Strategic planning with DBCs

Capacity determination based on Diagnoses Treatment Combinations

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April 2010

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Subject: Determination of required capacity
Date: 29 April 2010
Version: Final

Summary

The NKI-AVL has the ambition to strengthen its national and international position in the field of oncology hospital care and cancer research. Growth in the number of patients and investments in advanced technology and infrastructure are necessary to achieve this. Considering that expensive equipment and infrastructure is only affordable with high patient volumes, and that large numbers of patients are necessary to continue with top research, growth is a condition to maintain this top position.

Towards 2020, the capacity to treat cancer patients at NKI-AVL is planned to increase significantly. The growth in the number of patients for the upcoming years requires a significant capacity increase. The required increase of capacity, which will have significant consequences for the hospital, is driven by the expansion of the number of operating theaters from five to ten. The consequences, which this will have for the rest of the hospital, will reach further than just a simple doubling of the capacity, due to the interrelationships between the different departments (NKI-AVL business plan, 2009).

This study examines the possibilities for determining the capacity, required to cope with growth in the number of patients. First, the current capacity determination method is discussed and the Dutch registration system DBC (Diagnosis Treatment Combination) is presented. Second, for determining the required capacity we formulate the "Total activity equation". This equation determines the total required activities on each resource. We aggregate this total number of activities into required capacity for each resource. We construct an automatic capacity determination program, for the continuous use of the required capacity determination method in the daily management.

Within the NKI-AVL, the present capacity determination method is based on the capacity requirements of the individual departments. When there is a capacity shortage, within a department, this is discussed with the general hospital management. The management takes the final decision whether capacity is added. The mainly determination of required capacity per department results in a situation in which an individual department has capacity expansion, but this capacity expansion will have overloading consequences for interrelating departments that have no capacity expansion. A consequence is that the extra available capacity cannot be used due to the shortage of capacity at the other departments.

Within the health care, DBCs are used. DBCs are used for the registration of the diagnosis and treatment that a patient receives. The DBC code has a corresponding DBC profile. This DBC profile describes in detail which activities are performed during the treatment. The DBC profile is an average of care that a patient, with a corresponding DBC, receives. By multiplying the DBC profile data with the DBC frequency, we can determine the total activities during that period. We transform the total number of activities to the required capacity at each resource. For the determination of the total activities we formulate the "Total activity equation".

With obtaining the correct data, DBC profiles and DBC frequencies, problems can occur. Within the NKI-AVL, there are two sources at which the DBCs frequency data is available. However, the data of these two sources differ. Through the corrections that are performed on the DBC frequency (by the financial department) that are necessary for the invoicing of the DBCs at the insuring companies, the data no longer matches with the data from EZIS (electronic hospital information system). However, incorrect DBC profiles are more paramount than incorrect DBC frequencies.

In order to determine the required capacity we aggregate the 1188 unique DBC profile activities into 31 groups. We determine the required capacity on 14 resources using these 31 groups. We have chosen these 14 recourses due to the fact, that these 14 resources require large investment costs, or a large amount of floor surface. Table A displays the 14 resources

	Resource
1	Outpatient consultation rooms
2	Surgery rooms
3	Nursing beds | General 4th floor
4	Nursing beds | General 5th floor
5	Nursing beds | General 6th floor
6	Nursing beds | Day Care
7	Nursing beds | Day Care Chemotherapy treatment
8	Nursing beds | Day Care 4th floor
9	Nursing beds | Day Care 5th floor
10	Nursing beds | Day Care 6th floor
11	Nursing beds | Intensive Care
12	MRI Scanners
13	CT Scanners
14	PET Scanners

Table A: List of the 14 resources

We construct, in Excel, an automatic capacity determination program, to use the capacity determination during the daily management. Due to this automatic capacity determination program it is possible to determine the required capacity in the future. By considering the growth in the DBC frequency it is possible to determine the required capacity. Furthermore, it is possible to adapt the efficiencies and opening hours of the resources in the program. This adaption provides the management with a tool, which provides them with information to make and strengthen strategic capacity decisions. By knowing in time what the required capacity will be, on time decisions can be made. Capacity can be added in different ways. Increasing the capacity does not have to mean that equipment should be added. Improving the efficiency levels or extending the opening hours can also add capacity. Integrating all the departments and resources into one capacity determination model prevents that added capacity at one department causes capacity shortage at another department.

Preface

I started my graduation project in June 2009 at the Antoine van Leeuwenhoek hospital in Amsterdam. After an exciting time I am proud to present my master thesis, completing my Master Industrial Engineering and Management at the University of Twente.

Overall, although motivation has its peaks and valleys, this project has been a great experience. There were many people who supported and assisted me to accomplish my goal: graduating by providing the hospital with a tool to determine the required capacity.

First and foremost I thank my academic supervisors, Marco Schutten and Peter Vanberkel, for their critical but positive feedback, valuable meetings, and keeping me on the right track. The frequent meeting with Peter greatly improved the quality of this research. I thank Rita Roodbergen, staff co-worker and Hans Schoo, manager at the NKI-AVL, for their insight from years of experience and providing me with valuable information.

At last I thank my family and friends that supported me during the writing of this thesis and during my study.

Jesper Schmidt
Amsterdam, April 2010

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Glossary

AVL	Antoine van Leeuwenhoek hospital
BC	Behandel Centrum *Treatment Centre*
CT	Computed tomography scan
DBC	Diagnose Behandel Combinatie *Diagnose Treatment Combination*
DOD	Diagnostische Oncologische Disciplines *Diagnostic Oncology Disciplines*
FTE	Full Time Employee
HOD	Heelkundige Oncologische Disciplines *Surgical Oncology Disciplines*
IEM	Industrial Engineering & Management
IT	Information Technology
MOD	Medische Oncologische Disciplines *Medical Oncology Disciplines*
MRI	Magnetic Resonance Imaging scan
NKI	Nederlands Kanker Instituut *Dutch Cancer Institute*
NZA	Nederlandse Zorgautoriteit *Dutch Care Authority*
PET	Positron emission tomography scan
PLM	Production & Logistic Management
RT	Radiotherapy department
VIKC	Vereniging Integrale Kanker Centra *Association Integral Cancer Centre*
VLK	Van Leeuwenhoek Kliniek *Van Leeuwenhoek Clinic*

1 Introduction

The Netherlands Cancer Institute – Antoine van Leeuwenhoek Hospital (NKI-AVL) hosts this research on the improvement of capacity determination. This chapter first describes the NKI-AVL and the ambition of the NKI-AVL (Section 1.1). In Section 1.2, we describe the problem, which is the starting point for this research. This leads to the formulation of the central research question. Based on the problem and the central research question, we formulate the research objective and the research questions in Section 1.3.

1.1 NKI-AVL

The NKI-AVL, located in Amsterdam, consists of two institutes, the Netherlands Cancer Institute and the Antoni van Leeuwenhoek hospital. These two entities work closely together in order to deliver high quality fundamental and clinical research as well as hospital services including radiotherapy.

The case mix of only cancer patients is in comparison with other hospitals, in the Netherlands, focused. In the Netherlands it is the only specialized cancer treatment centre. The absence of an emergency department leads to a small number of emergency admissions and treatments

The prime mission of NKI-AVL is to “combat cancer by means of patient care, research and education”. Central in this is to develop and improve methods in the field of diagnostics and treatments that burden the patients as less as possible.

1.1.1 The ambition of the NKI-AVL

The NKI-AVL has the ambition to strengthen its national and international position in the field of oncology hospital care and cancer research. Growth in the number of patients and investments in advanced technology and infrastructure are necessary to achieve this. Considering that expensive equipment and infrastructure is only affordable with high patient volumes, and that large numbers of patients are necessary to continue with top research, growth is a condition to keep this top position.

The NKI-AVL wants to expand the capacity of the hospital. The first step was taken: in the beginning of 2009, a sixth operating room (OR) opened. This initiative comes in response to expected growth in number of patients, experienced capacity problems, and the demand from new medical-technology, which requires different types of operating theatres.

At the NKI-AVL and in the Netherlands, there are five tumor groups that occur the most: breast cancer, lung cancer, colon cancer, prostate cancer, and malign melanoma (skin cancer), together named the "Big Five" (Association of Cancer centers, 2009). For the NKI-AVL, this "Big Five" is important due to the high frequency of surgical medical oncology treatments and the large experience that is gained by this. Figure 1 displays the number of new cancer patients, in the Netherlands in 2007, per cancer type.

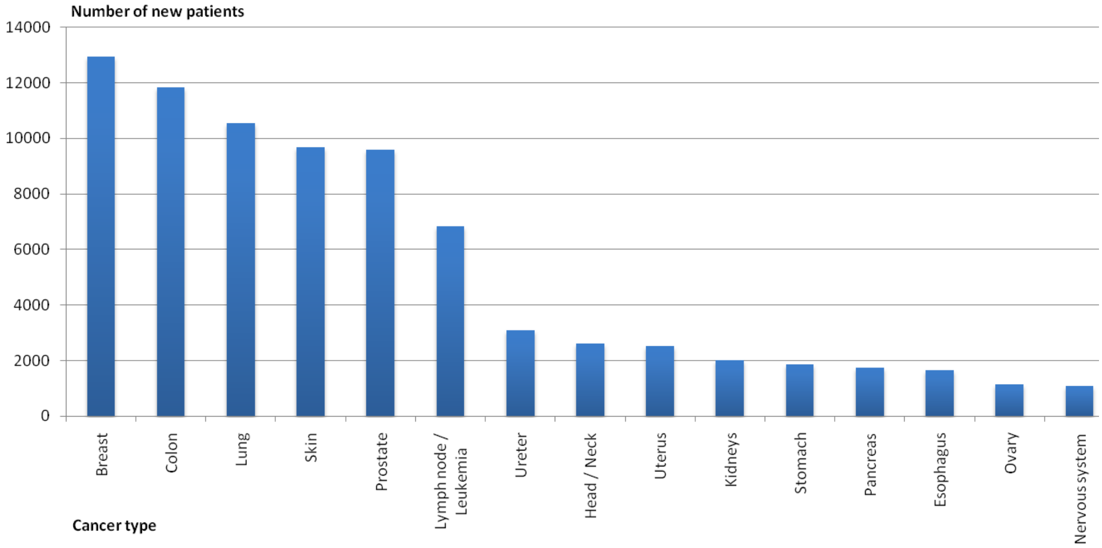

Figure 1: Number of new patients per cancer type in the Netherlands 2007 (source: VIKC)

Besides the normal growth, due to the growth of the Dutch population and from the increase of cancer, the NKI-AVL will focus on extra growth on the "Big Five" tumor groups. This will result in extra capacity requirements. Growth within these groups moreover provides financial space for the diagnostic and treatment of more complex disorders.

