MASTER THESIS

The design of a Business Intelligence application to control hospital funding in The Netherlands

Vincent Spijkerman, S1250159
Supervisors University of Twente:
Dr. Ir. A.A.M. Spil
Ir. B. Kijl
Supervisor PinkRoccade Healthcare:
Ir. G.W. van Tilburg
Date: July 9th, 2015

UNIVERSITY OF TWENTE.

pinkroccade HEALTHCARE

Management summary

Currently, Dutch hospitals have difficulties managing their financial performance. To get the increasing health expenditures in control, the Dutch hospital funding changed radically in January 2005. The Diagnostic Treatment Combination (DTC), which comprises the complete treatment of a patient, was introduced. However, the complexity of the DTC system makes it difficult for hospitals to see how well they are performing with respect to the agreements with health insurers. As a result, the Dutch hospitals are often faced with high costs which cannot be reimbursed by the health insurers. To control and manage the hospital funding there is a need for a decision support system. Advice is needed to create an Business Intelligence (BI) application for optimizing management decisions regarding the production of DTCs in Dutch hospitals. Therefore, the research objective is:

What is the potential of applying a BI application to Dutch hospitals in order to optimize strategic and tactical management decisions on hospital funding.

By elaborating the history of the Dutch hospital funding, the Dutch DTC-system, and Health Information Technology, insights are gained on the possibilities of BI in the Dutch healthcare and how the required data can be obtained. A literature study was conducted using the systematic and rigorous approach offered by Wolfswinkel et al. (2013). This provides an extensive review on BI in healthcare as well as the management of hospital production. This literature study raised questions whether these theoretical findings are also applicable to the Dutch healthcare system.

Subsequently, a stakeholder analysis regarding the control of hospital production was performed. These interviews made clear; the objective of the hospital funding system, information needs, control options and the key figures. The results provided an insight in the negotiations between health insurers and hospitals, and the information needs regarding hospital funding of the stakeholders.

Based on the literature study and the stakeholder analysis a BI application was designed. Performance management was used as designing method. The key performance indicator of the BI application is the quantity of DTCs produced per year. In the planning stage the BI application provides in the need for cost calculations per DTC and a forecast on the expected quantities. The performance can be monitored by the proposed build-in WIP grouper and by deriving final DTCs by care pathways. Taking corrective action can be done by adjusting the

waiting time per DTC per health insurer. Also, policy recommendations were made on how to implement the BI application.

It can be concluded BI has the potential to improve the financial performance of the Dutch hospitals by delivering actionable management information by using a data warehouse, analytical tools and dashboards. Together with performance management, as identified in the design of the application, this is the basis for a hospital to assess how well it is progressing towards its predetermined strategic objectives. It will help to identify areas of strengths and weaknesses, helps to decide on future directions, and enables taking corrective action for tactical decisions. Important precondition is the availability of sufficient reliable historical data as input for the BI application.

Preface

This graduation project was performed at PinkRoccade Healthcare in Apeldoorn at the Geniq department which delivers a business solution for integrated management information. This project is the last phase towards my Master's degree in Industrial Engineering and Management with a specialization in Health Care Technology and Management at the University of Twente. When I look back, I can conclude I have gained a lot of new knowledge the last couple of months during this project.

During my bachelor study Human Movement Sciences at the University of Groningen, I learned a lot about scientific research, anatomy, and other healthcare related subjects. However, I specifically chose for this master direction as I became more interested in the management of healthcare. Even though I had to work hard during the premaster to eliminate the deficiencies, the master courses went well and I gained a lot of in-depth knowledge on optimizing healthcare processes. By conducting this graduation project at PinkRoccade Healthcare I came in contact with Business Intelligence and the hospital funding in the Netherlands. These subjects were not yet covered during the study program, but certainly enhances my knowledge and will support me in becoming a healthcare professional.

I want to use this opportunity to thank the persons who were involved during the months of this graduation project. First of all I would like to thank PinkRoccade Healthcare for the opportunity of the internship. Unit manager David Fremeijer for the contribution on possible subjects and introducing me to my daily supervisor Gerard van Tilburg. Gerard, thank you for the guidance towards the subject and your constructive feedback. Together with your experience and extensive knowledge on the subject you were very helpful for this project. Furthermore I would like to thank the other members of the Geniq department for the numerous cups of coffee, the interesting chats and the daily walks. Besides PinkRoccade I would like to thank my lead supervisor Ton Spil for the complete process of graduation, the helpful tips and constructive feedback. And second supervisor Björn Kijl for supervising the thesis and your expert knowledge.

Last but not least I want to thank all my friends and family who helped me or just for being there. In particular Nicole, who kept me motivated during the tougher moments and helped improve the quality of the thesis by providing feedback on the content as well as the grammar.

Vincent Spijkerman

Apeldoorn, July 2015

Contents

1. Introduction

One of the most discussed topics in recent scientific research on healthcare are the growing health expenditures of most modern industrial countries. With a percentage of 16.9% of the gross domestic product (GDP) the United States allocated the world highest share of its GDP to health in 2012. That same year The Netherlands became the highest spending European country, with 11.8% of its GDP spent on health. This share of the GDP on health spending is considerable larger than the average of 8.7% of the EU member states in 2012. With an average spending of 7.3% of the EU member states in 2000, the growth of the spending on health is significant [1].

To get the increasing health expenditures in control, the Dutch hospital funding changed radically in January 2005. Before this date all hospitals were assigned a budget by the Dutch Healthcare Authority. Because a part of this budget was variable it was profitable for specialists to carry out more medical procedures than necessary. And because the hospitals did not want to exceed the fixed part of the production budget, this led to long waiting lists. These waiting lists decreased the accessibility of healthcare. Therefore, the Diagnostic Treatment Combination (DTC), which comprises the complete treatment of a patient, was introduced. From this time on only a DTC could be claimed for a patient, with a fixed reimbursement. This should be a stimulant to more efficient medical procedures and shorter waiting lists. At the same time the Ministry of Public Health stimulated a regulated free market between hospitals, with the result that the reimbursement of approximately 70% of the DTCs are nowadays negotiable for the health insurers [2]. The aim of this negotiable reimbursement is competition between hospitals in quality and price, what ideally will lead to maintaining affordable healthcare with increasing quality.

The health insurers purchase care for their insured in terms of DTCs by making agreements with care providers, including the hospitals. These agreements consist of the prices and the quantities of the DTCs per calendar year. The lower the prices of the purchased DTCs, the lower a basic premium can be offered to the insured, which maintains affordable care. This also stimulates the hospitals to work more efficient, the less hospitalized days per treatment, the less costs and more profit. The purchased quantities will reflect the quality of care, if the quality of care does not meet the requirements of the health insurers, they will not purchase care in this hospital. The purchase of quantities by the health insurers is based on historical production of the hospitals and the changes in the market. It is arranged that when the hospitals exceed the agreed upon quantity of claims for a DTC, the hospitals will not receive a

reimbursement for these extra DTCs and will have to pay the incurred costs themselves. On the other hand if the hospital produces less than the agreed quantity, there is a chance that the fixed costs are not covered. Therefore, good insights in the production of hospitals is very important.

However, the complexity of the DTC system makes it difficult for hospitals to see how well they are performing with respect to the agreed quantities with health insurers. As a result, the Dutch hospitals often are faced with high costs which cannot be reimbursed by the health insurers. To control and manage the hospital funding there is a need for a decision support system. This kind of management information can be provided by Business Intelligence (BI). BI can be thought of as getting the right information to the right people at the right time and place to enable fact-based decisions [3]. By means of a structured approach of preparing and using the obtained information, the business activities can be controlled. PinkRoccade Healthcare delivers a BI solution to the Dutch hospitals. Advice is needed to create an additional BI application for optimizing management decisions regarding the production of DTCs in the Dutch hospitals.

By means of a literature study and a stakeholders analysis the decision making process of the hospital production will be elaborated, and the information needs will be identified in this thesis. By combining these needs a BI application will be designed, and policy recommendations on the implementation of the application will be provided.

1.1 Research context

1.1.1. PinkRoccade Healthcare

PinkRoccade is a Dutch service providing company that is operating in the ICT industry. The company consists of two main divisions; Local Government and Healthcare, which are part of the parent company Total Specific Solutions. PinkRoccade Healthcare consists of three market-oriented segments; Hospitals, Mental Health, and Care. Each of these segments has three main activities; Service and Support, Consultancy and Projects, and Implementation and Integration. This research is directed to the Healthcare division of PinkRoccade and will specifically be focused on hospitals located in the Netherlands. PinkRoccade Healthcare is familiar with the primary process of hospitals, and the hospital information system / electronic health record (HIS/EHR) from suppliers, which are most frequently used in Dutch hospitals.

1.1.2. Geniq department

This research will be conducted at the management information department Geniq of PinkRoccade. The Geniq department is delivering a business solution for integrated management information. The Geniq solution is currently used in more than 40 healthcare organisations (hospitals, mental health and care), where it meets their need for information. With this information the healthcare organisations are supported in making management decisions and in their pursuit of efficiency and quality. The different modules in the Geniq solution are displayed in figure 1.

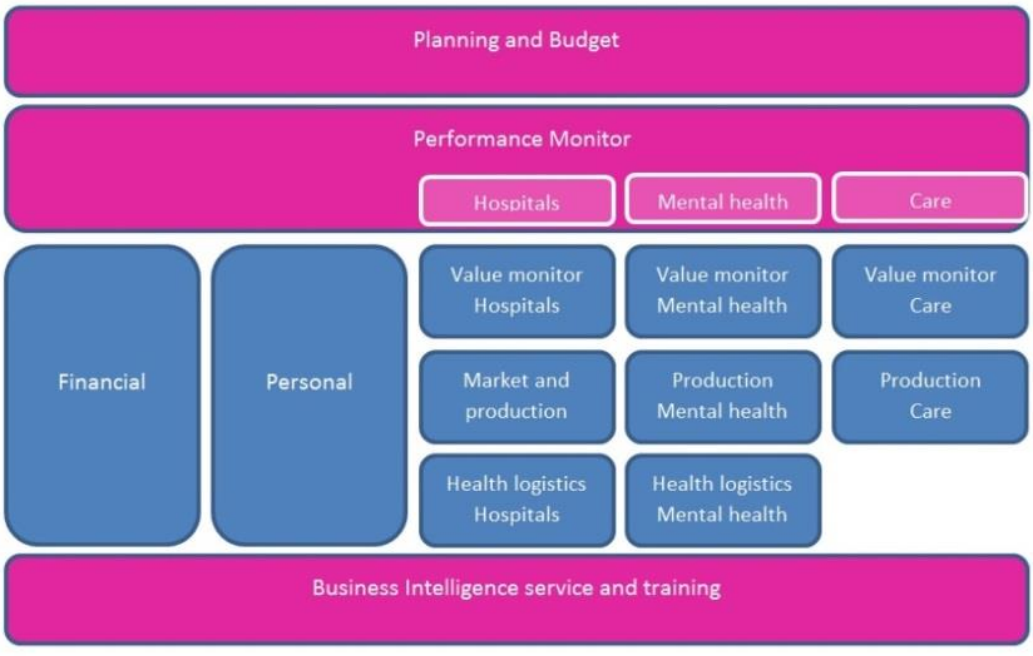

Figure 1: The different modules of the healthcare business solution Geniq.

