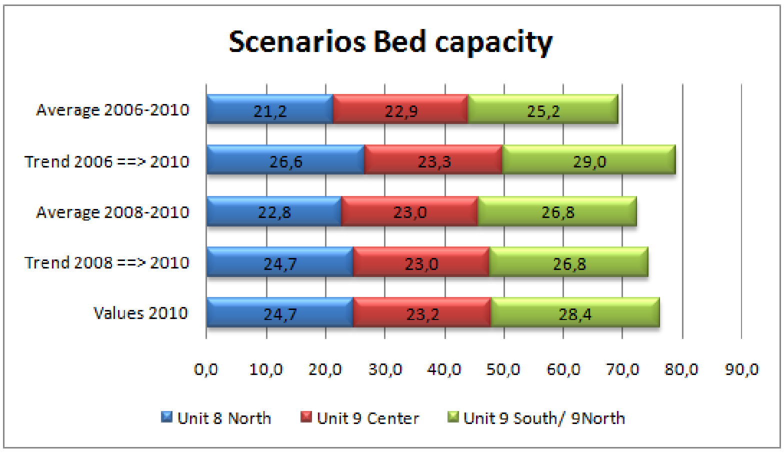


Figure 6.3: Bed capacity scenarios according to different values for # admissions and average duration of stay

As we can see, there are slight differences in terms of the capacity requirements for the different scenarios. For sure it would be interesting to see which scenario comes closest to practice. Basically the demand for capacity has increased over the last years, which is also reflected in the constructed scenarios. Scenarios that put a higher weight on more recent years yield higher values for the capacity requirements for the future. Especially, following the trend of the input parameters from 2006 to 2010 yields a rather steep increase in the required capacity. Zooming in on the different clinical units, we can see that the capacity requirement for unit 9 Center remains relatively constant across the different scenarios while Unit 8 North and Unit 9 South/9 North show a larger variation. This can probably explained by the fact that the subcategories treated in the latter units showed increases in their number of admission. For example GIC (digestion) patients are mainly treated in Unit 8 North and their number of admission had an increase of 53% between 2006 and 2010 (see Chapter 4). In case this trend continues in the future, this yields a relatively high bed capacity requirement for Unit 8 North or the Theme, correspondingly.

6.5 RESULTS WORKFORCE CAPACITY

In Chapter 5, we have described that the modeling of workforce capacity is slightly more tedious than of the other resources. We do not possess information on a direct relationship between the patient parameters and the workforce formations of the clinical units. This is why we make use of historical nursing days per FTE ratios which gives an approximation of the relationship. The historical data shows that nursing days per FTE vary, both within time but also across the clinical units. The variation might be due to the fact that one unit is performing more efficient than another one but also due to the fact that the patient population of one unit requires more effort than the patients from another unit. Within Section 6.5.1 we firstly consider the clinical units individually which implies that we use historical figures of the nursing day per FTE ratio per unit in order to estimate its required capacity for the future. Thereafter, in Section 6.5.2 we analyze the theming scenario that makes use of one global nursing day per FTE ratio in order to predict the capacity requirement for the entire theme. This ratio is different in case we incorporate the fixed share of the formation as we explained in Chapter 5.

6.5.1 FORECAST OF WORKFORCE CAPACITY PER UNIT

This section basically corresponds to the methodology explained in Chapter 5 (Section 5.3.1). Again we require parameters regarding the number of admissions and average duration of stay. Correspondingly to scenarios used to model capacity consumption for bed capacity, we use the following scenarios for workforce capacity: Values of 2010; the trend between 2008 and 2010; Average values averaged over 2008 – 2010; the trend between 2006 and 2010 and average values, averaged over 2006 – 2010.

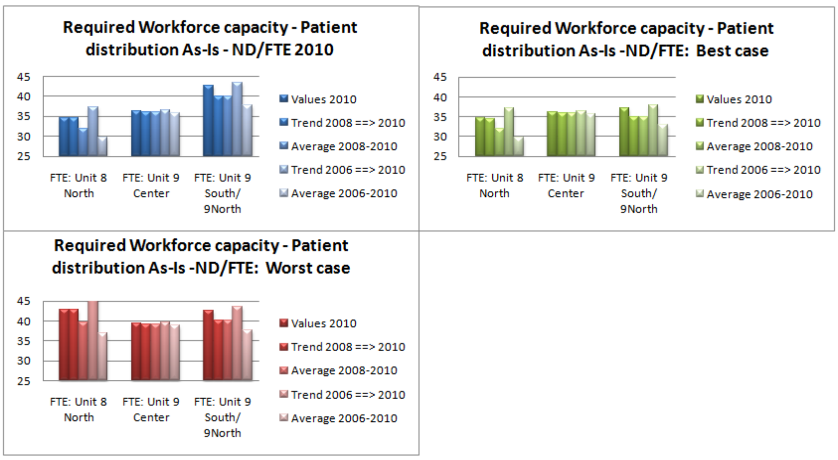


Figure 6.4: Scenarios regarding different values for # admissions and average duration of stay