In the current situation, the NKI-AVL has to deal with regulation at the door, which results in waiting lists. To better satisfy the current and future care requests, it is important to expand the total capacity of the hospital and its accompanying chain.

1.2 Problem description

Towards 2020, the capacity to treat cancer patients at NKI-AVL is planned to increase significantly. The growth in the number of patients for the upcoming years will require a significant capacity increase. This growth, which will have significant consequences for the hospital, is driven by the expansion of the number of operating theaters from five to ten. The consequences that this will have for the rest of the hospital will reach further than just a simple doubling of the capacity due to the interrelationships between the different departments (NKI-AVL business plan, 2009).

By remedying the bottlenecks in the OR, it is important to also research the effects on the whole hospital process. Considering the position of the OR in the care chain, expanding the capacity of the OR will result in expansion consequences in other parts of the hospital. The before and after routes that have to be adjusted will reach much further than the Intensive Care, holding, and the recovery and will most likely impact the outpatient clinic, diagnostics, and the other clinics. Before a patient will have surgery, he has to visit the outpatient clinic. Besides a surgery, there is also the possibility that a patient will have chemotherapy or maybe only chemotherapy and no surgery, and then there is also the after care of the patient and yearly checkups. Each department has a different relation to the operating theaters. Some departments will need to be expanded more than double; others will need less expansion.

While the central problem in this research applies to all modalities in the hospital, we primarily analyze the capacity increase on the clusters Medical Oncology Disciplines (MOD), Surgical Oncology Disciplines (SOD), know within the NKI-AVL as HOD, and partly on the cluster Diagnostic Oncology Disciplines (DOD). We analyze the capacity increase on these departments due to the high costs of equipment and the increase in floor space when these departments grow. Radiotherapy in not included because only 20% of the patients treated at the radiotherapy department are patients from the NKI-AVL; the other 80% are from outside of the NKI-AVL.

Figure 2 shows the structure of the organization. To reduce costs and have integrated care and research, the overhead is shared between the hospital and the research institute.

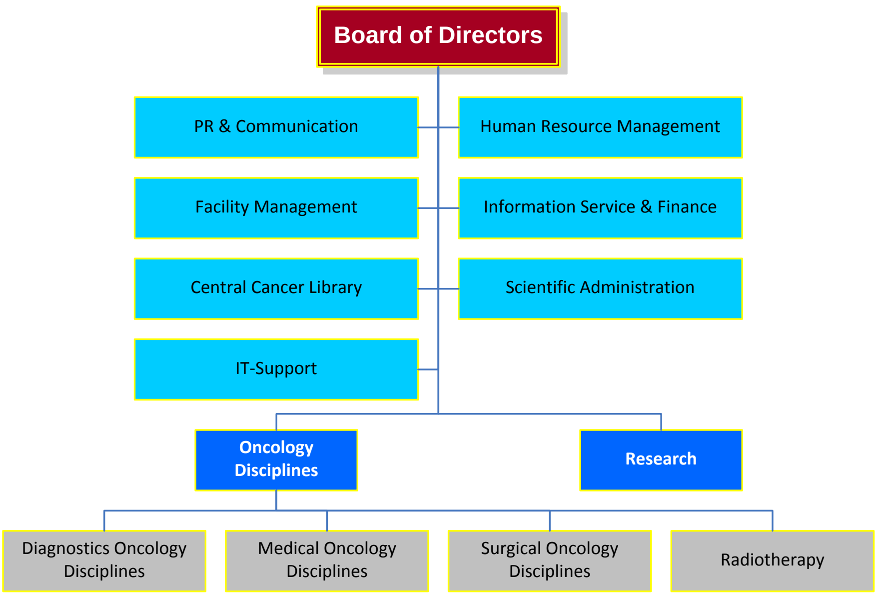

Figure 2: Structure of the organization

The problem above leads to the central research question:

- *How to determine the required capacity for the increase in the number of patients within NKI-AVL?*

1.3 Research Objective and Sub-questions

By answering the research questions below, we are able to answer our central research question and reach the following objective of this research:

- *Determine the capacity requirements caused by the growth in the number of patients. Visualize this for the NKI-AVL management so they can use this for strategic growth decisions.*

What is the current capacity determination method at the NKI-AVL?

- In Chapter 2, we will give an overview of the current capacity determination method of the hospital. We will describe the Dutch Diagnose Behandel Combinatie, DBC (Diagnose Treatment Combination) system and DBC profiles. The Dutch DBC system was introduced in 2005 and describes the treatment a patient receives based on the diagnoses.

What are suitable whole hospital models to determine the needed capacity for the expected growth?

- Chapter 3 will describe the literature on whole hospital models, the literature on the use of DBCs in hospital models, and literature on the use of DBCs in the determination of required capacity. The outcome of the chapter is used to answer the next question.

How to determine required capacity?

- In Chapter 4, we first describe the minimal required data that is needed for the capacity determination. We explain and formulate the basic capacity determination method. We discuss the difficulties of the data availability and the data quality.

How to determine the required capacity for the NKI-AVL?

- In Chapter 5, we describe how to determine the capacity, which is required for the growth in the number of patients, in order to balance capacity and demand within the NKI-AVL. We describe how to collect the data of the profiles for the different DBCs. From the Diagnose Behandel Combinatie, DBC (Diagnose Treatment Combination) data, we extract the frequency each DBC is performed. We describe how to transform the determined activities into the required capacity on each resource. After that, we validate the total activity equation.

How to automate the capacity calculation and develop this into a decision support tool?

- Chapter 6 will describe how to automate the capacity calculation. We describe which steps are needed to automate the capacity calculation and how it can be used by the management as a decision support tool for strategic capacity decision. We explain the tool and how it can be adapted in a later state. The automated capacity calculation might be used at a tactical level but this is not the intention during its development.

Figure 3 visualizes the structure of the report.

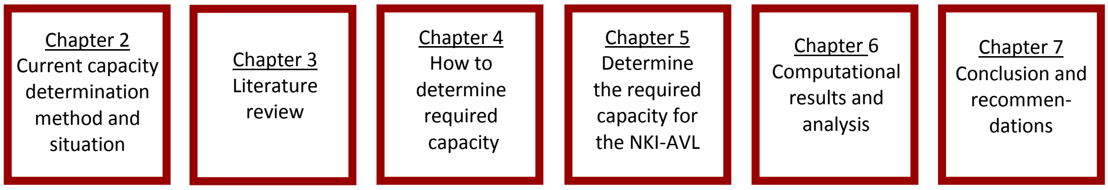

Figure 3: Structure of this report

2 Current situation at the NKI-AVL

This chapter describes the current situation at the NKI-AVL. This chapter starts with an outline of the current capacity determination method at the NKI-AVL (Section 2.1). In Section 2.2, we describe the DBC system in general and the DBC profile. Section 2.3 concludes this chapter.

2.1 Current capacity determination method

A good prediction of the required capacity prevents the waste of resources. Unused capacity wastes financial resources, which are scare in the healthcare sector. On the other hand, too little capacity causes waiting list.

The present capacity determination method within the NKI-AVL is based on the capacity requested from the different departments. The departments typically request more capacity when there is a noticeable shortage and when current waiting lists get too long. Based on historical data and meetings, the management makes the final decision on where to add capacity. This method is not robust and is always behind on reality.

As an example, consider the decision to expand to six surgery rooms. The sixth surgery room, added last year, was built when there was a noticeable shortage in surgery time (NKI-AVL business plan, 2009). Due to the shortages in available surgery room capacity, waiting lists were increasing. With the build of the sixth surgery room the problem of the shortage in available surgery time is not solved. The consequence from the increase in surgery time, due to the build of the sixth surgery room, is more patients at the nursing departments. The bed capacity of the NKI-AVL is not forecasted in order of the sixth surgery room. The shortage of beds is noticed at certain times. However, this shortage of beds can also be the consequence from a shortage in nursing personnel.

The individual per department capacity requirements and determinations will have consequences on other departments. Fulfilling a department capacity requirement can cause a shortage at another interrelating department. Combining these capacity requirements and knowing the consequences on all departments by increasing the capacity at one department, will increase the total capacity of the hospital.

2.2 DBC system

To have a clear understanding of how patient are registered and receive their assigned treatment, it is important to understand how the DBC system works. DBC is an abbreviation of Diagnose Behandeling Combinatie (Diagnose Treatment Combination). In Section 2.2.1, we describe the outline of the DBC system and how the DBC is coded. Section 2.2.2 describes in more detail the most important segments of the DBC code. In Section 2.2.3, we describe DBC profiles.

2.2.1 Outline of the Dutch DBC system

"The term DBC refers to Diagnosis Treatment Combination: the definition of the demand of care, the diagnosis and the treatment the patient will receive"(Van de Ketterij et al., 2002). The DBC system fits into the switch towards a demand driven health care system.

In the beginning of the 1980s, the base of the Dutch DBC system, the Diagnosis Related Groups (DRG) system, was created at Yale University. It was created upon request from the United States congress. The basic idea of the DRG system is to make the healthcare more cost efficient and it provides a method to monitor the quality of care.

Throughout the years, the DRG system adapted to the changing health care system and the progress in Medicine. The system was also adapted for data management, compensations, benchmarking, and other management needs.

In the DRG system, a number is assigned to a period in which care is provided to a patient that is taken into the hospital. This number functions as a relative weighing factor that represents the expenses for the provided care in the hospital of the clinical group that is assigned to that specific DRG. The DRG assigning is then a compensation system that determines how much the hospital gets paid.

Grouping patients in this manner provides the hospital a possibility to judge and control their expenses through DRGs. Hospitals can also use benchmarking through groups on quality and expense measurement. In the DRG system, there is only one DRG assigning per patient stay; because of this, all the services that take place between intake and discharge are included in that DRG.

The system groups' patients, by classifying patient care on common characteristics such as diagnosis and treatment, expected consumption of hospital resources, and length of stay. By grouping patients in this way, the hospital has a framework to manage and evaluate costs. Hospitals can use the system to benchmark by groups on quality and resource efficiency.

The DBC system, implemented in 2005, was developed to change a budget based system to a reward system, based on the actual cost of the individual treatment. Compared to other classification systems, the DBC system stands out on a number of characteristics. One major difference in the DBC system is that it is not based on the internationally recognized classification system, but based on 24 different systems of diagnosis classifications, divided by the different medical specialist associations. Another main difference with the classical DRG system is that the DBC system is based on the episode of care rather than the encounter.

In the old budget based system, a hospital received a yearly predetermined budget based on the expected nursing days, treatments, and outpatient clinic visits in the upcoming year. This budget did not reflect the real costs made by the hospital. The reward based system is still using a pre determined budget, but the financing of this budget comes from the DBCs the hospital performs. The reward of a DBC is based on the real costs.