1.2. Problem Statement

1.2.1 Problem description

The current procedure of hospital funding in The Netherlands caused that hospitals are often faced with high costs which are not reimbursed by the health insurers. With a result that already two hospitals were forced to file for bankruptcy. Research by the accountancy firm BDO showed that even 27 of the 76 other observed hospitals would have a negative operating result in the year 2012, if they were not compensated by the government that year [4].

The uncertainty about the hospital funding is caused by the complexity of the DTC system. Until January 2015 a DTC had a maximum completion time of 365 days and in case the treatment was not completed at that time a new DTC would be opened. The starting date of a DTC is the date the patient requests for care. The hospital will only receive a reimbursement from the health insurer when the DTC is completed. In theory it was possible that a DTC started on the 31st of December 2014 and would be claimed the 31st of December 2015. This means that at the earliest the 1st of January 2016 it is known what the exact production was over the year 2014. In order to get earlier insights in the cost of the provided care the maximum completion time of a DTC in 2015 is reduced from 365 days to 120 days. Using the previous example this means that according to the new rules on the 30th of April 2016 it should be known what the exact production was over the year 2015. This change in maximum completion time is illustrated in figure 2.

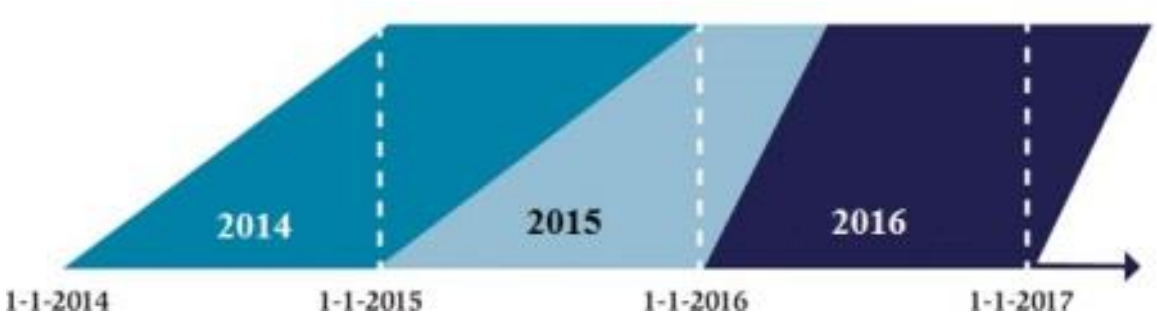

Figure 2: An illustration of the changes in the maximum completion time of DTCs from 365 days to 120 days.

In order to intervene in the production, information is needed on how the hospital is performing with respect to the agreed quantities during the year. Besides the production of 2014 the hospital also needs to know what the expected production of 2015 will be, as the agreements with the health insurers for 2016 are already made before November 2015.

The problem statement is as follows:

Dutch hospitals do not have sufficient information on the production of DTCs during the year. This makes it difficult to control the hospital funding and to make well-founded agreements with health insurers for the upcoming years. With the result that many hospitals may get into financial trouble.

1.2.2. Framework for planning and control

The framework of planning and control developed by Hans, van Houdenhoven, and Hulshof (2012) is useful to describe the scope of this research more clearly. This framework can be found in figure 2. The framework consists of four hierarchical levels of control and four managerial areas. The managerial areas are medical planning, resource planning, materials planning and financial planning. The contribution of this framework in contrast to other frameworks is that it encompasses all managerial areas, including medical planning and financial planning that are ignored by others. These areas should not be overlooked when healthcare processes are to be optimized [5]. The researchers mention information management as a fifth managerial area that should go hand in hand with the development of innovative organization-wide planning approaches. This research on the hospitals' production of DTCs is part of the managerial area of financial planning. Financial planning addresses how an organization should manage its costs and revenues to achieve its objectives under current and future organizational and economic circumstances. The hierarchical decomposition of the framework is split in a strategic, tactical and operational level of control. The operational level can be split up in the offline and online level. This research will be conducted on the strategic level as well as on the tactical level. The scope of this research is indicated in figure 3 by means of the bold borders.

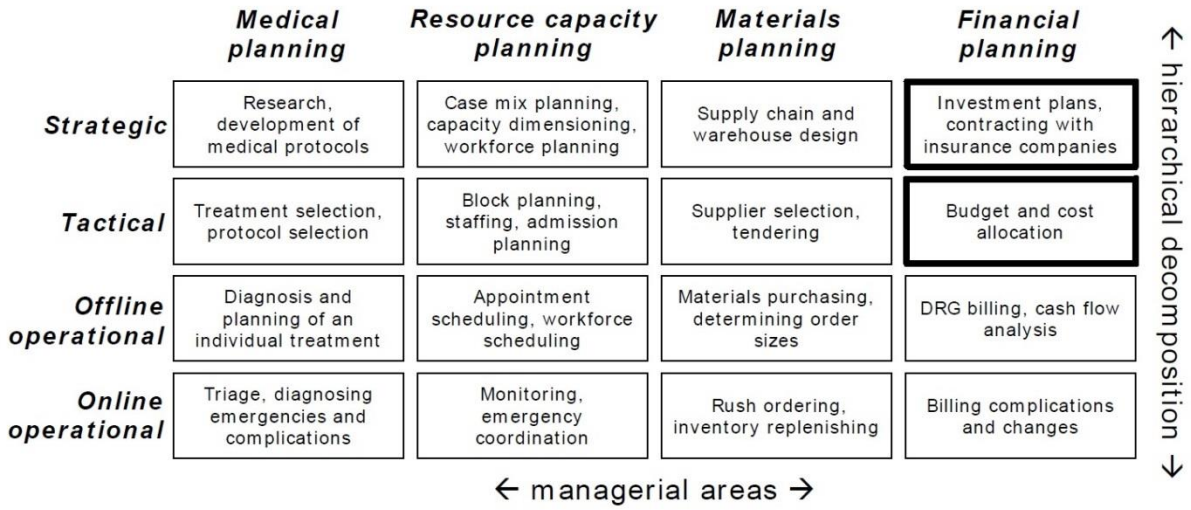

Figure 3: The Framework for Health Care Planning and Control by Hans et al. (2012) which indicates the scope of this research.

Strategic financial planning addresses structural decision making like, investments plans, and insurance contracts. These decisions are the fundaments of a hospital, it involves defining the hospital's strategy and direction. Strategic planning has a long planning horizon and is based on highly aggregated information and forecasts. In this research, the production of DTCs has to be forecasted in order to make agreements with health insurers for upcoming years. Strategy and direction of the hospital can change by these agreements. Tactical financial planning focusses on the healthcare delivery process. This level is located between the strategic and operational level. The decisions on this level are made on an intermediate planning horizon. The focus of this research is on the need for insight in hospitals' performance with respect to the agreed quantities of DTCs. In order to control the production of DTCs of the current year the decisions are located at this tactical level. The operational level involves the short-term decision making, which will not be addressed in this study.

1.3. Research objective and research questions

More information is needed on the production of DTCs to optimize the control on hospital funding of Dutch hospitals. Therefore, PinkRoccade Healthcare strives to deliver the necessary information to the hospitals by means of a BI solution. By providing information on the production of DTCs during the year, hospital managers are able to control the production of the required quantities, and hence prevent unexpected costs of departments by under- or overproduction. In order to optimize the contracting with health insurers a forecast of the production of the hospital is desirable, to have the necessary information for negotiation. The way to obtain the essential information will be displayed in the design of a BI application.

Based on the problem statement the research objective is as follows:

What is the potential of applying a BI application to Dutch hospitals in order to optimize strategic and tactical management decisions on hospital funding.

The aim of this research is to discover the potential of a BI application to optimize management decisions on hospital funding in Dutch hospitals. By using the BI application the hospital will be provided with essential information to respond adequately on developments in the production of DTCs. The proposed BI application includes analytic tools which will provide the information. This will help hospitals to control their funding and it will prevent hospitals to be confronted with financial losses. In order to reach the research objective, the following research questions will be answered:

1. **What kind of BI applications are present in scientific literature?**
   By means of a literature review information needs and established BI solutions can be identified.
2. **What are the information needs of the stakeholders?**
   A stakeholder analysis will be conducted. By means of the contacts of PinkRoccade Healthcare several spokesman of the relevant stakeholders will be interviewed on their thoughts about the need for information.
3. **How can the BI application be designed?**
   By using the results of the interviews, together with available scientific literature a BI application will be designed.
4. **How to provide in the stakeholders' information needs?**
   By explaining how the required data of the application can be obtained, the information needs will be provided. This includes analytical tools and descriptive models.
5. **Does the designed BI application deliver useful information?**
   PinkRoccade Healthcare will provide an anonymized hospital dataset that can be used to validate the proposed methods of the application. Data from one care-product-group within the hospital will be applied to the BI application to assess the performance.
6. **What should the policy be to implement the BI application?**
   Policy recommendations will be provided on the implementation of the BI application.

1.4 Outline

This thesis consists of eight chapters. After this introduction chapter, a background analysis on the subject will be provided. Subsequently, a literature study on business intelligence in healthcare, and management of hospital production is elaborated. The fourth chapter contains a stakeholder analysis from the conducted interviews. Followed up by the description of the design of the BI application. The sixth chapter, discusses the policy recommendations to be able to implement the BI application. The last chapter is the conclusion of this research, with a discussion and recommendations for future research. Finally, the reference material is presented and the appendices are attached.

2. Background analysis

For a better understanding of the complexity of the Dutch hospital funding and the decisions made for the Business Intelligence application, some background knowledge is required. First the history of the Dutch hospital funding will be discussed to understand the reforms made over the years. Secondly the Dutch DTC-system will be elaborated and compared to the international more common DRG-system. This will illustrate the uniqueness of the Dutch hospital funding system. Subsequently the Health Information Technology will be discussed to give insights on the possibilities of BI in healthcare and how the required data can be obtained.

2.1 History of the Dutch hospital funding

To narrow the scope of this subchapter only the recent healthcare system is considered. Background information on the history of the Dutch hospital funding from the beginning to the cash-on-the-nail system of 2001 is elaborated in Appendix A.

In the function-based budgeting model which was introduced in 1988 there was no direct relation between costs of treatments and the reimbursements. To create this direct relation, in 2000 the creation of a new system based on care-products was initiated: The so called Diagnostic Treatment Combinations (Diagnose Behandel Combinaties in Dutch). Since 2005 all Dutch hospitals are obliged to invoice claims using this system. The idea is that these care-products can be directly linked to the product prices, and hence these can be directly linked to the cost prices. In order to keep the system manageable one tariff is reimbursed for the complete DTC and not for all sub-products [6]. Only the fees of the specialists were negotiated individually. Since 2015 the fees of specialists are also included in the tariff of the DTCs. Therefore, hospitals will need to negotiate with the specialists about the level of their fees.

With the introduction of the Health Insurance Act (Zorgverzekeringswet) in January 2006 the distinction between mandatory sickness fund and voluntary private insurance became history. From this time on the Dutch government made it obligatory for all citizens of the Netherlands to have a health insurance. The insured is free to choose the health insurer of their choice and these health insurers are obliged to accept everyone who has chosen for their health insurance [7]. At the same time the regulated free market in the Dutch healthcare was introduced. The government had no longer direct control over the quantities and prices, but will set the regulation and will supervise whether the markets are working properly. This made the

patient, the health insurers, and the hospital the market players for hospital care. The three markets that occur between these market players are the health insurance market, the healthcare provision market, and the healthcare purchasing market [8]. These markets are displayed in figure 4.