Regarding the nursing day per FTE factor, we make use of three “sets” of scenarios: a last case, worst case and best case scenario. The last case scenario uses the nursing days per FTE ratios from 2010. The worst case scenario corresponds to the lowest nursing day per FTE ratio of the corresponding unit between 2008 and 2010, while the best case scenario makes use of the highest nursing day per FTE ratio within the same time. The results are displayed in Figure 6.4. Per scenario we display the number of yearly required FTE. Again Unit 9 Center behaves rather stable across the different scenarios. In case the worst case scenario applies for the future, they require slightly more FTEs (39 instead of 36). The other units show quite some variation across the scenarios. For Unit 9 South/9 North the last case and worst case scenario are identical which predicts a relatively high workforce requirement for the future.

In Section 5.3.2, we described the incorporation of a “fixed share” for the modeling of the unit formations. This approach suggest relatively greater formation sizes for Unit 8 North and Unit 9 South/9 North within the scenarios that make use of average figures (Average 2006-2010; Average 2008 – 2010)

6.5.2 FORECAST OF WORKFORCE CAPACITY PER THEME

Theming basically implies pooling of capacity as we have described before. We now consider the situation that the nursing days are realized by a joint pool of FTEs. For the parameters regarding the number of admission and the average duration of stay we use the same values as in Section 6.5.1 in order to construct the scenarios. Moreover we create three scenarios regarding the nursing days per FTE factor: the average value for all units in 2010, the factor corresponding to the best performance of all units between 2008 and 2010 and the factor correspond to the worst performance in the same time interval.

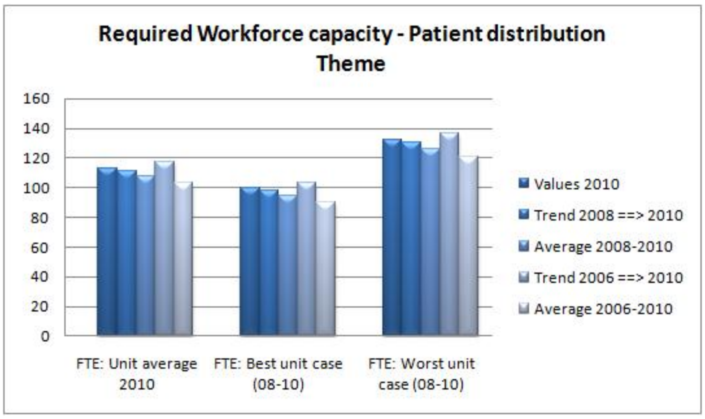


Figure 6.5: Theming scenarios

Consider Figure 6.5. We can see that the scenarios corresponding to the worst case nursing day per FTE factor predict the requirement of around 130 yearly FTE for the theme while the best case scenario reports approximately 90 yearly FTE. We can see that the patient parameters also cause a bit of variation in the output.

As mentioned before, in Section 5.3.2, we described the incorporation of a “fixed share” for the modeling of the unit formations. The fixed share basically consists of “Indirect care” or “preparatory care”. Recall that in our model we assumed a “fixed” quantity of 21,3 FTE per unit (according to the “Ruimte voor Nieuw study 2006). We can envision that this amount decreases due to theming as processes can be aligned or made more efficient. Therefore we created a set of scenarios that assume that the fixed share of the theme will be 90%, 80%.....50% of the aggregated fixed share of the individual units. Consider Figure 6.6. Here we depict the scenarios that work with the unit average nursing day per FTE factor from 2010. The graphic shows the prediction of the total capacity requirement for the theme in case the fixed share of the theme can be reduced.