The first step taken to come to this reward system was defining each '*product'*. These product definitions come from all possible combinations of care type, diagnosis, and treatment. The DBC appoints each activity in the treatment of the patient, starting at the first contact and ending with the last visit. Within the NKI-AVL, close to 3,000 of the around 30,000 DBC codes are used.

The DBC code is built from five individual parts. In appendix A, a figure of the build of the DBC code is displayed. The five individual components of the DBC code are:

- Specialism
- Care type
- Care request
- Diagnoses
- Treatment

To have an understanding of the DBC coding system we describe an example code. We take the DBC code 03.11.xx.318.202 as the example. The first part "03" is the code for the specialism "surgery". The "11" is for the type of care, where "11" is regular care. Within the NKI-AVL, the regular care "11", inter collegiate referral "13", and follow up "21" are the most common care types. The care request, the xx, in this code is an empty spot. Within the specialism of surgery, the care request is not used. For the departments that use the care request it is an extra code to further specify the diagnosis. The diagnose "318" stands for malign breast cancer. The treatment "202" In this example is a surgical operation with daycare.

At the first visit of the patient, the doctor opens a DBC. To a DBC does not only belong the treatment the patient will get, but also the initial appointment and the diagnose methods used to get the diagnosis. The DBC is not a single treatment but based on a whole episode of care.

The DBC code is connected to one or more codes that are used for the financial administration to prevent sensitive patient information from entering the financial administration.

Besides medical activities (surgeries, examinations, therapy), DBCs also encompass supporting activities (nursing days, specialists meetings). By assigning a cost price to all the activities in the care process, the total cost price of a DBC is determined. The use of the DBC for the care provider is to invoice the delivered care at the health insuring company. For a number of DBCs, the care provider and the health insuring company can make their own agreements on price, quality, and quantity. The two segments are called the A and B-segment. The DBCs in the A-segment have predetermined prices and the DBCs in the B-segment have negotiable prices.

- A-segment

For the treatments in the A-segment, the prices are set nationwide. This rate counts for the whole treatment, including all activities that take place during the treatment. All the activities that are included in the treatment are based on the nationwide average and are used to determine the price of a DBC in the A-segment. Also the expenses of the hospital (buildings, supporting personnel, etc.) become a part of every DBC. The insuring companies and hospitals can make agreements on the quantity of DBCs that the hospital will perform. Most of the hospital treatments belong to the A-segment.

- B-segment

A small number of DBCs belong to the B-segment. Within the B-segment, the hospital and the health insurer can negotiate on the price, quality, and quantity. The price of a DBC in the B-segment can, within a hospital, differ between health insuring companies. When no contract is in place, there is a so called ‘pass by rate’. This rate is published publicly by each hospital.

The first number of the DBC code, specialism, indicates which specialism department will perform the treatment. It is not the case that other specialism departments will not be involved in the treatment. Before the main specialism department can start with the treatment, a diagnosis has to be made. For example, an MRI or CT scan is required and a blood research to make the diagnosis.

The care type divides the patients into first visiting patients, recurring patients, and inter collegiate referral patients. The care request is only used by some specialists departments and defines the diagnosis more specifically. The care request is used within the specialism plastic surgery to define that more care is needed in the area that will be treated. For example, when the area is damaged due to treatment with radiotherapy or when a second surgeon is needed. There is a small difference in used capacity between the different care types and care requests. The biggest difference between the care types, first visiting patients and the follow up patients is that is most cases of the follow up patients the diagnoses are already know. In Chapter 6 this difference is used to divide the required capacity into the different care types.

2.2.2 Specialism, Diagnosis, Treatment

The three most important parts of the DBC code are the specialism, the diagnosis, and the treatment. These three determine which of the resources in the hospital are used.

– Specialism

The specialism department that is leading the treatment will be responsible for the whole treatment and will also provide most of the resources for the treatment. In most treatments, more than one specialism department is involved. In most of the cases, it is necessary to diagnose the patient. For this diagnosis, other departments than the main treatment specialism department have to be called upon. The departments that are included in the diagnose process do not have to open there own DBC for that patient. The DBC code assigned to the patient includes the diagnosis and the treatment. However, if a patient will also receive treatment at a different department, that department will open their own DBC for the patient. So it is possible that a patient has multiple DBCs for one diagnosis. For example, if a patient comes in with a mamma carcinoma, it is possible that this patient will have surgery and will get chemotherapy. The surgery is performed by a different specialism department than the chemotherapy.

– Diagnosis

The diagnosis of the patient already determines for a large part which resources will be used in the hospital. The code for the same diagnosis is different for each specialism. For example, a mamma carcinoma has a different code within the specialism surgery and the specialism medicine. With the diagnosis segment of the DBC code, the hospital has an instrument to investigate the number of patient with the same diagnosis. A hospital could use this data to specialize in certain patient groups.

– Treatment

The treatment a patient receives, determined by diagnosis and the care plan assigned by the doctor, will include everything from the first visit to the hospital to the end of the treatment. The code for the treatment that is included in the DBC code indicates the type of treatment and not which resources will be used. However, the average resources used by patients with the same treatment, diagnosis, and specialism can be determined. This average is called a DBC profile and is used by the hospital to determine the cost price of the specified treatment.

2.2.3 DBC profiles

Known in the industry as a ‘part list’, is a list of parts that are needed to produce a certain product. In industry such a part list is indispensable. Without this list it is unknown how many parts have to be purchased. In fact in a hospital there is no difference. In health care such a list, to provide a ‘*treatment’,* is called a care profile. Vanberkel et al. (2009) describe the care profile as all activities performed during the care path for that patient. “The care profile includes all hospital activities and the time effort by the medical specialist”(VanBerkel et al. 2009). Based on the care profile of the DBC, a list is put together that states how much average capacity is needed by one patient assigned the DBC (for instance 1.7 outpatient clinic consults, 0.9 lab request, 0.6 MRI scan, etc. per certain DBC). Knowing which resources and the amount used per DBC, hospitals can determine the required capacity necessary to fulfill their DBC volume agreements with insuring companies.

2.3 Conclusion

Currently, as described in Section 2.1, there is a capacity determination method. However, this method is not robust and always lags behind on reality. When there is a noticeable capacity shortage, the decision is made to add capacity. Shortage in capacity can develop long waiting list. When there is a capacity determination method that can predict the needed capacity beforehand, long waiting lists can be prevented.

With the introduction of the DBC system, the hospital was provided with a tool to register the used capacity in a clear manner. However, the possibility to use the registration for determining required capacity is not yet used or explored.

3 Literature review

Chapter 1 introduced the NKI-AVL and this research. In Chapter 2, we described the current situation at the NKI-AVL and the DBC system. This chapter will review available literature. As described in the method used by Fletcher and Worthington (2007), we started our literature review with some relevant papers. These relevant papers were identified by Vanberkel et al. (2009) in their survey paper on health care models that encompass multiple departments. In Section 3.1, we discuss the literature on hospital models. Section 3.2 discusses the use of DBCs in hospital models. We conclude the literature review in Section 3.3.

3.1 Hospital modeling

Hans (2006) distinguishes three levels of hospital planning and control: strategic, tactical, and operational. Strategic planning involves choices for hospital layout and how much capacity to have. To be able to treat all patients, overall capacity should meet the demand.

To determine this capacity, a model can be used. Due to the complexity of a hospital, often management is not considering the total care chain (starting at the admission and ending at the discharge), but mainly focuses on performances of individual department or units. Often, at no surprise, this has resulted in decreased patient access without reduction in costs or increase in performance (de Bruin et al., 2005).

Literature on the simulation of health care processes is flooded with studies on modeling. However, the majority of these studies only focus on the operation of a single department. By focusing on single departments, many of the complex relationships that exist between departments are ignored (Vanberkel et al. 2009).

From Jun et al. (1999) we concluded that prior to 1999 simulation was a tool widely used for modeling health care systems. However, not for modeling complex multi departmental health care systems. Fletcher and Worthington (2007) conclude that there are attempts to model whole hospitals. However, the literature tends to focus on framework models rather than whole hospital models. This is also concluded by Jun et al. (1999), as they describe that besides the increase of simulation studies in health care and the integration of optimization techniques in health care, there is still a void on complex multi departmental integrated systems in literature. Researches, on a general level, do take an atomistic view but confine their model scope to single departments and hereby exclude the complex relationships between departments (Vanberkel et al. 2009).

From the literature on hospital models, we conclude that there are multidisciplinary hospital models but that a generic whole hospital capacity planning model is still missing. Although whole hospital models are described, due to the highly complex and often difficult to understand hospital systems, the overall scope of the literature is on single and some multidisciplinary departments. The DBC system, which standardizes the description of treatments, can play an important role in understanding the complexity of a hospital system.

3.2 Use of DBCs in hospital models

The introduction of the Diagnosis Treatment Combination (DBC) system in 2005 changed the Dutch health care system from a function oriented budgeting system to a demand driven system. A DBC characterizes all activities and interventions within the hospital resulting from the consult the patient has with a medical specialist. Besides medical activities (surgeries, examinations, therapy), this encompasses also supporting activities (nursing days, specialists meetings). Van de Ketterij et al. (2002) describe the core theme of the transformation to the DBC system as “a change from supply control to demand control”. The system will change the hospital output prices that were based on budget and financing rules to a system were the prices are based on the production process (Folmer and Mot, 2003), whereas in the old budget system the possibility to provide a certain care was put centre stage. In the new demand driven system, the needs of the patient/consumer that have to be fulfilled are put centre stage (Van de Ketterij et al. 2002).

Van de Ketterij et al. (2002) reason the following for the switch to the new DBC system. The Function Oriented Budgeting system regulates the supply of services. In this system hospitals are, to a certain extent, sure of their revenues. Due to this stable principle, management is not discouraged to be more effective but neither is it encouraged. The DBC system has a high variability in revenues. The result is that no production means that there will be no turnover (Van de Ketterij et al., 2002). The consequences for the management are that they must be able to handle this variability and deal with cost control, efficiency, and effectiveness. “Insight in the links between production, costs, revenues and quality will become a dire necessity” (Van de Ketterij et al., 2002).

At the moment of introduction, the focus of the DBC project was almost completely on defrayment and making hospital care more transparent. Following on this, other aspects as quality improvement, capacity determination, and control are aspects for which the DBC can be an instrument. Due to that the patient demand is the centre stage in the DBC system, the patients’ demand can make it clear which capacity on which department is necessary to meet the demand (Van de Ketterij et al. 2002).

The switch from Function Oriented Budgeting to DBCs has led to less stable incomes and risks for the hospitals. A translation from production agreements to the needed capacity can lead to more stability (Van der Meer and School 2008).