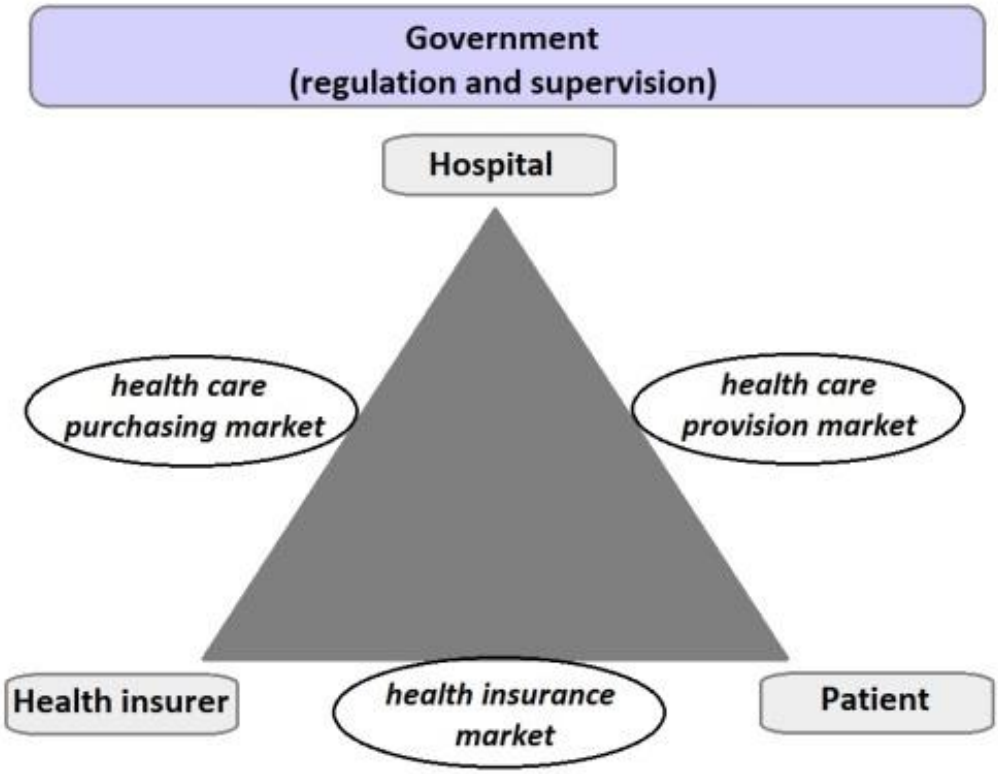

Figure 4: Markets and market players in the Dutch regulated free hospital care market.

For hospital funding two markets are important. In the healthcare purchasing market health insurers can negotiate with hospitals on price, volume and quality. Not all DTCs are covered by these agreements. Nowadays, the reimbursement and volume of approximately 70% of the DTCs are negotiable. Due to these negotiating capabilities the health insurers have an increasing influence on the production and income of hospitals [6]. In the healthcare provision market the hospital is delivering care to patients. The patients are free to choose any hospital for their care, but restrictions can be imposed by the type of health insurance. The total care delivered in terms of DTCs to the patients together with the prices negotiated for these DTCs make today's hospital funding. This can be displayed in the standard economic formula of total revenue TR = P x Q, where the price of a DTC is expressed in P and Q expresses the quantity of this DTC delivered to the patients. In a hospital multiple DTCs are delivered during a year, making the formula for hospital funding $TR = \sum P_i \text{ X } Q_i$. However, a maximum can be set on the quantity of DTCs or on the complete hospital funding.

A hospital will only receive the reimbursement from the health insurer when the DTC is completed. The correct DTC is derived automatically with the use of a so called grouper, a centralized computer programme. A hospital delivers data on the delivered care products to the grouper, which derives a declarable DTC and/or care products. The outcome is returned to the hospital with an electronic seal, or else it cannot be declared to the health insurer [9]. Till 2015 a DTC had a maximum completion time of 365 days and in case the treatment was not completed at that time a new DTC would be opened. Since January 2015 this maximum completion time is reduced to 120 days.

The hospitals did not have the financial means to finance the uncompleted DTCs by themselves. Therefore, the health insurers (partially) finance the uncompleted DTCs in advance. In the beginning of the DTC-system the financing in advance was based on the annual production agreements. When all of the DTCs were reimbursed for a year it could be calculated whether the hospital would have to refund a part of the received funding. With the introduction of the DOT-system (DTCs On their way to Transparency) in January 2012 the finance in advance is based on the work in progress (Onderhanden werk in Dutch). On a monthly basis the work in progress (WIP), in terms of care products of uncompleted DTCs, is send to a WIP-grouper [9]. This grouper will derive the value of the delivered care products, and the health insurers finance 80% of this value in advance. The main idea is that hospitals should refund less after all DTCs are completed for a year. However, this system disregards the agreements made on volume or budget. Which causes that hospitals are still being confronted with refunds.

2.2 The Diagnosis Treatment Combination

The Dutch DTC-system is a case-mix based system. Case-mix refers to a patient-type or a mix of patients treated in a hospital or healthcare unit. The first case-mix system was introduced in the 1970's, that system was created at the Yale University and implemented in collaboration with the company 3M. Since 1983 the US healthcare uses a case-mix system based on Diagnosis Related Groups (DRGs). DRGs are clinical meaningful groups of patients that have similar clinical characteristics and similar patterns of resource consumptions [10]. DRGs are nowadays widely used in Europe and many other countries in the world, like Australia and Taiwan. Although these countries use the same principles as in the US the DRGs differ in their characteristics and patterns of the country [11]. Also in the Netherlands a model based on DRGs was developed already in 1985 by Prof. Nederstigt. He created DRG profiles using data of the Dutch hospitals and by interviewing specialists. However, the Dutch

government decided to develop an alternative case-mix model instead of the proposed DRG-model of Nederstigt [2]. One of the reasons to reject the DRG-model was the fact it did not include treatment of outpatient patients, or the fees of medical specialists.

The developed DTC-system aimed to support the market competition between the hospitals in care delivery. In contrast, the DRG-system was introduced to control the rising healthcare expenditures. This market competition required a clear system of DTCs on which health insurers and hospitals could negotiate the price, volume, and quality of the delivered care. Moreover, the DTCs also should make it possible to benchmark the performance of hospitals and to provide a clear link between revenues and performance. In the DRG-system different types of hospital admissions or out-patient contacts are defined, but the DTC-system defines different types of diagnostic treatment combinations. This means that all hospital services during the complete process are included in only one DTC. While in the DRG-system normally one DRG is assigned per patient according to the most important procedure or diagnosis , in the DTC-system several DTCs can be opened per patient if several diagnoses require treatment. With the result that a DRG-based system consist of 600 to 2,000 individual DRGs, where the DTC-system in 2010 consisted of approximately 30,000 individual DTCs [11]. This large amount of individual DTCs caused the system to be in-transparent and sensitive to fraud. With the introduction of the DOT-system in January 2012 the number of DTCs reduced to 4,400 DTC-care products [9].

For clear registration of the performed care every DTC has a unique code that includes all information. From 2005 till 2012 the codes consisted of 14 digits, which contained information on the medical specialty, the type of care, the demand for care, the diagnosis and the treatment. Table 1, shows an example of a surgical DTC code. The medical specialty was specified in the first four digits (code 0301 to 1900). The type of care was specified in two digits indicating either regular care (code 11) or continuation of regular care (code 21). The demand for care, specified in two digits, was only used in a couple of medical specialities, namely plastic surgery, urology, gastroenterology and radiotherapy. This was only registered if the demand for care was expected to result in more than average care consumption. The diagnosis was specified in three digits and was based on the International Classification of Diseases 10th revision (ICD-10). It describes the diagnosis of the patient in medical terms. The treatment was also specified in three digits, it expresses the treatment setting and treatment nature. Lastly, the treatment setting was either outpatient, in day care or with clinical

episodes. The treatment nature varied per medical speciality and could be for instance open-surgery or endo-surgery [11].

Medical specialty	Type of care	Demand for care	Diagnosis	Treatment
0303 Surgery	11 Regular care	00 Inapplicable	113 Appendicitis	201 Open-surgery outpatient
	21 Continuation of regular care			202 Open-surgery in day care
				203 Open-surgery with clinical episodes
				204 Single-outpatient with procedure
				206 Inpatient without days Open-surgery with clinical episodes
				301 Endo-surgery outpatient
				302 Endo-surgery in day care
				303 Endo-surgery in day care with clinical episodes
				306 Inpatient without days Endo-surgery in day care

Table 1: Example of a classification coding of a surgical procedure.

With the introduction of the DOT-system in 2012 the registration of performed care changed significantly. The backbone of the DOT-system is the new DTC-product structure, which is displayed in figure 5. This is the way in which the diagnoses and treatments are organized and grouped into a manageable number of care-products. The DTC-care products replaced the old DTCs and aims to deliver better information, and a streamlined registration and declaration process by a more compact structure.

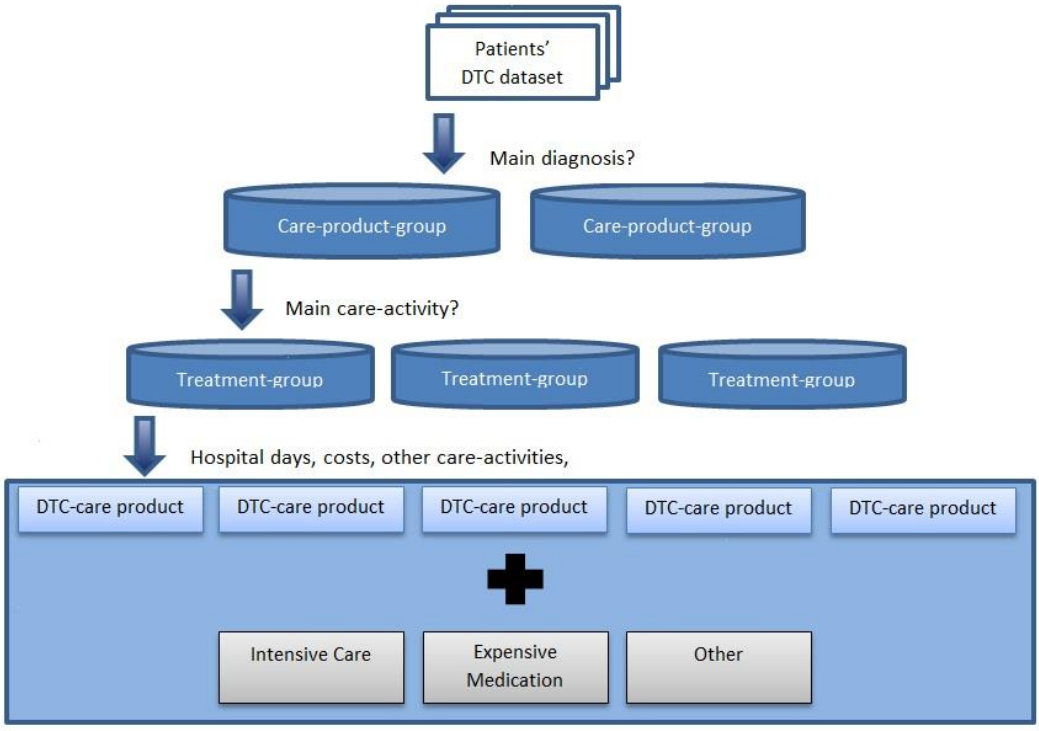

Figure 5: The DTC-product structure of the DOT-system

The DOT-system is characterised by optimal recognisability and manageability, not only within the logistics of the DTC process, but also for negotiations between health providers and health insurers. Based on these requirements and the globally used ICD-10 classification, 140 care-product-groups were formed, which include various treatment groups. The most common used DTCs were deduced to 4,400 DTC-care products. Because the DOT-system is based on the diagnoses, the product structure is uniform regardless of the specialism. And the DTCs became international exchangeable [12].