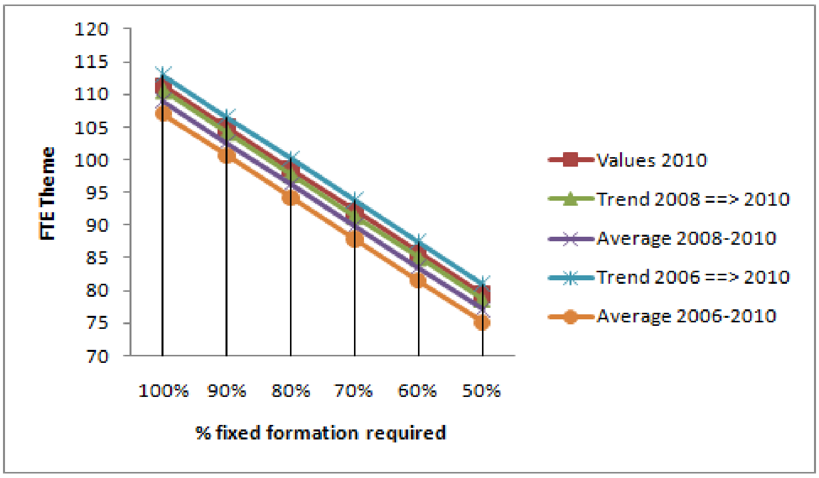


Figure 6.6: Scenarios corresponding to reduction of the fixed share

7 CONCLUSION AND REFLECTION

Finally, we conclude this thesis by firstly highlighting the main contribution of our research in Section 7.1. Moreover we dedicate Section 7.2 to describe implications and limitations and indicate areas of future research

7.1 CONTRIBUTION OF OUR RESEARCH

This thesis was meant to conduct research in the area of strategic capacity planning in a hospital. We aimed to tackle the following question:

What are historic developments regarding demand and capacity consumption of Health Care resources and what is the impact on a future capacity plan at the surgery department of the Erasmus MC?

Firstly this question was treated from a scientific perspective by drawing a theoretical framework consisting of multiple sources in the literature. The research took place within the Erasmus MC and focused on the surgery department. A good strategic capacity planning of resources should ideally be performed with a broader scope. However, we see our work as a case study that might have served as a pilot for later research.

In order to outline historic developments regarding demand and capacity consumption of Health Care resources it is important to keep in mind that the Dutch Health Care system has undergone a transition in the last years. The consciousness of capacity planning has risen after the DBC (Diagnostic Treatment Groups) system has been introduced in the Netherlands in the year 2005. This had the effect that the Dutch Health Care system developed from a supply-focused to a demand driven system. (see Van de Ketterij et al. (2002)). This also explains our motivation to focus our attention on the developments regarding Health Care demand. Within the theoretical framework we found that the Netherlands is one of the few countries with an increasing number of hospital admissions. When considering the data of the surgery department of the Erasmus MC, we could confirm this general trend as the total number of admissions had increased over the last years. Moreover, the trend of a decreasing average duration of stay of clinical patients in the Netherlands is also found for surgery patients within the Erasmus MC.

Next to the plain general trends, we found that the composition of the patient population, defined as patient mix, plays an important role in the determination of capacity consumption of resources. Different patient (sub) categories require different quantities and qualities of resources. In our study, we applied a grouping of the different DBC categories in a restricted number of categories. While in the Erasmus MC the number of GIC (digestion) patients has increased over the last years, the number of Trauma patients has slightly decreased. In order assess a possible future patient mix, we basically found two approaches: Pro-active steering of demand and demand forecasting. A hospital might be interested in focusing on certain patient groups as some patient-groups are more profitable than others. Moreover the hospital might want to attract patients that have a diagnosis where a hospital is specialized in. We focused our research on demand forecasting. On basis of historical data regarding the number of admissions and average duration of stay per sub-category we constructed scenarios that forecast future patient mixes. (similar to Barros et al (2010))

We basically defined the capacity consumption of Health Care resources as a derivative of Health Care demand. Therefore our methodology represents a mathematical model that models linear relationships between the patient-related input parameters and the resource-related output parameters. The idea is to forecast the future capacity requirements on basis of historical information on demand. While bed as well as operation time capacity was rather straightforward to model, the relationship between patients on the one hand and an appropriate workforce formation has proven more cumbersome. Within the theoretical framework, we have described different methods that are used in order to come to a strategic workforce formation according to Hurst (2003). Our conclusion was that the time-activity approach virtually is the best of the mentioned approaches as it take admission numbers as well as case-mixes into account. In order to draw the relationship between Health Care demand and supply we basically have to know how much time a nurse spends on a patient. In practice this requires extensive measurements. Schouppe et al (2007) described a quantification of the workload for nursing in Belgium. After a precise identification of the activities of the nurses, they created standard times for these activities based on past measurements. These standard times require continuous updates as measurements vary over time and can show certain trends. Finally Schouppe et al (2007) created an instrument to reallocate the nurses on basis of the workload measurements.