Already for a long period, hospitals use their production parameters such as nursing days, surgeries, and day treatments, to translate the production agreements with care insuring companies to their needed capacity. The capacities, for diagnostic and therapeutic facilities, are not included in the determination of capacity. With the introduction of the DBC system, the hospitals now make production agreements with the care insurers based on DBCs. The hospitals can make strategically decisions to specialize in certain patient groups. This provides them with a more stable demand. Until now, there is almost no literature on capacity planning with DBCs (Van der Meer and School 2008).

Van der Meer and School (2008) present a method to translate DBCs prognoses into needed capacity. Due to the variance in the care process of the individual patients, they use the average care used by a patient and the average capacity needed. Due to the fact that in practice, within the hospital, not averages but whole numbers are used, this fractioned capacity has to be transformed into required capacity. However, how this precisely works is not described. By integrating the capacity determination based on DBCs into the planning and control cycle, capacity planning is not a single improvement step anymore, but will belong to the continuous improvement and control cycles of a hospital. Through insight in the relation between capacity use, the required buffer space, and the desired flow, a hospital can make better choices on required capacity. This decreases the risks on unexpected hold ups in the patient process. By indicating these bottlenecks in the planning phase, fewer problems will occur during the daily execution of care (Van der Meer and School 2008).

In literature only one article, Van der Meer and School (2008) that describes some form of DBC use in the planning and control of the hospital was found. The potential of the DBC system is described and in general how the DBCs can be used to determine the needed capacity is discussed.

3.3 Conclusion

Only a few articles on whole hospital modeling exist in literature. Due to the complexity that a complete hospital encompasses, most studies describe single departments with a few that describe multi department models. The literature on the use of DBCs in complete hospital models is even less. Before the introduction of the DBC system, the potential of DBCs on capacity determination was noticed and described in literature, but until now not integrated in a case study. This research will describe the use of the DBC system in a case study were the DBCs are used to determine the required capacity, and for monitoring and control.

4 Capacity determination

Chapter 2 describes the current capacity determination method at the NKI-AVL and the DBC system. Chapter 3 reviews the literature on hospital modeling and the use of DBCs in capacity determination. This chapter describes an equation to determine the required activities on each resource, the "total activity equation". In Section 4.1.1, we describe the required data for the total activity equation. In Section 4.1.2, we formulate the total activity equation. In Section 4.2, we describe possible opportunities for the total activity equation in a real situation. Section 4.3 describes the availability and quality of data. In Section 4.4, we describe difficulties for implementation of the total activity equation in another hospital. We conclude this chapter in Section 4.5.

4.1 The total activity equation

Section 4.1.1 describes the required data for the total activity equation and in the next section, Section 4.1.2, we describe and formulate the total activity equation itself.

4.1.1 Required data

The required data to perform the capacity determination consists of two sets: the frequency of "performed" or "planned" DBCs and the DBC profiles. The choice to use planned or performed DBCs is based on the use of the total activity equation. "Planned" DBCs are the DBCs that are planned to be performed in an upcoming time period and are used for predicting future capacity requirements. The "performed" DBCs are the DBCs that are performed in a past time period and are used to validate the model. We formulate the frequency of the DBCs 'j' in the total activity equation as 'f_j'.

As described in Section 2.2.3 the DBC profiles contain the information on the amount each resource is used. DBC profiles are used in every hospital in the Netherlands for the determination of the cost price of the DBC. The number of activities that will be required on resource 'i' for performing DBC 'j' is called 'r_{ij}'.

4.1.2 Total activity equation formulation

The total activity equation determines the needed capacity based on the frequency of DBCs and the DBC profiles. The only variable in the total activity equation is the frequency of planned DBCs. The frequency of planned DBCs is multiplied with the activities data in the corresponding DBC profiles. The outcome of this is the total number of required available activities on resource 'i', for performing the planned number of DBCs 'j'. By combining all the required available activities, for each DBC that is planned, the total number of required available activities on resource 'i' is determined.

Section 4.1.1, describes which data is needed for the total activity equation to perform the capacity determination. We define the hospital resources named in the DBC profile as 'i'. We define the activity on resource 'i' that is used by DBC 'j' as 'r_{ij}'. The frequency, in which DBC 'j' occurs, in a year or period, is defined by 'f_j'. The outcome of the total activity equation is the total number of required available activities on each resource for performing all the planned DBCs. We define the total number of required available activities as 'A_i'.

Total activity equation:
$A_i = \sum_j f_j * r_{ij}$

Definitions:
r_{ij} = required activities for DBC 'j' on resource 'i'
f_j = frequency of planned DBC 'j'
A_i = total activities on resource 'i'

f_j = integer for all j = 1, … , m (DBC)

The total activity equation delivers detailed information on the total number of activities that are performed by performing the planned DBCs; used at a strategic planning level, this information can be used to determine when extra capacity is required.

By defining the total capacity, it is also possible to use the total activity equation in an opposite way and determine the possible number of DBCs that can be performed with the specified capacity. The total activity equation can then be used to determine when the maximum performance of DBCs is reached and changes are needed to be able to treat more patient. The total activity equation makes an explicit relationship between DBCs and capacity.

4.2 Data Availability and Quality

The total activity equation is straightforward and robust. However, numerous challenges were faced trying to apply the equation. In Section 4.2.1, we will describe the patient flow and data flow at the NKI-AVL. Section 4.2.2 will discuss the data availability followed by the data quality in Section 4.2.3.

4.2.1 Patient flow and data flow

The DBC or DBCs that a patient gets assigned are registered in the electronic hospital information system (EZIS). This registration is done by the doctors and other authorized personnel. Described in the DBC profile, to every DBC belong certain activities. These activities are registered every time they are performed. It is possible that activities are registered that do not belong to the associated DBC. This enables to have incomplete DBCs and DBCs that do not match their DBC profile and these DBCs can then not be invoiced at the insurance company. It is also possible that the registration of certain activities is the consequence from a change in treatment. This is then actually a change of DBC. This change of DBC is not always changed in the system by the doctor. The consequence is that there is a mismatch in the frequency of DBCs, between EZIS and the financial department. Figure 4 displays the DBC frequency data flow and the patient flow.

When the patient visits the hospital, a DBC, matching the diagnoses and treatment, is assigned and registered by the authorized personal in EZIS. All activities performed during the treatment are also registered in EZIS. The activities performed during the treatment belonging to the assigned DBC are matched with the corresponding DBC profile and when they match, it is registered by the financial department to be invoiced at the insurance companies.

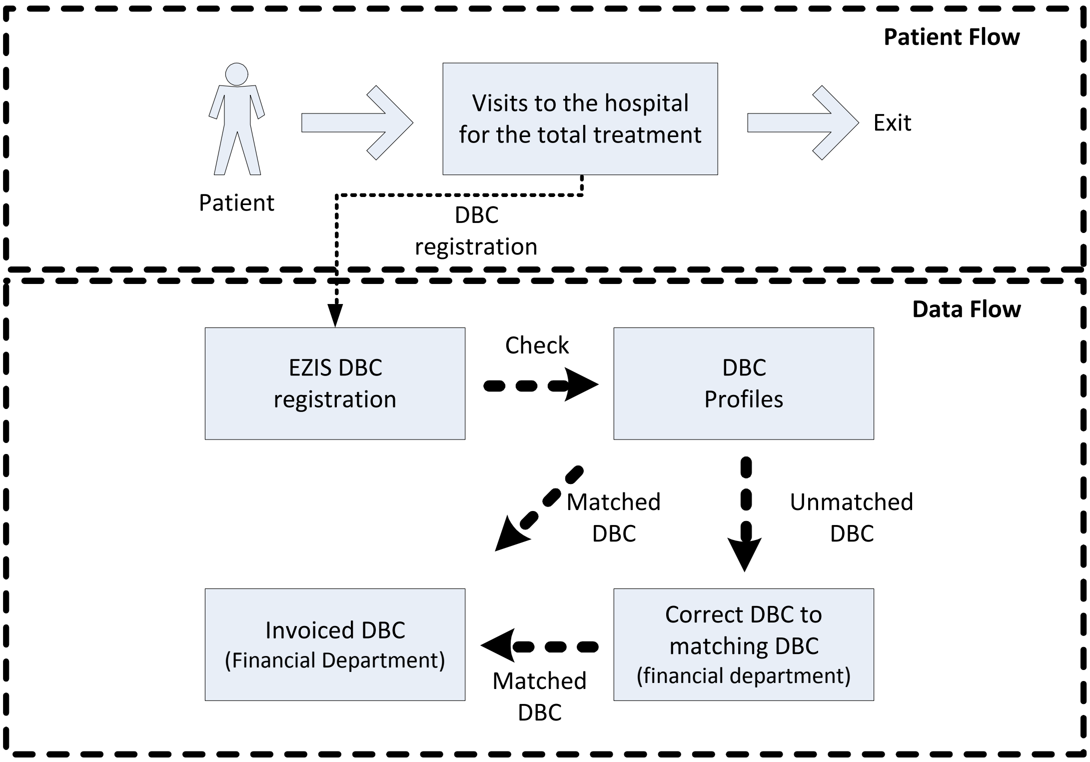

Figure 4: DBC registration at the NKI-AVL

Non matching DBCs are corrected by the financial department. The financial department may change the DBC code when the registered activities do not match with the DBC profile. The changes that the financial department makes cannot be seen in EZIS. As a consequence, the data on frequencies of DBCs in EZIS is not the same as the data at the financial department.

4.2.2 Data availability

Collecting the required data for the determination of the required capacity at the NKI-AVL has been difficult due to the different registrations and corrections that are performed. Due to the corrections, different departments have mismatching data and the checked data is always behind on reality. In the case of the NKI-AVL the checked and validated data is a year old. It is only possible to check the data after closing the registration year. It can then be validated which DBCs were invoiced at the insurance companies. The registrations that are performed by the doctors and the other authorized personnel in the EZIS registration system, are also not completely reliable. Due to alterations in the treatment of a patient a different DBC has to be registered. With the registration of this new DBC the old DBC is not always immediately eliminated, or not eliminated at all. This causes double registrations in the EZIS registration system. The EZIS registration system is as a source for the required data to determine the required capacity not reliable. We discuss the quality and reliability of the data in Section 4.2.3.

Within the NKI-AVL, more than enough data is available. However, it is the challenge to get the right data. Within the EZIS system the data is primarily arranged for production information and patient information. Besides the arranging of the data it is also possible to generate and adapt overviews of the data. Generating and adapting overviews can be done by all the authorized personnel. This makes it possible that certain overviews are generated by one person and then later in time this overview is adapted by another person. This way generated data can be transformed multiple times and does not match anymore with the original generated data.