The codes in this system are made up of 9 digits of which the first six digits represent the care-product-group. The first two digits represent the 22 chapters of the ICD-10 classification. To continue with the former example concerning the diagnosis of appendicitis, see table 1, the corresponding chapter in the ICD-10 classification is chapter 11, which includes diseases of the digestive system. Not all of the ICD-10 chapters are adopted in the DOT-system. Chapter 16 and 20 are included in other chapters and chapter 22, which includes codes for special purposes is replaced by chapter 97 and 99, because these type of care is typical for the Netherlands or to further increase the recognisability. The next two digits represent the subchapters of the ICD-10 classification. In the example this should be subchapter 95. The last two digits represent the content of the subchapters. If the content is similar to the ICD-10 classification the code 01 is used and if the content differs the code 99 is used. In the example the content is not similar as it includes two subchapters, resulting in the care-product-group code 119599. To define the care products within the care-product-group a decision tree is developed. A decision tree is a range of successive choices that ultimately lead to only one DTC-care product. These choices are applied automatically via the grouper, which is elaborated in the previous chapter. The decision tree within the care-product-group diseases appendix/peritoneum is displayed in figure 6.

The first step in the decision tree is the distinction of the following care-products:

1. First is considered if it is an invasive product (surgery or intensive therapy). Further branches of this branch are often classified on the basis of the costs.
2. If not, it can be a conservative clinical product (without surgery). Further branches of this branch are classified on the basis of the number of hospital days.
3. If not, it can be an outpatient or day care product. Further branches of this branch are classified on the basis of specific activities.

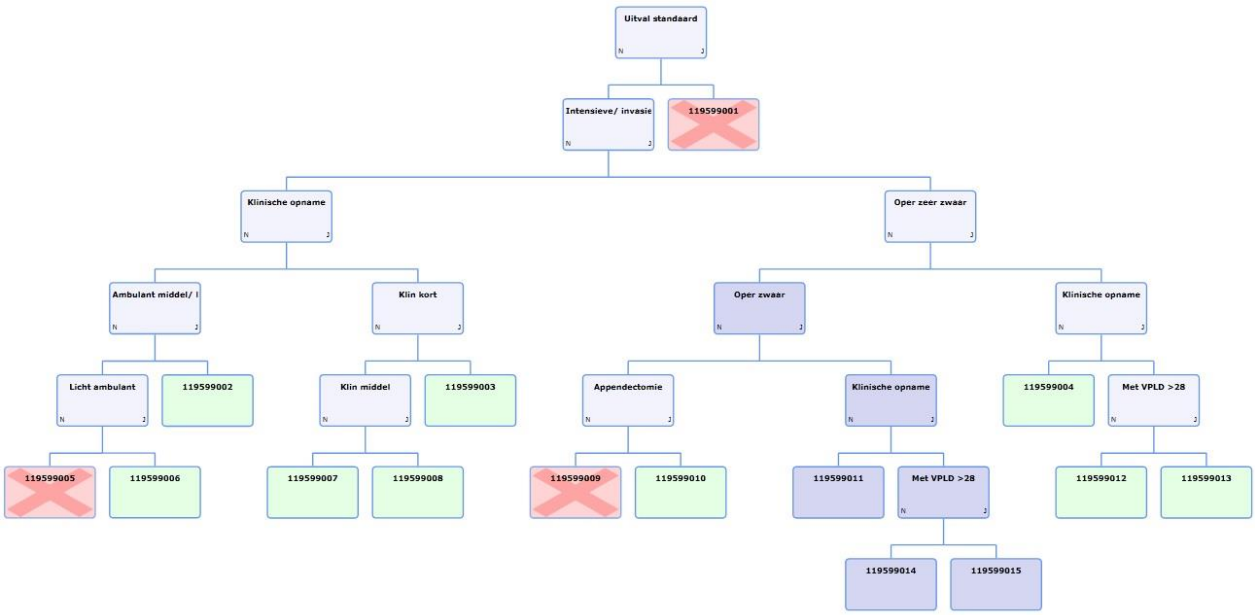

Figure 6: The decision tree within the care-product-group 119599.

If everything goes according to plan, the decision tree leads to the correct DTC-care product. The possible correct registered DTC-care products are displayed in green. A limited number of relatively expensive care products, especially the intensive care and expensive medication, is kept out of the DTC-care product and will be declared separately by the hospitals. These products are called add-ons. If the decision tree leads to one of the DTC-care products that are displayed in red, it is called a product failure. This product failure cannot be declared, because of incorrect or incomplete registration of the delivered care. Once this is resolved the decision tree can be applied again. To reduce structural failure of the grouper, adequate recording at the source is required [12].

In designing the DTC-system as well as the DOT-system, multiple parties of the medical societies were involved. Some of these parties have a prominent role in regulation and maintenance of the current DOT-system. The Dutch Healthcare Authority is the supervisor of the healthcare and checks whether the health providers and health insurers comply to the laws and regulations. It also advices the Ministry of Health and sets the tariffs for the DTC-care products that are excluded from negotiable reimbursement. The maintenance of the DOT-system is performed by the independent organization DBC Onderhoud. This organization is responsible for creating new DTC-care products and for converting the DTC-system to the DOT-system. They also created the grouper that enables automatic deduction of DTC-care products. Another task is to inform the users of DTCs and to answer their questions.

2.3 Health Information Technology

Health Information Technology (HIT) is the use of IT in the domain of healthcare. It consists of management of health information across different information systems and it enables exchange of this information between care providers, health insurers, government and patients. HIT involves both computer hardware and software to store, retrieve, share and use the health information for communication and decision making. According to Chaudhry et al. (2006) HIT has the ability to improve the quality of healthcare, prevent medical errors, increase administrative efficiencies, reduce healthcare costs, and maintain affordable healthcare [13]. There are several HIT applications being used in the Dutch healthcare which have high potential.

One of the HIT applications which covers all the activities performed in the process of providing the care for patients in all departments of a hospital is the Hospital Information System (HIS) [14]. A HIS is an electronic information system which mainly focuses on the administrative needs of the hospital. The exact possibilities of the HIS depend on the software supplier, but it should include at least the management of administrative patient information (name, date of birth, place of birth, address, contact information, general practitioner, health insurer, etc.), support of the health care logistics (recording data, with whom the patient came in contact, at what location, for how long, and the responsible specialist), and support of the reimbursement process [15]. Currently, five HIS suppliers are active in the Dutch healthcare market. The market leader is Chipsoft, followed by CSC-ISOFT, quCare, Siemens and Epic [16].

In a hospital up to 200 different information systems can be in use. A HIS manages the information flows between these information systems and allows the health provider to work efficiently. A representation of the main information systems that are connected to the HIS is displayed in figure 7. From this figure, you may conclude that a HIS is an integrated information system which improves the activities of the hospital by increasing the user's knowledge. A HIS provides information to specialists, nurses, patient management, administration and staff. It provides the required information in a usable format to the user to make accurate and timely decisions. It can be imagined that when patient information is for instance only available in the Laboratory Information System it does not meet the definition of increasing the user's knowledge since there is no timely access to the information, therefor spread of information is necessary [17]. Each of the information systems that is integrated in the HIS is designed to control the performance of a specific business process. The gathered

data is stored per information system in a database, such as administrative data of X-rays in the Radiology Information System (RIS).

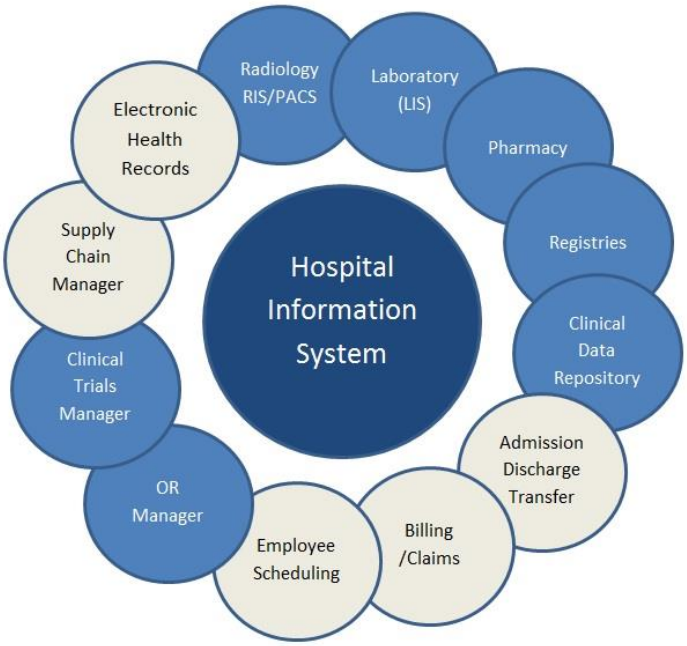

Figure 7: A representation of information systems that are included in a HIS, where the colours represent different functions in the hospital.

The Electronic Health Record (EHR) is an information system within the HIT and it replaces the hospital's medical record and integrates clinical information of the patient from pharmacy, radiology and laboratory systems. The clinicians have direct access to the EHR of patients and are able to add clinical data [18]. Some suppliers include the EHR in their HIS, but often the EHR is a separate system and only relevant information for administrative and finance processes are derived from the EHR into the HIS [19]. This data is necessary for the DTC-grouper to determine the correct DTC, which enables to claim the DTC at the health insurer. The EHR systems can be in use in individual healthcare organisations, in inter-operational healthcare organizations, on a regional level, or even nationwide [20]. Although, in the Netherlands there is no nationwide use due to possible risks by the lack of national standards for information exchange and breach of privacy.

Two other HIT applications in hospitals are the clinical decision support system (CDSS) and the computerized provider order entry (CPOE). A CDSS is a computer system that is designed to support the clinicians in decision making about individual patients. It includes automated alerts and reminders for the health providers and patients, clinical guidelines, diagnosis support, and relevant reference information. Generally the data of the EHR systems is used for the evidence-based decision making [21]. Together with the CDSS, the CPOE systems are

seen as key technology for reducing medical errors. A CPOE allows health providers to enter medical orders electronically, instead of using paper, telephone or fax. Types of medical orders are medication, procedure, laboratory, radiology or admission orders. This electronic input increases patient safety by reducing communication errors. And if the CPOE system is connected to a CDSS the order can be checked for inconsistencies like drug-drug interactions, allergies or dosage [22].

One of the HIT application outside the hospital is the DTC Information System (DIS) by DBC-Onderhoud. This nationwide system receives and manages information of all DTCs. It contains data from the basic registration system on the care that is delivered and has been declared by the health providers. The health providers are required by law to supply the anonymous data on a monthly basis. All the data that is submitted to the DIS is checked for errors before being added to the database of DIS. To ensure correct registration, the health provider will be notified when an error is detected. Every quarter of a year the DIS supplies a production-volume report to the individual health providers, which include the production of completed DTCs. This production can be plotted against time, specialism or DTC. Besides the individual reports the DIS also delivers sector- and global reports. The DIS aims to make the medical practice and financing more transparent. It monitors market developments and when necessary DTCs can be adjusted [12].