However, comparable data regarding the workload of nurses was not available within the Erasmus MC. This suggests implementation of a less complex method as Professional Judgement approach or the Nurse per Occupied bed approach which is also implemented by Elkhuizen et al (2007). In fact we developed an own method which is similar to the Nurse per Occupied bed approach. In the following we point out our approach in a nutshell:

We basically calculated historical values regarding the “Nursing day per FTE” ratio and use them as a variable to predict the future workforce requirements. This ratio was different for the different units of the surgery department which can be due to the differences in their patient mix but also due to differences in efficiency. We also generated the so-called Theming-scenario that implied that the workforce (as well as bed) capacity of the units is pooled together and therefore has a less restrictive capacity limit. We obtained some evidence that a unit or a theme has a fixed part of the formation (or a basis-formation) that has to exist irrespective of the number of admissions and a variable part that increases with an increasing number of admissions. Therefore we included this option in our alternative methodology as well. In order to predict the future capacity requirements we generated a set of scenarios regarding realistic future numbers of admissions, average durations of stay, operation times and nursing days per FTE ratios. Basically we found that if we follow the trend from the last years regarding the increase of the number of admissions, the future requirement of bed, operation time and workforce capacity will increase as well. The associated scenarios report the highest values regarding the required capacity. This increase is expected in the area of GIC (digestion) and Transplantation. However, it is difficult to judge whether a further increase of the number of admissions is realistic. The idea is that in the future the Erasmus MC makes increased usage of strategic capacity planning and obtain a better feeling on preferred and realistic scenarios.

7.2 DISCUSSION OF IMPLICATIONS AND LIMITATIONS

One main limitation of our work is the explicit focus on the surgery department of the Erasmus MC. We have already mentioned that according to Hans et al (2006), planning and control processes should ideally not be limited to small entities as departments of hospitals but rather be tackled more globally. This offers a larger range of possibilities in terms of redistribution of capacity and avoidance of bottlenecks. We can think of the redistribution of nurses from a department with a rather low working pressure to a department with a high working pressure. However, often then a problem arises regarding the qualification of the nurse. The Roland Berger study report (2007) has shown that employees within Dutch hospitals possess a comparatively high degree of specialization. This makes it more difficult to freely shift employees from one department to another. A nurse that is an expert regarding Trauma surgery patients might be a relative beginner within the emergency department. It is important that the work quality does not suffer from the (re)distribution of resources as in the new system the patient is put into a central position. The focus on the surgery department was feasible within the scope of a master thesis. However, we definitely recommend that in the future, the Erasmus MC should tackle capacity planning within a more global scope.

A second limitation of this work is given by the fact that we did not possess data on the time use of the nurses working in the unit. As we were basically drawing the link between patients and resources we were in particular interested in questions like "How many patients of Category Trauma Severe" can a nurse treat per year?" We have defined a nursing day as a complete day a patient remains in the clinic. However, how much time of actual nursing does he require on average? Does it depend on his category how much time he requires, en if so-on which degree? Sermeus et al (2007) concluded that differences in the patient mix have an influence on quantities of nursing resources but only amount between 20-40%. During our visit we were visiting the hospital in Leuven/Belgium (UZ Leuven). It turned out that they had an extensive time registration system in place that allows them to track the time use of nurses in detail. Schouppe et al (2007) explained this so-called Workload Indication for Nursing (WIN) in their paper. It is important that data regarding time use is continuously updated as circumstances change. Therefore the data we have seen within the "Ruimte voor Nieuw" study within the Erasmus MC that had the purpose to obtain more insight into the time use of nurses was only of limited use for us as it was dated from the year 2006. Belgium in contrast to the Netherlands nowadays uses diagnosis related patient groups in order to be able to make changes in the distribution of the nursing resources which might justify the extensive time registration system. However, in order to improve capacity planning within the Erasmus MC we recommend the introduction of a time registration system in the Erasmus MC as well.

A third aspect we would like to stress within this discussion concerns our choice of modeling. We have explained that due to the introduction of the DBC (Diagnostic Treatment Groups) system in the Netherlands, the Dutch Health Care system developed from a supply-focused to a demand driven system. Therefore we focused on patient demand in order to derive capacity consumption from it. In practice however, this might be an oversimplification of reality. We can envision that a well-known specialist for liver surgery starts working at the Erasmus MC which represents a change in supply. The patient demand is likely to adjust to this adjustment in supply as patients tend to be sensitive for a good quality of the surgery. This makes supply the exogenous factor and patient demand endogenous which represents exactly the opposite to our choice of modeling. This is just an example for the fact that the world is not as simple as we describe it within our approach of this thesis. However, we believe in the general idea that similar to other industries supply should adjust to demand (and not vice versa) which is why we chose our approach.

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