Defining the correct required data is done differently at each department or even each person. The interpretation of the required data can also be different between persons. It is often not clear which person can provide the right data. Within the NKI-AVL this is often not a person of the department itself but somebody from the IT department or the financial department. Concurrently, departments do not know where their data of the department is available, or which data is available. Therefore, it is difficult to request the data.

Clearly defining where the data is available and who is responsible for which data will make the data more available and this will also improve the quality of the data.

4.2.3 Data quality

Due to the different registration and the transformations of data that are performed the quality of the data is not always reliable. A good data control system could prevent this and improve the quality. However, such a data control system is not available within the NKI-AVL.

For the data, on DBC frequency and the DBC profiles, we have chosen to use the data from the financial department. The financial department is also the only department within the NKI-AVL that has the data of the DBC profiles. This is checked data and is connected with the financial part of the hospital. This data is validated by the accountant and is the most reliable. In the first setup for determining the required capacity we have used the data on frequency of DBCs from the EZIS system and the data of the DBC profiles from the financial department. The outcome of the total activity equation with this data as input did not match with the data from the department itself. This proves that the data on the frequency of DBCs out of EZIS is not matching the data on the frequencies from the financial department.

The data, on the frequency of DBCs, from the financial department is originating from data out of the EZIS system, but the financial department has corrected and validated this frequency data to match the registered activities at the departments. However, the corrected data is not put back into the EZIS system. This is why there is a difference in the two data sets.

The DBC profiles are made to determine the cost price of each DBC. The data of the DBC profiles originates from the year 2008. It is possible that the DBC profiles made in 2008 do not match with the care provided in 2009. Keeping the DBC profiles up to date is one of the most important criteria to have a reliable capacity determination model.

The accuracy of the DBC frequencies is of a lower influence on the capacity determination than the accuracy of the DBC profiles. An incorrect frequency will have a lower impact on the total capacity, while this only will have a small influence on all the departments in the corresponding DBC profile. An incorrect DBC profile will affect the capacity for the complete frequency of that DBC.

To keep the capacity determination reliable, it is of high importance to keep the DBC profiles up to date. Due to the fact that the health care is continuously changing, it is important to update the DBC profiles at least each year. The more reliable the DBC profile data is, the more accurate the capacity prediction can be.

4.3 Possible opportunities for the use of the total activity equation

Although the first intention of the model was to provide the management with a strategic decision support tool, the model can now also be used for financial purposes. In Section 4.3.1 we discuss the strategic possibilities and in Section 4.3.2 we describe the financial possibilities.

4.3.1 Strategic capacity prediction

By changing the DBC frequency, in the model, with the predicted growth DBC frequency, from 2008 until 2020, the model makes clear how the growth of the total number of activities will affect the different departments during those years. It will also enable to see when particular equipment has to be purchased. By having insight when these moments occur it is possible, on time, to investigate which equipment has to be purchased or to improve the efficiency in such a way that it is possible to postpone the purchase of equipment. The strategic capacity information that the total activity equation provides enables the general management to predict capacity lack at an early stage and take action on time. It prevents the situation in which action is taken when the capacity shortage is already occurred.

Besides the detection of capacity shortages at an early stage the total activity equation can provide a possibility to see the effects of efficiency change at the departments. By multiplying the total activities on a resource with the efficiency the theoretically needed activities are determined. By changing the efficiency values it is possible to see what the effects are on the capacity of the departments.

4.3.2 Finance and control

Besides for capacity determination, the total activity equation can also be used for financial purposes. By adding the cost prices and income of the DBC to the DBC profile it is possible to make an estimation of the profit.

By including the profit, the total activity equation can provide information on which specialism, diagnosis, and treatments generate profit and which cause a loss. By knowing the profit and losses, investments can be made to attract profitable DBCs.

Also the capacity can be determined and compared with the used capacity registered at the departments. This provides a continuous control if the supply and demand of capacity is balanced.

4.4 Difficulties for implementation in another hospital

For the implementation of the total activity equation in another hospital, the required data has to be collected. As experienced at the NKI-AVL, collecting the required and correct data is not always an easy task. The different registrations at the departments can make it difficult to obtain the correct data. The registered capacity and the really used capacity often do not match.

Due to the specialist characteristics of the NKI-AVL, compared to the total unique DBC codes used in the Dutch healthcare, only 10 percent of the DBC codes are used at the NKI-AVL. In a more common hospital a much larger percentage of the 30.000 DBC codes will be used, with a consequence that more data has to be collected. Using more DBCs will lead to a higher change of mismatching DBC profiles.

4.5 Conclusion

To determine the total number of activities, an assumption of a linear relationship is formulized. The complexity of the total activity equation is low, due to the more complex DBC profiles in which most of the required data is stored. Collecting the correct data is much more complex. As described in Section 4.2, the quality of the required data is not always reliable and the availability of the correct data is low.

The availability and quality of data is of high interest to have a reliable capacity determination and prediction. With the around 3,000 DBC codes used at the NKI-AVL this is already a large amount of data that needs to be collected. In a more general hospital much more DBC codes will be used with the consequence that more data needs to be collected and checked.

Due to the flexibility of the total activity equation it can be used in two ways in the capacity planning. Either to determine the required capacity for the planned DBCs, or to validate the used capacity with the number of performed DBCs. By combining the revenue with the DBC profiles, as described in Section 4.3.2, the total activity equation can, besides for capacity determination, also be used for financial purposes.

5 Equation implementation at the NKI-AVL

Chapter 4 describes the total activity equation. In this chapter, we describe how we use the result of Chapter 4 to determine the capacity that is required to provide the care to the growing number of patients at the NKI-AVL. In Section 5.1, we describe the data that we use. Section 5.2 describes how we aggregate the outcome of the total activity equation to meaningful management metrics for strategic decisions. Section 5.3 describes the validation of the total activity equation. In Section 5.4, we conclude this chapter.

5.1 Used Data

To use the total activity equation, we need to gather the required data. As described in Section 4.1.1, this data contains the DBC profiles, in which an average care request is made, and the frequency of the each DBC. Besides this data, we need data and information to transform the raw outcome of the formula to more usable numbers and figures, such as the required nursing beds instead of total nursing days. To validate the formula, we need data from each department.

5.1.1 Frequency of DBCs

In Section 4.2.1, we described that, at the NKI-AVL, there are two systems in which the DBC frequency is registered. Figure 5 displays these two systems.

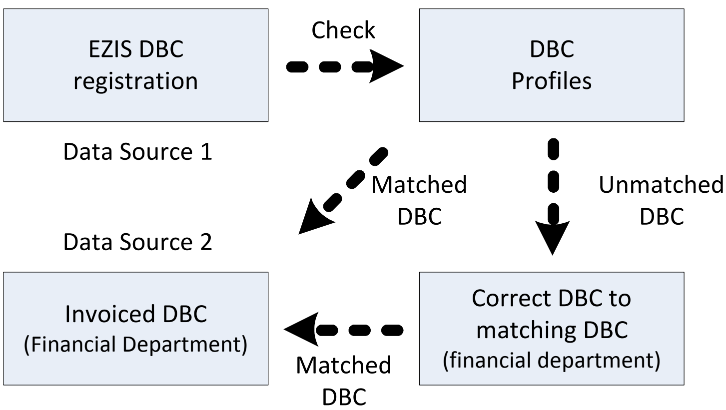

Figure 5: DBC frequency data sources at the NKI-AVL

Due to the fact that there is a registration in two systems, we have two data sources on the frequency "f_j" of DBCs. Source 1 is the registration system EZIS and Source 2 is the registration at the financial department. Table 1 displays some examples of the difference in DBC frequency of Source 1 and Source 2.

DBC	Source 1	Source 2
j = 1	1345	1035
j = 2	332	256
j = 3	588	376
j = 4	157	155
j = 5	116	48

Table 1: Frequency example of source 1 and source 2

To determine the required capacity, we use the data on the frequency of DBCs from the financial department. This data is most reliable due to the financial control system and it is checked by the accountant. The frequency data of the financial department is also the best matching with data registered at the departments within the NKI-AVL. We could count the data registered at the departments as a third source to obtain the required data from. However, the data registered at the departments is not directly connected with a DBC. The registered data at the departments can be used for the validation, because it reflects the total used capacity at the departments. We need the data from EZIS or from the financial department in order to connect the frequency of the DBC with the capacity. Figure 6 displays a graph with the difference in activities, at four departments, due to the difference in DBC frequency between EZIS and the financial department. The data from the department is directly extracted from the departments

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Figure 5: Capacity difference of EZIS and Finance

We use the DBC frequencies from the year 2008. 2008 was the first year, after the introduction of DBCs in 2005 and the introduction of the EZIS registration program in 2008, in which the frequency of DBCs is reliable and validated. In the previous years, there is too much disorder in the data, due to wrong registrations. We use the data of the DBC frequencies from source 2, the financial department. In total, there are xxxx unique DBCs, divided over 14 specialism, with, in 2008, a total number of xxxx performed DBCs.

5.1.2 DBC profiles

Every DBC has a corresponding DBC profile. This profile is an average of the care patients receive during their treatments corresponding with their diagnoses. In every profile, which care a patient receives is exactly described. In total there are more than 65,000 records to describe all the DBC profiles used at the NKI-AVL. This information is so detailed that it needs to be adapted for the strategic purpose of the equation and for the management. The DBCs profile data is originating from the financial department. The DBC profiles are made to determine the cost price of the DBCs. These are also the only available DBC profiles, at the NKI-AVL. Table 2 displays an example of the DBC profiles. In the example, we describe two different CT scans and two different Lab tests. The numbers in the table represent the number of activities that are performed on average, for the treatment corresponding with the DBC. In total there are 1188 unique activities, in the xxxx different DBC profiles.

Activity DBC	CT scan Thorax	CT scan Bones	Lab test sodium	Lab test potassium		N = 1188
j = 1	0.15	0.8	1.9	2.1	…	1.24
j = 2	1.5	0.23	3.5	1.3	…	1.9
j = 3	0	0.2	1.11	0.9	…	0.11
j = 4	0.77	0.9	1.29	1.4	…	0
⋮	⋮	⋮	⋮	⋮		⋮
j = xxxx	0.32	0.48	2.5	2.74	…	0.56

Table 2: Example from the Raw data of the DBC profiles

To be able to determine the required capacity in meaningful management metrics, we need to aggregate the DBC profiles into groups. The aggregation of the activities, within the DBC profiles, into different groups is chosen in such a way that the outcome can be transferred into required capacity on the resources. This adaption is done by combining similar activities into one group. As examples, all lab research requests within a profile are combined into the group “lab request”, all the CT scan activities are combined into the group “CT scans”, and all the nursing days are combined by department. We combine all the separate activities into 31 different groups. In appendix C, a list of the 31 separate groups can be found.