Although most HIT applications are focused on administrative and financial transactions and are already in use since the 1960s, the adoption of IT in healthcare lags behind compared to other industries by 10 to 15 years [23]. One of these applications that is widely used in industry, but still fairly new in healthcare, is BI. Since the 1970s decision support systems were designed to support decision making. Various decision support systems like executive information systems, management information systems, online analytical processing, and predictive analytics emerged over the years. In the 1990s Howard Dressner, introduced the term “Business Intelligence” to describe all of the analytical applications of these systems [24, 25]. Negash (2004) defines BI as the combination of data gathering, data storage and knowledge management with analytical tools to present complex and competitive information to planners and decision makers [24].

This definition implies that BI provides actionable information delivered at the right time, at the right location, and in the right form in order to make timely and fact-based decisions [3]. BI can refer to on-line decision making, this means that the information is instantly delivered

when requested. But most of the time BI narrows the timeframe of delivering the information, so the information is still useful at the moment the decision maker will have to make the decision. In both cases BI can be seen as a tool to make proactive instead of reactive decisions on strategic and tactical level. It converts the gathered data into useful information and, through human analysis, into knowledge [24]. One of the tasks performed by BI that is particularly interesting for this research is the ability of creating forecasts based on historical data, past and current performance and by estimating the direction of the future.

The BI process consists of two primary activities, getting data in and getting data out, which is illustrated in figure 8. Gathering raw data for BI is also known as data warehousing, this involves moving data from multiple source systems into an integrated data warehouse [25]. The sources can be available within the organization (for hospitals the information systems as displayed in figure 7), be supplied by an external data provider (like the DIS by DBC-Onderhoud) or made available by a business partner (for example another hospital). The data of these sources can be structured or semi-structured. Structured data will be available from sources that consists of databases, for example a CDSS. But most of the available data will be semi-structured data, data that does not fit neatly into relational or flat files. Examples of semi-structured data are spreadsheet files, reports, memos, and e-mails [24]. During the data warehousing process the gathered data will be transformed so that it is meaningful for decision support. For example records from several systems are matched. But also new fields can be created during data transformation, such as time periods of activities or totals [25].

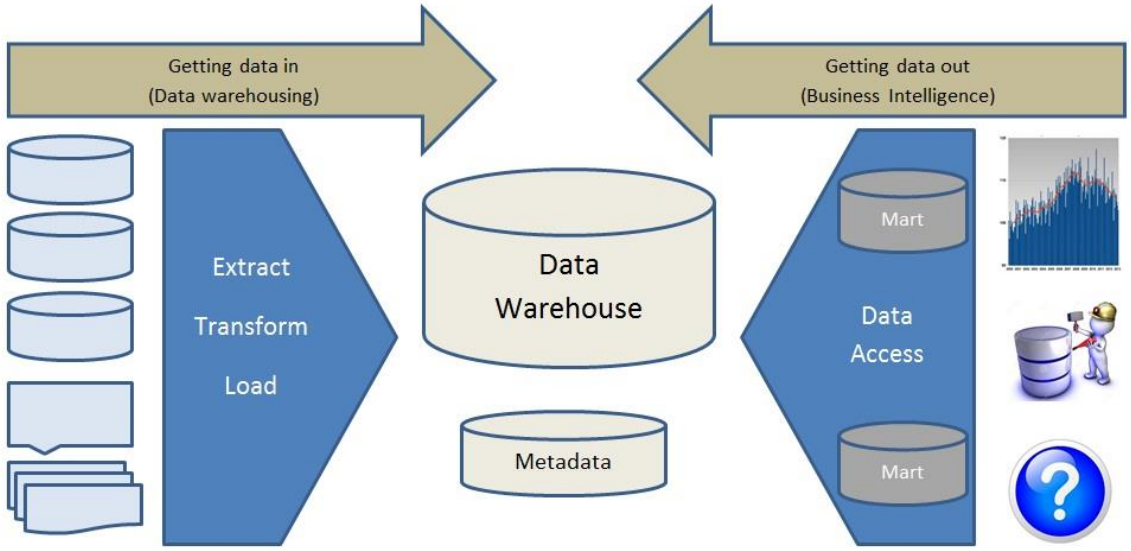

Figure 8: The Business Intelligence framework with the two primary activities.

In some cases the data warehouse consists of several dependant data marts, which have a more narrow scope than the data warehouse. These data marts only focus on a specific functional area, application or organizational division. The metadata is very important in the data warehouse as it describes the field values, sizes, ranges, field definitions, data owners, latency and transformation processes. Particularly with multiple sources the data warehouse technicians and end users must understand the characteristics of the manipulated data to use it effectively. By combining the available decision support data of the possible sources in a data warehouse or data mart it is ensured that only a single version of truth will occur [25].

Gathering data has only limited value for an organization, only when users or applications access the gathered data and use it to make decisions it will realize value for the organization. Hence turning this data into information is most important for organizations. Generally only this activity is called BI. The BI applications access data from the data warehouse to perform enterprise reporting, on-line analytical processing, querying, and predictive analysis. In many departments of hospitals BI can deliver an assortment of unique reporting and analysis applications [3]. Some of the business benefits for hospitals mentioned by Mach and Salem (2010) are:

- The ability to optimize resources (like operating rooms, equipment and devices, staff and supplies) in all individual departments of the hospital.
- The ability to develop and monitor key performance indicators and clinical indicators to improve performance and quality.
- The ability to effectively understand and manage the supply chain and logistics to maintain costs and ensure consistent supply.
- The ability to increase patient safety through efficient diagnostics and the identification of best practice treatment protocols.
- The ability to maintain costs and improve performance and quality through human resources management and physician profiling.
- The ability to conduct planning, budgeting, and forecasting more efficiently and accurately within the hospital.

This chapter provided a background analysis on the research topic. It provided an overview of the history of the Dutch hospital funding. Also the DTC system being used in healthcare in the Netherlands was explained. Further, the Hospital Information Technology and Business Intelligence was discussed. The next chapter will elaborate on the literature study.

3. Literature study

A literature study is performed in order to create a theoretical framework on the current research on BI in healthcare, and the management of hospital production. For the literature review the databases PubMed, Web of Science, and Scopus have been used. This has resulted in 14 useful articles.

A well based literature review is an important foundation of every scientific research. In order to ensure the review is reproducible it must be clear how and why the specific samples of the literature have been obtained. However, this does not mean that all existing literature on the subject has been found. This is not necessary a problem, as long as the obtained literature will be representative for the review [26]. To carry out this review the systematic and rigorous approach offered by Wolfswinkel et al. (2013) has been used, which is based on Grounded Theory and is iterative in nature. The Grounded Theory is designed by Glaser and Strauss in 1967 and is useful to generate a thorough and theoretically relevant analysis of the topic. The five-stage approach of Wolfswinkel et al. (2013) is labelled as the Grounded Theory Literature Review Method and is displayed in table 2.

The first four stages are elaborated in the methodology chapter of this study. In the first stage the most suitable data set is roughly identified in four steps. In the second stage there is a search for literature by the boundaries set in first stage. In the third stage the obtained articles are reviewed and refined. Hence, the fourth stage shows how qualitative research methods extract the value from the selected studies [27]. The fifth stage is elaborated in the results chapter of this study, and shows the findings and insights obtained by the literature review.

Number	Task
1. Define	
1.1	Define the criteria for inclusion/exclusion
1.2	Identify the fields of research
1.3	Determine the appropriate sources
1.4	Decide on the specific search terms
2. Search	
2.1	Search
3. Select	
3.1	Refine the sample
4. Analyse	
4.1	Open coding
4.2	Axial coding
4.3	Selective coding
5. Present	
5.1	Represent and structure the content
5.2	Structure the article

Table 2: The Grounded Theory Literature Review Method by Wolfswinkel et al. (2013)

3.1 Methodology of the literature study

As mentioned in the introduction of this chapter, the methodology of the literature study consists of four stages which are elaborated step by step. This section shows which decisions were made during the literature review. By reproducing these steps, the same results should be obtained.

3.1.1 Define

The first step is defining the criteria for inclusion and exclusion. The aim of this thesis is to design a BI application for optimizing management decisions regarding the production of DTCs in Dutch hospitals. A literature review on BI applications for management decisions regarding hospital production, would make the scope too narrow. To give the literature study a broader scope it is divided in two parts, resulting in two different searches.

Business intelligence is a relatively new concept in the research field of hospitals. Therefore the first of the two parts of the review has to provide a clear view on the current research of BI in hospitals. The focus will be on management decision making and not on clinical decision making, as this is not a medical research. Furthermore, to not overlook important articles the research domain is extended to healthcare.

The second part of the review will have to give an overview of the useful articles on management of hospital production. In this search the research domain is also extended to healthcare, as the management of care production is not only an issue for hospitals. The hospitals' care production is part of the managerial area of financial planning, so it is useful to extend the search with this term.

For the literature review databases PubMed, Web of Science, and Scopus were used. These are the most frequently used databases in the field of healthcare and management. PubMed is the most used and important bibliography for medicine and its peripheral areas, like nursing and healthcare. Web of Science is a bibliography that strives to provide the most reliable, integrated multidisciplinary literature. And Scopus is the largest abstract and citation database of peer-reviewed literature.

The inclusion criteria for each of the databases is the language of the literature found, that had to be in English. For PubMed, the abstract must be available. For Web of Science, and Scopus only documents of the types article, review, or book (chapter) were included in the search results. Conference papers and reviews were excluded because these sources lack background information and tend to be subjective.

The decision on the specific search terms of the first part of the review was clear to formulate. The current research of business intelligence in healthcare and hospitals is found with the search query:

"business intelligence" AND (hospital OR healthcare)

For the second part of the review the specific search terms were more broadly defined to prevent the exclusion of relevant literature. The field of hospital or healthcare is the same as in the first part of the review. The financial planning can also be expressed as budget planning. But besides planning also control and management are search terms that can obtain valuable literature. Financial management was excluded as search term as this made the review too broad. Useful literature was found by using the search query:

(hospital OR healthcare) AND ("financial planning" OR "budget planning" OR "production planning" OR "budget management" OR "production management" OR "financial control" OR "budget control" OR "production control")

3.1.2 Search

In the search stage of The Grounded Theory Literature Review Method an actual search is conducted in the identified databases. The results of this search are displayed in figure 9.

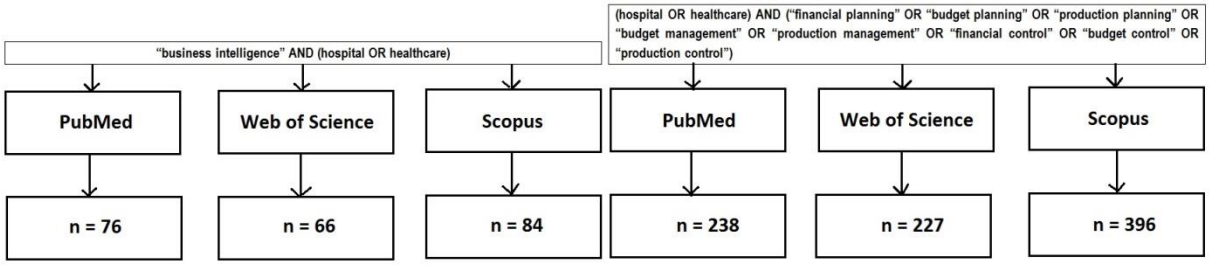

Figure 9: The results of the search after the define stage.

In this stage there is the possibility to redefine search queries and related criteria, as new seemingly suitable terms may arise during the actual search. Even though not much literature was found on business intelligence in healthcare or hospitals, the search query has not been relaxed Because this is a relatively new research field, and the obtained articles will provide a clear view on the current state of BI research in hospitals and healthcare.