We have chosen for these 31 groups to get to the required capacity for the resources and due to the ongoing internal use of the data by different departments. We do not directly aggregate to resources since more information of the DBC profiles is required to determine the required capacity on the resources. To determine the required number of MRI, CT, and PET scanners no extra data of the DBC profiles is required. However, to determine the required number of nursing beds we need, besides the number of nursing days, also the number of patient intakes. Furthermore, there are besides normal nursing days also daycare nursing days performed at the nursing wards. These patients are only present on part of the day at the nursing ward. The determinations of the required number of beds for the daycare patients need to be performed in a different way than the determination of the nursing beds for the normal patients. To determine the required capacity we need more data than the activities performed on the resources. Section 5.2 describes how we come to the required capacity on the resources and which data we use. Table 3 displays an example of the aggregated activities.

Activity DBC	CT scan	MRI scan	Ward days floor 4	Ward days floor 5		N = 31
j = 1	0.8	0.75	0.17	3.24	…	1.12
j = 2	1.52	0.09	3.5	0.12	…	1.9
j = 3	0.2	0.4	0.01	0.41	…	0.32
j = 4	0.89	1.1	0.01	0.01	…	0
⋮	⋮	⋮	⋮	⋮		⋮
j = xxxx	0.59	0.87	2.54	0.01	…	0.58

Table 3: Example of the aggregated activities of the DBC profiles

As described in Section 5.1.1, capacity may have been used that is not connected to a patient DBC. The NKI-AVL performs activities for third parties. On the MRI scanner this is just a little bit, but at the pathology department and on the PET scanner around xx% of the capacity is used for third parties. This capacity is not connected to a patient DBC. This external capacity use is combined into a DBC profile, the so called external DBC (E_DBC). Within the NKI-AVL this DBC is reflect to as the B_DBC.

The remaining capacity, which is used but cannot be referred to a patient DBC or a third party, is combined into an extra DBC the so called drifting DBC (D_DBC). Within the NKI-AVL this DBC is reflect to as the ZW_DBC. The D_DBC is also used by the financial department as a correction DBC.

The E_DBC profile and the D_DBC profile are divided into the same 31 groups as the other DBC profiles. Because these two DBCs are not an average, as are the patient DBCs, but a total used capacity DBC the frequency in which the E_DBC and the D_DBC occurred in 2008 is one.

Within the DBC profiles and mostly in the E_DBC and the D_DBC, negative values exist. Within a patient DBC this should not be possible. The negative values within the E_DBC and the D_DBC come from a correction which is applied, by the financial department, for administrative purposes. With the correction, certain values are rounded down to zero or downgraded to match the capacity use by the DBCs. With the negative values, present in the DBCs, the outcome of the equation did not match with the registered data at the departments. After removing the negative values and a recalculation of the total activities, the outcome of the departments now match. For the determination of the capacity, we eliminated all the negative values in the DBCs. From the xxxx D_DBC values xxxx were negative, xxxx from the in total xxxx E_DBC values were negative. This shows that most of the negative values belong to the D_DBC and are used as a correction factor by the financial department.

5.2 Determining the required capacity

To determine the required capacity we transform 20 out of the 31 groups into 14 resources. We have chosen these 14 resources because, these resources require a large investment, have large consequences on the available floor space, and have a direct relation with the strategic capacity choices that have to be made. As discussed in Section 5.1.2, we first aggregate the DBC profiles into the 31 groups, due to continuous use of the data by the departments. Of the 31 groups, 11 groups will not be transformed into required resources. Table 4 displays a list of these 11 groups. These 11 groups are summary statistics and improve the image of the expected growth. They are determined on request of the management. Furthermore, the management can, during meetings with the departments, use the data to check whether the assertions on the growth from the departments match with the predictions of the model.

	Excluded group
1	REMOVED CONFIDENTIAL INFORMATION
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

Table 4: List of the 11 excluded groups

The 20 groups that will be transformed into the required resources are the nursing days including the intensive care and daycare, the number of outpatient clinic consultations, the number MRI, CT, PET scans, and the total hours of surgery. We adapted these numbers to the required number of units of nursing beds, MRI scanners, CT scanners, PET scanners, consultation rooms, and surgery rooms, which need to be available to perform the increasing care request. Table 5 displays a list of the 14 resources. Appendix D displays the list in the Dutch language.

We separate the required number of nursing beds by the floors at the NKI-AVL. Each floor, at the NKI-AVL, has a specific purpose and a different patient mix. The 4th floor is used for patients that receive a medicine treatment. The 5th floor has a mix of patients that receive a treatment in an area above their waist. The 6th floor is used for patients that receive a treatment in an area below their waist. Beside the general patient on these floors, there are also daycare patients treated at these three levels. The determination of the required beds for these patients needs to be performed in a different manner than the determination for the general beds. These beds are the nursing beds for daycare at the three levels.

	Resource
1	Outpatient consultation rooms
2	Surgery rooms
3	Nursing beds | General 4th floor
4	Nursing beds | General 5th floor
5	Nursing beds | General 6th floor
6	Nursing beds | Day Care department
7	Nursing beds | Day Care Chemotherapy treatment
8	Nursing beds | Day Care 4th floor
9	Nursing beds | Day Care 5th floor
10	Nursing beds | Day Care 6th floor
11	Nursing beds | Intensive Care
12	MRI Scanners
13	CT Scanners
14	PET Scanners

Table 5: List of the 14 resources

To determine the required number of general nursing beds at each floor (resource 3, 4, 5 of Table 5), we need besides the total number of bed days of each floor also the number of patient intakes of each floor and the efficiency of the ward. We can extract the number of patient intakes and the number of bed days from the DBC profile data. For the determination of the ward departments' efficiencies, we use the data of 2008. In 2008 there were 50 beds on each floor. To determine the efficiency of the ward, we subtract the number of patient intakes from the number of nursing days and divide this by the number of beds. Equation 1 displays the formula for the determination of the efficiency at the ward departments.

$$\frac{\text{Total nursing days} - \text{Total patient intakes}}{\text{Total number of beds}} = \text{Efficiency}$$

Equation 1: Equation for determining the efficiency of the nursing department

We perform the subtraction of the number of patient intakes from the number of bed days to eliminate the double registrations (Dutch care authority, NZA). We eliminate the double registrations, because of the fact that on the day that a patient is released from the hospital a new patient can be taken into the hospital on the same bed. This way a double day in the same bed is registered. To determine the number of required beds, we subtract the number of patient intakes from the total number of nursing days, divide this by the efficiency and finally divide this by 365 (the number of days in a year). Equation 2 displays the formula for the determination of the number of required beds for general use at the nursing department.

$$\frac{\text{Total nursing days} - \text{Total patient intakes}}{\text{Efficiency}} / 365 = \text{required number of beds}$$

Equation 2: Equation for determining the required beds for general use at the nursing department

We determine the required number of beds at each floor for daycare treatment (resource 8, 9, 10 of Table 5), in the same way as the number of general beds. The difference is that we do not have double bed days. Therefore, we do not have to subtract the number of patient intakes. The daycare beds are not used 365 days in a year, but only 250 days. To determine the number of daycare beds at the ward, we divide the number of required nursing days by 250 days. Equation 3 displays the formula for the determination of the number of required beds for daycare use at the nursing department.

$$\frac{\text{Total daycare nursing days}}{\text{Efficiency}} / 250 = \text{required number of beds}$$

Equation 3: Equation for determining the required beds for daycare at the nursing department

We determine the required number of beds at the daycare department, resource 6 of Table 5, in a similar way as the number of general nursing beds. The data that we need to determine the number of required beds is the number of daycare days at the daycare department, the average number of patient that can be treated per day on a bed, and the efficiency of the department. The number of daycare nursing days is extracted from the

DBC profiles. The average number of patient that can be treated each working day on a bed is determined from the average duration of a treatment and the opening hours of the daycare department. The daycare department is opened 250 days a year. The efficiency of the daycare department is determined by reiterative exploration. To determine the number of required beds, we divide the number of nursing days by the average treatable patients per day per bed divided by the efficiency and finally divided by days opened per year. Equation 4 displays the formula for the determination of the number of required beds for daycare use at the daycare department.

$$\frac{\text{Total daycare nursing days}}{\text{Treatable patients} \ / \ \text{Efficiency}} \ / \ 250 = \text{required number of beds}$$

Equation 4: Equation for determining required beds for daycare at the daycare department

For a certain chemotherapy treatment, it is not allowed to register a daycare nursing day, these patients, however have been present at the daycare department and have used capacity. To determine the required number of beds, resource 7 of Table 5, for chemotherapy treatment at the daycare department, we use the same method as for the determination of the required beds for other treatments at the daycare department. The difference in the method is the average number of treatable patient per bed per day. Equation 5 displays the formula for the determination of the number of required beds for chemotherapy treatment at the daycare department.

$$\frac{\text{Total daycare chemotherapy treatments}}{\text{Treatable patients} \ / \ \text{Efficiency}} \ / \ 250 = \text{required number of beds}$$

Equation 5: Equation for determining required beds for chemotherapy treatment at the daycare department

We determine the required number of intensive care (IC) beds at the IC department, resource 11 of Table 5, in the same way as the number of daycare beds at the nursing departments. The efficiency of the IC department is determined in the same way as the efficiency of the nursing department. The total number of IC nursing days is divided by the number of IC beds. To determine the number of IC nursing beds, we divide the total number of IC nursing days by the efficiency and divide this by 365 days. Equation 6 displays the formula for the determination of the number of required beds for intensive care at the IC department.

$$\frac{\text{Total IC nursing days}}{\text{Efficiency}} \ / \ 365 = \text{required number of IC beds}$$

Equation 6: Equation for determining the required beds for intensive care at the IC department

We determine the required number of MRI, CT, and PET scanners , resource 12, 13, 14 of Table 5, by dividing the total number of scans per year by the theoretical maximum number of scans per year per scanner and then divide this by the efficiency. We extract the total number of performed scans, on the MRI, CT, and PET scanner, from the DBC profile data. The number of theoretical maximum possible scans on a scanner and the efficiency is provided by the diagnostic department. Equation 7 displays the formula for the determination of the number of required MRI, CT, and PET scanners.

$$\frac{\text{Total number of scans}}{\text{Theoretical maximum number of scans}} \text{ / Efficiency = required number of scanners}$$

Equation 7: Equation for determining the required number of scanners

To determine the required number of outpatient consultation rooms, resource 1 of Table 5, we extract the total number of outpatient visits from DBC profile data. In the first aggregation, we have separated the outpatient by first visits, follow up visits and other visits. We have separated this in the first step to provide a better overview, for the strategic capacity decision, of how the number of visits is divided over the types of visits. For the determination of the required number of consultation rooms, we combine the three types of visits. We determine the required number of consultation rooms by dividing the total number of outpatient visits by the average visits of patient in a day per room, multiplied with 250 working days in a year. Equation 8 displays the formula for the determination of the required number of consultation rooms.

$$\frac{\text{Total number of outpatient visits}}{\text{Patients per room * 250 days}} \text{ = required number of rooms}$$

Equation 8: Equation for determining the required number of outpatient consultation rooms

For the determination of the required number of surgery rooms, resource 2 of Table 5, we extract the total number of surgery hours from the DBC profiles. We need the total number of surgery hours, this is including the total number of surgery robot hours[1]. Besides the surgery hours, we need the data on opening hours per day, efficiency, and the number of opened days. This data is extracted from the NKI-AVL business plan (2009). To determine the required number of surgery rooms, we divide the number of hours by the opened hours per day multiplied by the opened days per year and divide this by the efficiency. Equation 9 displays the formula for the determination of the number of required surgery rooms.

$$\frac{\text{Total hours of surgery}}{\text{Opening hours per day * 250}} \text{ / Efficiency = required number of surgery rooms}$$

Equation 9: Equation for determining the required number of surgery rooms

[1] *The surgery robot is used at certain surgeries. We aggregate this separately from the DBC profiles in the first step. The hours with robot surgery are kept as summary statistics for the management.*

5.3 Validation of the total activity equation

The outcome of the total activity equation is a representation of the situation in 2008. In the NKI-AVL case it should match because the data comes from the profiles of 2008 and the profiles are based on the data of 2008 from internal registration at the departments and due to the earlier calibration that was already performed by the financial department.

To validate the prediction of the model, we compared the outcome of the model using the growth profile of the DBCs, with the outcome of the model using the performed DBCs of 2009, with the data of 2009 registered at each department. Figure 7 displays two of the three situations that we validate. Situation "A" is the predicted required capacity in 2009, predicted with the predicted DBC frequency of 2009 based on the DBC frequency of 2008. Situation "B" is the predicted required capacity, predicted with the DBC frequency realized in 2009. Situation "C" is the actual realized use of the resources in 2009.

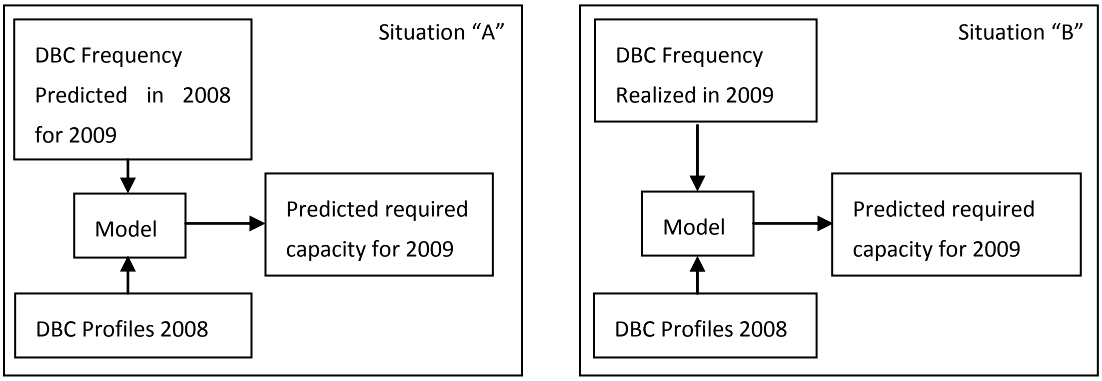

Figure 7: Situation "A" and situation "B" of the required capacity prediction

It appears that certain values grew faster in 2009 than the growth profile predicts. We can explain this difference due to continuous changes in the health care and the development of better treatment plans. The DBC profiles that are used for the determination are made in 2008. To keep the formula outcome reliable and up to date the input should be up dated continuously with the newest data.

Figures 8 until 16 display the outcomes of the model, using the growth profile, for 2009, of the DBCs, compared with the outcome of the model using the performed DBCs of 2009, and the registered data, of 2009, of the department.

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5.4 Conclusion

To determine the required capacity, we started with the DBC profiles and the DBC frequency. The DBC profiles contained too detailed information to determine the capacity. By aggregating the 1188 unique activities into 31 groups, we are able to determine the required capacity.

To determine the required capacity, we obtained extra information of the departments. This extra data, efficiency, average consult per day, duration of chemotherapy treatment, etc, is required to transform the total number of activities to required resources. Of the 31 groups, 11 groups are not used for determining the capacity. We started with these 31 groups due to the continuous use of the data within the NKI-AVL. The 20 remaining groups are required to determine the required capacity of the 14 resources listed in Table 4.

Figure 17 displays the data flow and the steps, we have made to determine the capacity.

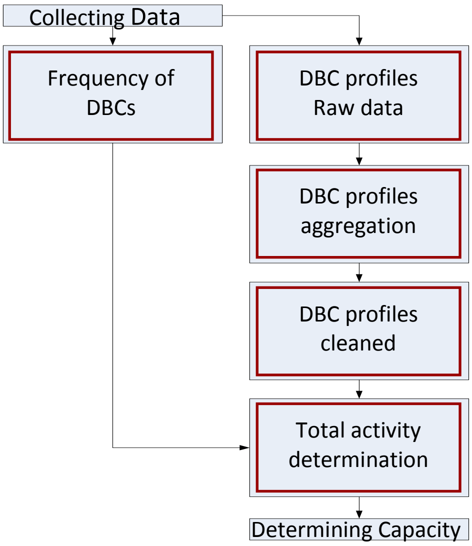

Figure 17: Data flow and aggregation steps

The data of the frequencies of DBCs did not have to be adapted. The DBC profile data had to be adapted. The first step is the aggregation from 1188 unique activities to 31 groups. In the second step, we eliminated all the negative values. These negative values originate from the financial department, where they are used for administration purposes. However, this is capacity that is used and should not be eliminated. In the second last step, we have combined the DBC frequencies with the DBC profile data to determine the total number of activities for the 31 groups. In the last step, we transformed the total number of activities into the required capacity on the 14 resources.

6 Computational Results

In Chapter 5, we described the implementation of the total activity equation at the NKI-AVL. In this chapter, we will describe the results of the capacity determination and how we come to these results using the model. In Section 6.1, we describe the automated capacity determination model. In Section 6.2, we describe and analyze the prediction of the capacity. Section 6.3 concludes this chapter.

6.1 The automated capacity calculation program

We programmed the automated capacity calculation program in Excel. We have chosen for Excel because, within the NKI-AVL Excel is common and the users of the calculation program can work with Excel. This enables that, later in time, the users of the program can change the input data themselves.

The program has seven sheets. The first sheet has all the data of the DBC profiles in the state as it is available at the financial department. All the separate activities within each DBC are described in this data. We have added an extra column to the data to combine the data into the 31 groups as described in Section 5.1.2. The next sheet is a pivot table of the changed profiles according the 31 groups. The “frequency” sheet contains the data on the frequency of each DBC in the year 2008 and the predicted frequency of the DBC for each year until the year 2020. The predicted frequency is determined by multiplying the frequency with the growth factor on the input sheet.

On the “input” sheet all the variable input can be changed. On this sheet the growth percentage, for each year until 2020, of the A and B segment, the utilization percentage of the surgery rooms, the utilization percentage of the nursing beds, the intensive care and the daycare, the number of consults per day per outward consultation room, and the number of scans that can be performed per year on a MRI, CT, and PET scanner can be changed. The maximum number of scans per year on a scanner will not change much. Due to some efficiency improvement slightly more scans could be made. The last input is the number of full time employees (FTE). The utilization percentage of the nursing beds is divided per floor, this is done because each floor has a specific type of patients. The daycare beds are split into chemotherapy treatments and others. Figure 18 displays a screenshot of the “input” sheet of the automated capacity program.

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Figure 18: Screenshot of the “input” sheet of the automated capacity program.

On the "capacity" sheet, the capacity of a particular year is determined. The year can be selected and the capacity is divided in sub groups. These groups are first visit "11" DBCs, follow up "21" DBCs, the A and B segment of the DBCs, and the total capacity. We have divided the total capacity into the groups to provide a better picture on how the capacity is divided and which capacity is used by which group. The A and B segment are interesting because, for the A segment there are fixed prices for each DBC and in the B segment the prices are negotiable with the insurance companies. Due to this, the B segment DBCs may have a higher profit. The first visit "11" and follow up "21" separation is chosen to get more insight in the capacity that is used for patients that come for the first time and patients that have follow ups. Figure 19 displays a screenshot of the "capacity" sheet of the automated capacity program.

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Figure 19: Screenshot of the "capacity" sheet of the automated capacity program.

The last sheet, "total capacity", contains the total capacity which is required for the growth. We display the total number of activities of the 31 different groups. This provides the user with a quick overview. As described in Section 5.1.2, we started with these 31 groups due to the continuous use of the data by other departments. For the strategic purpose of the model these 31 are sufficient. Appendix C displays a list of the 31 groups. Of the 31 groups, 20 groups are combined into 14 resources. These 14 resources are the most important for the strategic capacity determination at the NKI-AVL. Table 4 in Section 5.2 displays the 14 resources. These 14 groups are converted into required equipment and rooms. The number of nursing days is converted into the number of nursing beds, the surgeries hours are converted in required surgery rooms, the number of outward consultations is converted into the number of consultation rooms, and the number of MRI, CT, and PET scans into the number of scanners. Figure 20 displays a screenshot of the "total capacity" sheet of the automated capacity program.

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Figure 20: Screenshot of the "total capacity" sheet of the automated capacity program.

We let the number of employees grow linearly with the same rate as the total number of DBCs. We have chosen for this linear growth, due to the complicated relationship between employees and a DBC. It is impossible to relate the required number of employees to a DBC. We have chosen for the same growth rate as the total number of DBCS for the number of employees because, with the current number of employees all the DBC can be performed. For the strategic planning, it is also not necessary to have a detailed overview of the number of employees that are needed. An estimation of the number employees is for the strategic purpose sufficient.

On an additional sheet, a single DBC or multiple DBCs can be filled in and their corresponding frequencies. This sheet can be used to determine the capacity for a group or a few DBCs. This sheet can also be used to find a DBC profile.

We have tested the calculation program by changing the input and checking the outcome. By changing the growth rate from a different rate for the A and B segment to the same rate we could check the outcome of the model which then should be the same growth as the total rate. Besides this, we have also verified the outcome of the model with the data available at the departments.