The search query for useful articles on management decisions regarding hospital production was already extensive and thorough. Relaxing the search query would have made the literature search less transparent and less on topic.

3.1.3 Select

In this stage the sample of literature was actually selected. The selecting method is displayed in figure 10. The selecting stage of this review differs slightly from Wolfswinkel et al. (2013). Wolfswinkel et al. start with filtering out the doubles, while in this review the doubles were filtered out at the end of the selecting stage. By filtering out doubles at the end, time was saved at the beginning and possible useful literature had more chance to be selected.

The input for the selecting stage is the literature obtained in the search stage. The irrelevant literature is removed from the sample of literature on the basis of not fitting the criteria. This is done in three steps, first the sample is refined based on the title of the literature. Subsequently, the sample is refined based on the abstract and eventually refined based on the full text of the literature. In order to further enrich the sample of literature, forward and backward citations have been checked. The selecting stage was repeated for all three databases.

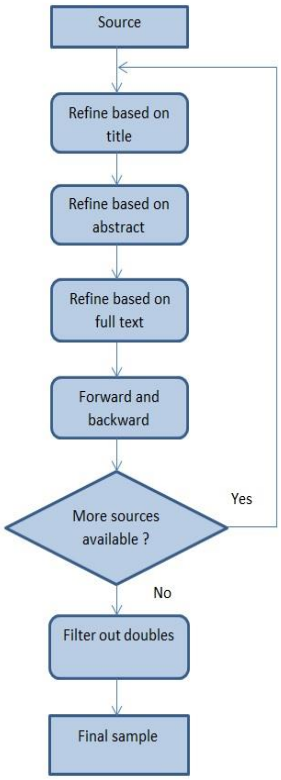

Figure 10: Select stage of reviewing

During the step of refining the sample based on the full text, it is necessary to have licences of the publishers to get full access to the text. Six articles were removed from the samples because there was no licence of the publisher. Also articles without correct citations were removed from the sample. Forward citations yielded the term performance management. This was not included in the literature study, as it made the scope too broad. However, performance management is used in upcoming chapters. An overview of the literature selecting stages can be found in figure 11. The final samples of articles are displayed in table 3 and table 4.

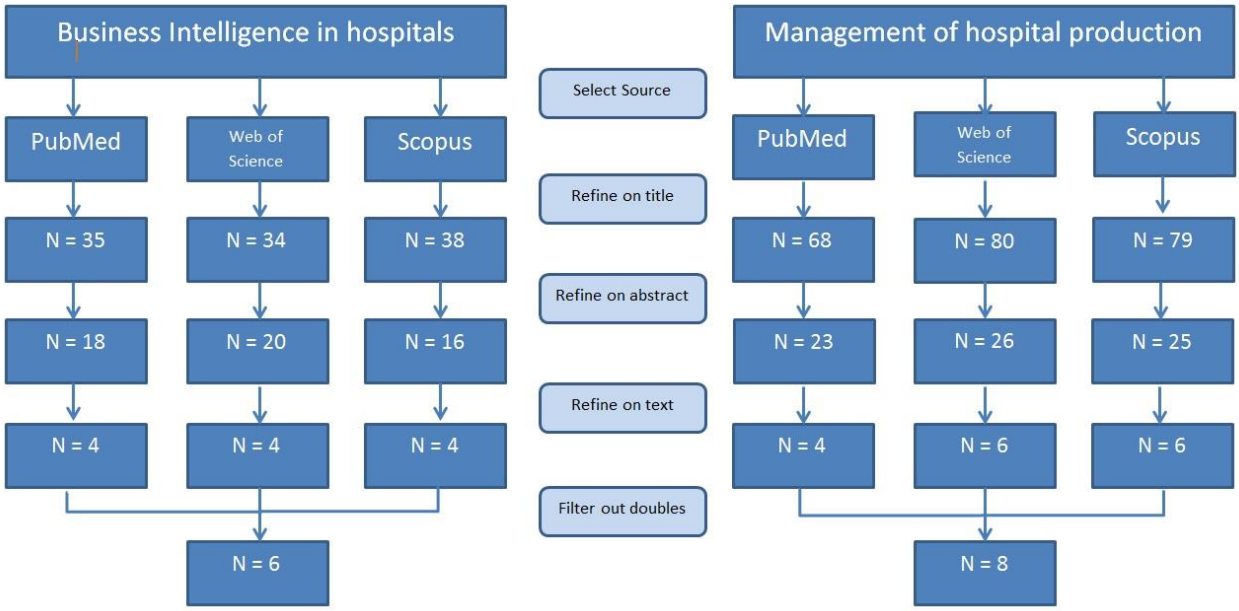

Figure 11: An overview of the literature search.

3.1.4 Analyse

The purpose of this stage was to analyse the selected articles and to structure them to obtain valuable categories. The first step was to read the selected articles randomly and highlight every word, sentence, or paragraph that seemed relevant for the review. Based on these excerpts the step of open coding took place. By re-reading all of the excerpts some concepts started to appear in mind. These concepts capture parts of the excerpted data and are ideally mutually exclusive or well defined [27]. By conceptualizing and articulating, the hidden aspects of a set of excerpts appeared. The ultimate goal of open coding is to identify a set of categories, with a set of theoretical and methodological insights attached [27]. Per article up to 15 categories were found. In the step of axial coding the interrelations between categories and their sub-categories were identified. These higher-order categories represent the main themes of this studies' findings in the data. The last step of this stage was selective coding. The categories found were integrated and refined, so the main categories emerged. Selective coding is the process of identifying and developing relations between the main categories. The findings of the analytical coding steps are displayed in table 3 and table 4.

Author	Title	Publication Year	Need for BI	Possibilities	Differences to industry	Quality of data issue	Cost of BI Issue	Privacy Issue	Acceptance Issue
Ashrafi N, Kelleher L, Kuilboer JP	The Impact of Business Intelligence on Healthcare Delivery in the USA	2014	X	X	X	X	X	X	X
Cook TS, Nagy P	Business Intelligence for the Radiologist: Making Your Data Work for You	2014			X				X
Ferranti JM, Et al.	Bridging the gap: leveraging business intelligence tools in support of patient safety and financial effectiveness	2010	X			X	X		X
Foshay N, Kuziemsky C	Towards an implementation framework for business intelligence in healthcare	2014	X			X	X		X
Karami M, Et al.	Enhance Hospital Performance from Intellectual Capital to Business Intelligence	2013	X	X					
Mettler T, Vimarlund V	Understanding business intelligence in the context of healthcare	2009	X	X	X			X	X

Table 3: Findings of the selecting and analyse stage of Business Intelligence in healthcare.

Author	Title	Publication year	Manufacturing production	Business units	Strategic management	Tactical management	Forecasting	Role Specialists	Political reasons	Control Functions
Datz D, Et al.	Strategic Workforce Planning for a Multihospital, Integrated Delivery System	2012			X	X	X			X
De Vries G, Bertrand J, Vissers J	Design requirements for health care production control systems	1999	X	X	X	X		X		
Ensor T, Amannyazova B	Use of business planning methods to monitor global health budgets in Turkmenistan	2000		X	X		X		X	
Jacobs VR, Fischer T	A Pragmatic Guide on How Physicians Can Take Over Financial Control of Their Clinical Practice	2012			X	X		X		
Pasupathy KS	Forecasting model for strategic and operations planning of a non-profit health care organization	2010	X		X		X			
Tai G, Williams P	Quantitative analysis of investment allocation over various resources of health care systems by using views of product lines	2013		X	X	X				X
Vissers JM, Bertrand J, De Vries G	A framework for production control in health care organizations	2001	X	X	X	X	X			X
Vrangbæk K, Bech M	County level responses to the introduction of DRG rates for “extended choice” hospital patients in Denmark	2004			X	X			X	X

Table 4: Findings of the selecting and analyse stage of the management of hospital production.

3.2 Results of study

This chapter provides an overview of the currently available literature related to BI applications for management decisions regarding hospital production. The first section provides an overview of the literature on BI in healthcare. The second section provides an overview of the literature on the management of hospital production. This chapter end by summarizing the contributions of this study. This chapter covers the fifth stage of The Grounded Theory Literature Review Method of Wolfswinkel et al. (2013), which aims to present and structure the results of the literature review.

3.2.1 Business Intelligence in healthcare

Already in 2009 Mettler and Vimarlund mention that the use of BI in healthcare is becoming increasingly relevant and there is a managers' need for real time information to improve healthcare performances [28]. In 2014 a third of the healthcare organizations in the USA is not using BI tools, half of the organizations uses a single BI tool and one sixth of the organizations uses multiple BI tools. Although, there are currently less than 100 articles available on this topic [29].

This might be explained by the fact that BI is more commonly used in other industries than healthcare, however the same objectives can be met. Like in other industries, BI in healthcare focuses on revenue, expenses, utilization, and quality. For instance demand forecasts and treatment successes can be derived by analysing historical data. But in contrast to other industries, the obtained information in healthcare influences a range of stakeholders such as specialists, patients, government, insurance companies, hospital administrators, and more. Together with the large amount of different processes and patient groups, this makes the use of BI in healthcare more complex than other industries [28-30].

A precondition for effective use of BI is the quality of the data. Where in other industries the information technology is already well developed, the use of healthcare information technology is still in an early stage. Although the amount of data generated by and for healthcare organizations is overwhelming, the useful data for improving care or operations can often not be accessed without time-consuming processes [31]. Especially the quality of the operational data is a key success factor for BI in healthcare. However, according to Foshay and Kuziemsky (2014) it is no exception that much of this important patient information is only available on paper[32]. As it is essential to improve the quality of the data before processing it by BI tools investments have to be made. Despite there are good reasons

to believe this investment will lead to savings and efficiency, especially the smaller organizations are restrained by the high initial costs of adopting new technologies[29, 31].

Privacy and security are also concerns with BI in healthcare, as sensitive data about patients is collected and analysed. Although there are laws to protect patients' personal health information, it does not take away the fear related to the electronical storage of healthcare data. To give the patients the confidence that their health data is protected and to defend this data against security leakage, solutions will have to be developed. The better these solutions the more chance the healthcare management will be eager to incorporate BI [28, 29].

According to Ashrafi (2014) et al. another reason for the small amount of research on BI in healthcare is the user acceptance across the organization. Poor use can result in errors that threatens patient safety, cause loss of productivity and cause failure to realize the quality and efficiency benefits [29]. For proper use collaboration within an organization is necessary. Establishing clear and defined ideas about the information needed is the basis for trust in the technology [29, 31]. Without trust in the organization and the outcomes of the technology there will be little user acceptance [31]. Therefore, strong support and leadership from the top management is a key success factor for implementing BI in healthcare [32]. Furthermore, the end users must also be capable to interpret the supplied information and determine what is relevant to avoid mistakes[29]. Cook and Nagy (2014) even plead for education on BI in healthcare in the study programs for radiologists, as it has become a part of the department management [30].

In spite of the aforementioned issues which explain the low implementation rates, the articles agree on the need for BI in healthcare. BI has the ability to improve healthcare quality, safety and efficiency [28-33]. According to Karami et al. (2013) many healthcare organizations have a lot of unused strategic information in their information systems. When this information is meaningfully displayed, managers will have a real time view of the company performance against the strategic objectives. This application can for instance be used to focus on scarce resources [28, 33]. Ferranti et al. (2010) claim this will lead to more efficiency and as the patient population grows and budgets are constrained, such efficiency will be crucial to the success of healthcare organizations [31]. BI in healthcare will also eliminate information asymmetry and makes hospitals well informed to respond to environmental changes and identifying new market opportunities [33]. It enables the organization to understand past events and make predictions about the future, and it creates insights for decision making [29].