We let the frequency of the DBC grow according the growth profile (NKI-AVL business plan 2009), the required capacity for each year can then be determined. The E_DBC and the D_DBC grow with the same rate as the growth of the total number of DBCs. We have chosen this because, this way the correction factor that comes from these two DBCs grow with the same rate with the total number of DBCs. It would be better to correct the E_DBC and the D_DBC every year and keep it up to date. Due to corrections in the DBCs and that certain activities are performed but are not referable to a DBC, these two DBCs are needed in the DBC profiles.

The hospital could improve the efficiency of the departments and threat more patients with the same capacity. Changing the efficiencies of the departments has no effect on the structure of the total activity equation. It has effect on how the outcome of the total activity equation is transformed into the required capacity. The total activity equation just returns the required number of activities. The total number of activities is then transformed into the required capacity on the resources. Balancing the required capacity with the available capacity can be done in different ways. During the determination of the required capacity we did not include efficiency improvements. The model provides a capacity answer which matches the current efficiency parameters.

6.2 Prediction of the required capacity with the model

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The automatic capacity calculation program is a tool for the management to provide them with information to make strategic capacity decision and provide them with information to strengthen the choices that are made.

As we described in Section 5.3, due to changes in the health care, there are resources that will grow faster than the average growth within the hospital. These changes in the health care can be manage in the model by updating the DBC profile data and the data for transforming the activities into resources not every year but every half year.

Furthermore, the model can also be used for controlling the used capacity. By comparing the used capacity, registered at the departments, with the required capacity from the outcome of the model. Determining the required capacity can be performed by using the DBC frequencies of the DBCs in that same period.

6.3 Conclusion

The automated capacity calculation program provides the user with a tool to determine the required capacity. By enabling to simply change the input data, the model can be kept up to date with new data. For both purposes of the model, determining the required capacity and checking the used capacity with the owned capacity, it is of high interest that the DBC profiles are kept up to date. The frequency of the DBC could be adapted to the current situation at the end of each year or every half year based on the production of the first half year.

7 Conclusion and Recommendations

In this chapter we conclude the research in Section 7.1. In Section 7.2, we discuss recommendations following from this research.

7.1 Conclusions

The central research question of our research is:

- *How to determine the required capacity for the increase in the number of patients within NKI-AVL.*

By answering the research question formulated in Section 1.3, we conclude our research.

What is the current capacity determination method at the NKI-AVL?

The present capacity determination method within the NKI-AVL is based on the capacity request from the different departments. The departments mainly base their determination of required capacity when there is a noticeable shortage of capacity and current waiting lists. Based on historical data and meetings, the management makes the final decision on the added capacity. This method is not robust and is always behind on reality.

What are suitable whole hospital models to determine the needed capacity for the expected growth?

Only a few articles on whole hospital modeling exist in literature. We did not find a suitable hospital model for determining the required capacity. There is one method described in literature on the use of DBCs for capacity determination. However, how this precisely works and how it exactly can be used by the daily management of a hospital is not clearly described.

How to determine required capacity?

To determine the required capacity we formulated the total activity equation.

Total activity equation:

$A_i = \sum_j f_j * r_{ij}$

Definitions:

r_{ij} = required number of available activities for DBC 'j' on resource 'i'
f_j = frequency of planned DBC 'j'
A_i = total activities on resource 'i'

f_j = integer for all j = 1, … , m (DBC)

The total activity equation determines the total number of activities by multiplying the DBC frequency with the DBC profiles. The complexity of the total activity equation is low, due to the more complex DBC profiles in which most of the required data is stored. Collecting the correct data is of a much higher complexity. Collecting the correct data within the NKI-AVL caused some problems. Due to the different sources at which data is available it is not clear which data is the correct one. After the validation of the data, we choose to use the data of the financial department.

<u>How to determine the required capacity for the NKI-AVL?</u>

To determine the required capacity, we obtained the DBC profiles and the DBC frequency. To determine the capacity, we aggregated the 1188 unique activities, in the DBC profiles, into 31 groups. Besides the total number of activities, determined with the total activity equation, we obtained extra information on efficiency; average consults per day, duration of a chemotherapy treatment at the daycare, etc. This data is required to transform the total number of activities into the required capacity y on the corresponding resources.

For the strategic purpose of the model, 14 resources were selected. These resources have the biggest impact on the hospital resources, either through high investment or otherwise through required floor space. The aggregation of the DBC profiles and the transformation to the required capacity on the resources is displayed by Figure 21.

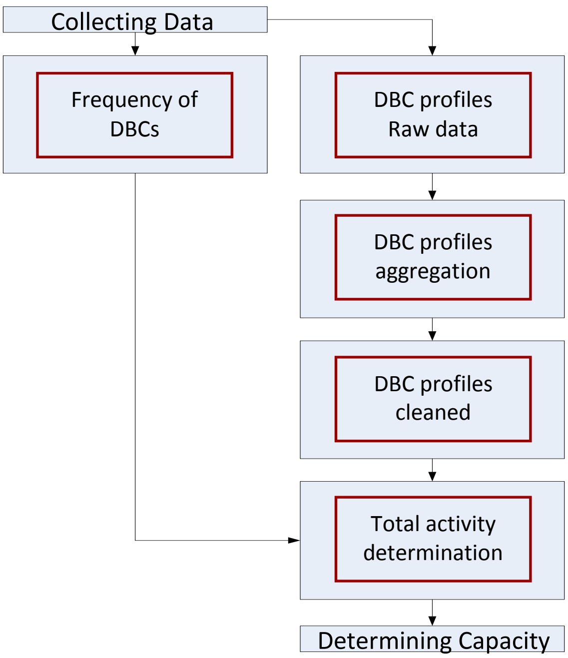

Figure 21: Data flow and aggregation steps

The first step is the aggregation from 1188 unique activities to 31 groups. In the second step, we eliminated all the negative values. These negative values originated from the financial department where they are used for administration purposes. However, this is capacity that is used and should not be eliminated. In the second last step, we have combined the DBC frequencies with the DBC profile data to determine the total number of activities for the 31 groups. In the last step, we transformed the total number of activities into the required capacity on the 14 resources.

<u>How to automate the capacity calculation and develop this in a decision support tool?</u>
We programmed an automate capacity calculation program in Excel. We choose Excel due to the widespread availability within the NKI-AVL and the available knowledge, in Excel, of the users of the automated capacity calculation program. The program provides an overview of the required capacity. The input data that determines the required capacity can easily be changed by the user. This provides an easy option to change the efficiency levels at the departments or when necessary the opening hours of a department.

The automated capacity calculation program provides the management with tool in which they can play around with efficiencies and opening hours. This provides the management with information on how to solve the lack of capacity. It is now possible to change the input data and see the immediately effect on the required capacity.

7.2 Recommendations

We divide our recommendations in practical recommendations, Section 7.2.1, and recommendations for future work in Section 7.2.2.

7.2.1 Practical recommendations

The most important detail throughout this research is the data quality. As we describe in Section 4.2.2 and in Chapter 5, the quality and reliability of the data is good for the year in which they are determined. In Section 5.3, we conclude that the DBC profiles of 2008 do not match perfectly with the delivered care in 2009. The DBC profiles will always be behind on reality, since first there should always be data available to determine the profiles. These values first have to be collected from practice before average values, for the DBC profiles, can be determined. Keeping the data more reliable and more available it should be clear for everybody who is responsible for which data. At the NKI-AVL, there were multiple data sources for the frequencies of DBCs. Besides this, we used data of the departments. On the departments it is often not clear who is in charge of the data or which data is available. Knowing which data is available and where will significant improve the availability and quality of the data. Furthermore, easy accessible data of good quality will improve the use of data, which will benefit the hospital.

It is difficult to predict which DBCs will grow faster in the coming years. There is an average growth, but with the increase in types of cancer and the difficult prediction of the development of cancer it is difficult to predict the growth of the frequency.

Improvement in the registration at the departments is needed to provide the financial department and the management with valuable information. The more accurate the data at the departments is the better the DBC profiles can be determined.

7.2.2 Recommendations for future work

Combining the capacity determination with an efficiency determination or a case mix with the ideal patient mix can provide the management with even better information. Through this, it is possible to instead of determining the required capacity, determining the ideal patient mix for the current available capacity. With an included efficiency determination it becomes possible to determine the capacity based on the improved efficiency.

For a better reliability of the data, a hospital wide research on the available data could be carried out. By determining who is responsible and which data is available at which place will improve the quality of the data and prevent double sources for data.

It is impossible to exactly specify how many patients will enter the hospital with a certain type of cancer. For each patient that will enter the hospital which the specified cancer type there will be many other patient with different types of cancer. To improve the capacity prediction it would be of great interest to know these relations between the cancer types. For example when a patient with colon cancer enter the hospital, what will be the prediction that he will reenter the hospital later in time with another diagnosis and which diagnosis. Combining this prediction with the capacity determination model the prediction of the capacity will improve.

Bibliography

de Bruin, A., Koole, G., and Visser, M. (2005). "Bottleneck analysis of emergency cardiac inpatient flow in a university setting: an application of queueing theory." Clinical & Investigative Medicine, 28(6):316–7.

Fletcher, A. and Worthington, D. (2007). "What is a 'generic' hospital model? " Retrieved July, 2009, from http://eprints.lancs.ac.uk/7051/1/004583.pdf

Hans, E., Van Houdenhoven, M., Wullink, G., Kazemier, G. (2006). "A framework for hospital planning and control." Working paper University of Twente.

Jun, J., Jacobson, S., and Swisher, J. (1999). "Application of Discrete-Event Simulation in Health Care Clinics: A Survey. " Journal of the Operational Research Society, 50(2):109–123.

Vanberkel, P.T., Boucherie, R.J., Hans, E.W., Hurink, J.L. and Litvak, N. (2009). "A survey of health care models that encompass multiple departments." Working paper University of Twente.

Folmer, K. and Mot, E. (2003). "Diagnosis and treatment combinations in Dutch hospitals" cpb report 2003.

Koopmans, L. (2002). "Opgelegde schaarste verlaten" Medisch Contact, nr. 4, 21 januari 2002

van de Ketterij, J.L., Schaepkens, F.F.J.M. and de Vries, P.G., (2002). "DBC2003 What's in it for me?" Health information developments in the Netherlands, May 2002.

Van der Meer, E.T. and School, M.A.A. (2008). "De logistiek van het ziekenhuis." Medisch Contact, nr. 49, 5 december 2008.

Westert, Gert P., Burgers, Jako S. and Verkleij, H. (2009). "The Netherlands: regulated competition behind the dykes?" BMJ 2009;339:b3397.

Aveyard, H. (2007) "Doing a literature review in health & social care, a practical guide." Berkshire: Open University Press, McGraw-Hill.

Herontwerp – innovatie en groei. Business Plan februari 2009. Amsterdam, NKI-AVL

NKI-AVL (2008). Annual report 2008. Amsterdam, NKI-AVL.

Appendix

Table of content

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