Ashrafi et al. (2014) mention the top five BI applications sought by healthcare organizations. These are the following: (1) enterprise analytics, (2) predictive analytics, (3) accountable care organization analytics, (4) healthcare data integration/ data warehousing, and (5) population health [29]. It can be concluded that there is a higher need for management decision support than clinical decision support. Mettler and Vimarlund (2009) sum up some potential healthcare analytical applications, which are all included in the extensive framework of Karami et al. (2013). This framework is displayed in table 5 and shows the possible useful tools per BI application in the healthcare domains [33].

Domain	Application	Data Warehouse	Analytical Tools	Dashboard
Operational	decision support	√	√	√
	strategic modeling	√	√	
	marketing	√	√	√
	workflow management	√		√
	disease modeling	√	√	
	agility	√	√	√
Financial	revenue cycle enhancement	√	√	√
	cost management	√	√	√
	collections	√	√	
	claims adjudication	√	√	√
Quality	patient satisfaction	√	√	√
	customer relationship management	√	√	
	quality metrics performance	√	√	√
Public Health	disease management	√		√
	population health management,	√	√	√
	bioterrorism readiness and response	√	√	
	epidemiological surveillance	√	√	√

Table 5: The possible tools per BI applications in the healthcare domains by Karami et al. (2013).

According to Karami et al. (2013) there are more possibilities to apply BI in healthcare, these can be derived from the applications mentioned in the framework. The framework is divided into three BI tools. First, data warehouse could for instance lead to better disease management. Second, analytic tools like data mining or text mining could be used for marketing purposes, as predictive analytics can help by strategic modelling. Third, dashboards could for instance give insights in patient flows [33].

3.2.2 The management of hospital production

The designed BI application will have to control the hospital production. In the two articles of De Vries, Bertrand and Vissers (1999, 2001), the hospital production is compared to manufacturing production [34, 35]. They agree on the fact that the hospitals are faced with growing demands, but also with tighter budgets and constraints on the availability of resources. Examples of these resources are capacity, materials or services. Therefore, hospitals will have to improve their performance. In hospital setting, this performance could for instance be expressed as the amount of patients that are treated within budget boundaries [34, 36]. In accordance with the findings on BI in healthcare, De Vries et al. (1999) acknowledge that a hospital is not a manufacturing organization. A major difference in respect to manufacturing organizations is that a hospital is a service organization. Therefore, production management in healthcare could be defined as the design, planning, implementation, and control of coordination mechanisms between patient flows, and diagnostic and therapeutic activities to maximize output with the available resources [34].

De Vries et al. (1999) see a hospital as a durable virtual organization, a network of organizations with distributed ownership who work together on the same market. From the outside a hospital looks like one organization, but in fact it consists of many autonomous organizations within one building [34]. According to Tai and Williams (2013) it is even essential to see a hospital in perspective of product lines, for the maximum use of the available resources. They state there is little agreement on the exact definition of the production of hospitals. In their view it is defined as the specific goods and services provided to the patients. This makes the hospital a multiproduct firm in which each product consists of multiple goods and services. In potential this leads to a range of product lines as large as the number of unique patients. However, to manage a healthcare organization from a product line perspective it is necessary to standardize the patient treatment processes in such a way that it excludes individual patients. This enables effective capacity planning and management for healthcare at a macro level [36]. Vissers et al. (2001) extend this by stating that the unclear definition of products and processes in hospitals, in combination with the high variability between specialist practices does not facilitate the standardized production control approaches [35]. In order to manage production in healthcare, clear product ranges have to be identified and defined per business unit. In the Netherlands this is achieved with the introduction of the DTC system. If different market strategies exist within these product ranges, a separate control system should be designed for each product-market combination.

The management decisions regarding the hospital production take place roughly on strategic and tactical level. According to Vissers et al. (2001) strategic planning decisions concern the direction in which a hospital is heading the next couple of years and on this level the company policies and strategic targets are set. Decisions are taken concerning the product range, the target mix and volumes of patients for the hospital. For a good planning of the number of patients within a DTC, the historical data regarding the number of patients per DTC and patient volumes agreed upon with the health insurances are needed as input data [35]. The coordination of the production over the business units must be executed at the hospital level and is also part of the strategic decisions making process [34, 35].

According to Pasupathy (2010) forecasts play an important role in supporting an organization to make strategic decisions. By means of these forecasts adjustments can be made to the allocation of resources to any anticipated change in the environment. The article demonstrates a method to forecast the revenue variables for effective budget planning purposes in healthcare. Financial forecasts are useful for healthcare organizations to predict how the future finances will pay out, so that resources can be effectively allocated. For these forecasts at least two years, and ideally six years of historical data should be used[37]. Also seasonal factors can be taken into account in the forecast when the allocation of the resource is within a year[35, 37]. A forecast accuracy of 85% or more is seen as useful for management decisions.

Hospital management is also responsible for realization of the agreed volumes. This structural coordination is part of the tactical level of decision making. It can be controlled by checking the progress on the number of patients treated during the year and to anticipate if the number of patients treated differs from the volume planned at the strategic level [35]. This performance check can be executed at the operational level, but the quality of the operational control will determine the impact on the performance that is realized. Vissers et al. (2001) use figure 12 to illustrate the problem with the quality of the operational control.

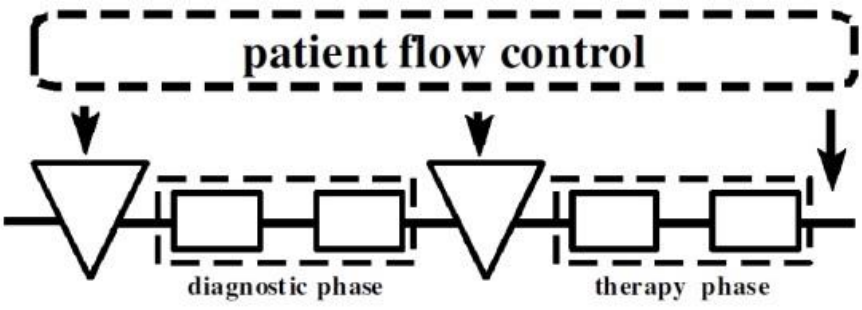

Figure 12: Patient flow control on operational level

When patients enter a hospital there is limited knowledge on the urgency and specific diagnosis. Because there is much uncertainty regarding the demand in this diagnostic phase, there should be much flexibility in assigning a patient to a resource. Once the specific diagnosis is set, the therapy phase will start. Normally a patient will have to wait some time before being treated. The demand in this phase will be more certain. Because a specific known treatment path can be followed, which can be translated into fixed activities for a patient [35]. De Vries et al. (1999) mention also some characteristics that have a strong impact on the predictability of the outcomes of healthcare processes. Well defined complaints with high predictability of the outcome like a bone fracture should be distinguished from treatments for ill-defined complaints without certainty about the outcome. Also for routine processes a treatment path can be defined, where in the non-routine processes it is much harder to define a treatment path [34]. After the therapy phase the demand is known.

To get more control on the operational level and hence on the hospital care production Jacobs and Fischer (2012) argue for more financial control by specialists [38]. This is in line with De Vries et al. (1999), who state that the hospital management has limited possibilities to control hospital production processes, compared to the key position of specialists. Because in most healthcare systems it is common specialists are contracted and not salaried by the hospital, they have different objectives than the hospital organization [34]. Specialists are by law responsible for the best medical care and outcome for the patient, but not for the best medical care for a defined reimbursement [34, 38]. Therefore, the responsibility for administrative, financial, medical and organizational processes for better process and financial control should lie with the specialists. The main reason is the ability of the specialists to combine the interest of different stakeholders in healthcare. To obtain better financial control information is needed by the specialists. Jacobs and Fischer mention that the specialists will have to define the data they need to steer the processes, and this data should be available periodically [38].

The article of Datz et al. (2012) delivers a model for workforce planning for hospitals. The management decisions on the workforce planning are based on the production of the hospital. The four phases identified in the workforce planning model could also be useful for the management of the production of the hospital. This is especially reflected in their conclusion, which states that for the continuous changing healthcare landscape a proactive prediction and planning is needed and functioning in a reactive mode is no longer sustainable. The first phase of the workforce planning model is reviewing the strategic direction, in which the business objectives are set for the following three years. The second phase is conducting a workforce

analysis which focuses on evaluating the supply and demand of the current and future workforce, while identifying actual and potential gaps in the critical positions. In order to obtain reliable results a three-year forecast is necessary. The third phase is the development and implementation of the workforce planning. According to Datz et al. (2012) the execution of well-developed workforce plans can offer great promise in achieving competitive advantage for organizations which face rapid and continuous change. The fourth phase comprises monitoring, evaluating and revising the workforce planning. In this phase the accuracy of the forecasts is monitored, ensuring that the workforce plans achieve the expected results. Adjustments can be made based on data or external factors like a healthcare reform [39].

When a gap is detected between demand and supply of a resource, taking action is desirable. Vissers et al. (2001) argue buffers of waiting patients can help using a resource more efficiently. By creating buffers the demand uncertainty can be reduced [35]. Vrangbæk and Bech (2004) mention that if waiting lists are too long, patients will seek treatment in hospital with shorter waiting lists [40]. This makes waiting lists a way to control a resource[35, 36, 40]. Another solution to close the gap between demand and supply, is an increase of the resource, this could be possible by negotiating with the resource supplier [39].

Ensor and Amannyazova (2000) describe the possibilities of global health budgets using case mix adjusted payments as used in Turkmenistan. According to them this system is often mistrusted for not providing sufficient financial control. However, agreements between health purchasers and health providers, offer a way of developing a process of global budgeting which is transparent and accountable. The initial global budgets can be based on historic expenditure and later adjusted to encourage particular system changes. Evaluation of the performance can be used to modify the budget in the current or future years. Their idea is that the hospital statisticians monitor the financial performance on a quarterly basis and show expenditure and activity compared to the previous years. In this financial performance it must be taken into account that an annual growth of 10 percent is allowed in Turkmenistan. Monitoring should also include qualitative and quantitative goals, like extending child care, and financial targets and is part of the business planning process [41].

Vrangbæk and Bech (2004) discuss in their paper the possible effects of free choice of health provider by patients in Denmark. Denmark has a DRG-based healthcare system and the payments to hospitals are mostly via global budgets combined with negotiated targets for performance with the counties. Although other healthcare systems are not paid by counties it can be illustrative for the type of reactions that can be expected. Free choice by patients causes uncertainty for hospitals and health insurers on planning, managerial control and economic accountability. A good point of discussion is the possibility that hospitals can obtain benefits by attracting patients for political reasons, like being the only hospital with certain treatments in the region, and it can be used to maintain units/ functions that would otherwise be threatened by closure [40].

3.2.3 Conclusion

This chapter provided an overview of the existing literature related to BI applications for management decisions regarding hospital production. It can be concluded there is a small amount of literature available on BI in healthcare. BI in healthcare is more complex than other industries due to a range of stakeholders, and the large amount of different processes and patient groups.

Preconditions for effective use of BI in healthcare are the quality of data, privacy and security, and user acceptance across the organization. If these preconditions are met BI has the ability to improve healthcare quality, safety and efficiency. If the information is meaningful displayed managers will have a real time view of the company performance against the strategic objectives. According to the framework of Karami et al. (2013) a data warehouse, an analytical tool, and a dashboard are possible tools for the BI application of this research [33].

This BI application will deliver decision support for the management of hospital production. Production management in healthcare could be defined as the design, planning, implementation, and control of coordination mechanisms between patient flows, and diagnostic and therapeutic activities to maximize output with the available resources [34].

The case-mix based DTC-system offers a way of developing a process of global budgeting which is transparent and accountable. This system makes it possible to manage healthcare as a production company. In which each department needs its own separate control system per product range. On a strategic level a forecast is essential to make decisions concerning the product range, the target mix, the planning, and volumes of patients for the hospital. The forecast is based on historical data and there should be the ability to include seasonal factors,

adjustments on healthcare reforms, and the annual growth set by the government. However, for useful forecasts a proper amount of data needs to be available. Also the possibility of free choice of the patients has to be taken into account. The tactical decisions are made by checking the realisation progress of the agreed volumes. The quality of the data of the operational level is essential for a good representation of this progress. The stage of patient's treatment has large influence on the predictability of the performance.

There is a key position for the specialist as well as the top management for the use of BI for management of hospital production. The top management has to set the strategic direction by using the forecasts, but the execution of the direction is done by the specialists. Since the fees of specialists are included in the tariff of the DTCs, the objectives of the specialists will have to be more in line with the objectives of the top management.

This conclusion raises questions whether the theoretical findings are also applicable to the Dutch healthcare system. Therefore, in the next chapter a stakeholder analysis is performed. By interviewing these stakeholders new insights on the objective of the hospital funding system, information needs, possible control options and key figures can be obtained and the findings of the literature study can be strengthened. Together with the results of the interviews a BI application for management decisions regarding hospital funding will be designed in the fifth chapter.

4. Stakeholder analysis

The use of a stakeholder analysis is a popular tool for management, development and policy purposes. Stakeholders are individuals, groups, and organizations who have an interest (stake) in a particular case/subject. A stakeholder analysis shows the importance of the stakeholders and their potential to influence actions and aims of the hospital [42]. By interviewing the stakeholders and analysing the data insight is generated on how decisions regarding the control of hospital production are taken. This may help identifying threats and opportunities that influence these decisions. The obtained information will be used as input for the design of the BI application.

This chapter starts with the identification of the stakeholders, to insure the correct stakeholders are interviewed for this research. Subsequently, the methodology of data collection is discussed and finally the findings will be presented.

4.1 Identifying the stakeholders

The first step of this stakeholder analysis is identifying the actors who might have a role in the decision making process. The aim is to evaluate and understand the stakeholders from the perspective of the hospital and to determine their interests and influence on the hospital production. By gaining knowledge about the stakeholders' behaviour, intentions, interrelations, and agendas the decision making process can be better understood [42].

The interests and influence of the stakeholders from both within as well as outside the hospital need to be taken into consideration when evaluating threats and opportunities on the management of hospital production. These threats and opportunities can for instance be useful for the strategic planning of the DTCs. And for the success of implementing and the use of the BI application managers require strategies for mobilizing, neutralizing or defeating the stakeholders, depending on their potential to support or oppose the BI application [42].

The primary stakeholders are essential for the survival and wellbeing of the hospital and are the actors that will make the final decisions, like the board of directors of the hospital. But also the actors who influence these decision makers are primary stakeholders, like the specialists. Secondary stakeholders are the actors with whom the hospital interacts but are not essential in the decision making process the BI application will support, like the patient. For identifying and mapping all possible stakeholders figure 13 was used. This is a simplification of figure 4 which shows market players in the Dutch hospital care market.

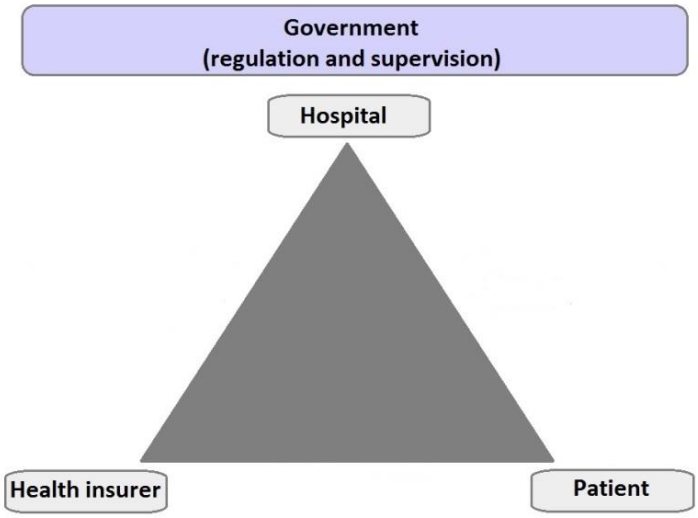

Figure 13: A representation of the stakeholders in the field of hospital production

The figure shows four main groups; government, hospital, health insurer, and patient, which each represent one or more stakeholders. These stakeholders, together with a quantification of their level of influence on the decision making process, are displayed in Table 6. The list only includes individuals or a group of individuals who have a direct interest in the decision making process and could affect the use of the BI application [43]. The level of influence also shows the potential of all possible stakeholders in terms of valuable information for the design of the BI application.

Stakeholder	Level of influence
Government	
Ministry of Health	low / medium
Dutch Healthcare Authority	medium
DBC Onderhoud	medium
Hospital	
Medical specialists	high
Board of Directors	high
Financial management	high
Head of administrative department	medium
Information management	medium
Health insurer	
Health purchaser	high
Board of Directors	medium
Patient	
Patients	low

Table 6: A list of all possible stakeholders and their level of influence regarding hospital production.

For each of the possible stakeholders a spokesman is approached to collect the necessary data for the analysis. The participating spokesmen and their role in the decision making process will be elaborated in the third subchapter. The data for the analysis is obtained by means of interviews, the methodology of this data collection is discussed in the next subchapter.

4.2 Methodology of the data collection

Multiple data collection methods are available for stakeholder analyses, which can be divided into quantitative and qualitative approaches. In the analysis of quantitative approaches the quantitative data will be measured to develop and employ theories about a certain topic. This means that the required data has to be in a numerical form, like percentages. In general this means that the questions are specific and narrow in nature. To obtain valuable results with quantitative approaches a large amount of participants is necessary. As this research aims to understand the decision making process of the hospital production, and to identify the information needs of the stakeholders for the BI application specific and narrow questions will not deliver the desired results. In addition, the amount of knowledgeable participants is too small.

For these reasons a qualitative approach is used in this analysis. In the analysis of qualitative approaches the data, in terms of words, is used to describe the information in themes and patterns. The data is collected by asking broad questions to a specific set of participants. One qualitative approach is a survey, where the participant is given a predetermined set of questions. In this research, there was not chosen for a survey because of the possibility that the approached stakeholders would turn the survey aside due to a lack of interest or the absence of supervision. Hence, if the given answers would be too concisely or unclear, there would be no possibility to go more in- depth on a specific item [44]. To overcome these pitfalls, an interview approach was chosen as the data collection method in this stakeholder analysis.

Qualitative interviews can be differentiated in structured, semi-structured and unstructured. In structured interviews there is the tendency to formulate the questions too specific and narrow, which can lead to quantitative data [45]. In unstructured interviews there is the possibility to lose the aim of the interview, with the result that undesirable data will be gathered. The stakeholder interviews were therefore executed in a semi-structured way. A semi-structured interview is organised around a set of pre-determined open-ended questions and is complemented with questions that emerge during the dialogue between the interviewer and the interviewee [45]. This interview approach allows to delve more deeply into important answers, without losing the aim of the interview.

The preparation of the interviews consisted of several steps. The first step was constructing effective pre-determined open ended questions. These had to cover the main themes for

developing the BI application for the control of hospital production and are for this manner quite broad. The main themes are the objective of the hospital funding system, the information needs, control options, and the key figures. The constructed questions are displayed in table 7. For each of the stakeholders additional sub-questions were constructed to go more in-depth on stakeholder specific items.

Objective of the hospital funding system
1. What do you (as a stakeholder) consider to be the main objective of the current hospital funding system?
Information needs
2. What information is necessary to meet this objective?
3. Is there currently enough information available to achieve this objective?
- At a strategic level?
- At a tactical level?
4. Is the current information up to date and available on time?
5. In what kind of way or manner should the desired information be delivered?
Control options
6. Are there currently options to control the hospital production?
7. What kind of control options would be acceptable to meet the target?
Key figures
8. Who should be provided with the desirable information to meet the objective?

Table 7: A list with the pre-determined questions that cover the main themes of the stake holder analysis.

After the construction of the pre-determined questions, a spokesman of each stakeholder group was approached. These spokesmen were either identified by contacting the organization they are representing or via the employees of PinkRoccade Healthcare. An email was sent to these spokesmen containing background information on the subject and the goal of the research. The spokesmen were asked if they would like to contribute to the research by an interview of 45 to 60 minutes in the period of April/May 2015. If the spokesman was prepared to contribute to the research an appointment was scheduled. Two days before the interview took place the pre-determined questioned were send to the spokesman, to provide them the opportunity to prepare the interview.

The interviews were conducted at the location of the interviewee's choice, to guarantee the interviewee would have to do less effort and will feel at ease to speak freely [44]. First, an introduction of the interviewer and interviewee took place. The purpose of the interview was explained and the terms of confidentiality were addressed. To reduce the risk of unanticipated harm anonymity was guaranteed and potential sensitive information would be excluded from the analysis [45]. The interviewees were also asked whether they agreed the conversation would be recorded for documentation purposes. This had the advantage that answers did not have to be recalled from memory with the risk of information loss. Directly after the

interviews transcripts were made and returned to the interviewee to obtain permission for publication in the analysis.

4.3 Findings

This subchapter consists of two parts, the first part will give an overview of the spokesmen that contributed to this research. As the data is anonymous only their positions and their influence is mentioned. In the second part, the data of the interviews is interpreted. In this phase the data is compiled into the main themes for developing the BI application [44]. The interviews have been analysed by open coding, axial coding, and selective coding, as described in subchapter 3.1.4

4.3.1 The contributing stakeholders

In total seven interviews with eight spokesmen of stakeholder groups were conducted in this research. These stakeholders and their positions are displayed in table 8. Of the eleven identified stakeholders eight were interviewed, which provides a good representation of stakeholders for the data collection.

Stakeholder	Position
Government	
Dutch Healthcare Authority	Manager Supervision
Hospital	
Federatie Medisch Specialisten	Senior Advisor
Financial and Control	Controller
Sales Department	Senior Advisor
Planning and Control	Advisor
Health insurer	
Health Purchaser	Health Purchaser Specialized Medical Care
Zorgverzekeraars Nederland	Executive and Management Advisor
Patient	
Nederlandse Patiënten Consumenten Federatie	Senior Policy Officer

Table 8: The list of stakeholders which were interviewed for the stakeholder analysis.

The stakeholders of the government are represented by the Dutch Healthcare Authority. In May 2015 the Dutch Healthcare Authority and DBC Onderhoud were merged into one organization. Since this was the middle of the interviewing period, there was no spokesman available of DBC Onderhoud. Unfortunately, also no spokesman of the Ministry of Health was available for an interview in this period. However, the Dutch Healthcare Authority is the supervisor of the healthcare and checks whether the health providers and health insurers comply to the laws and regulations. It also advices the Ministry of Health and sets tariffs of certain DTC-care products and is therefore a good representation of the government stakeholders group.

Four stakeholders within the hospital group were interviewed during this research. The medical specialists are represented by the Federation of Medical Specialists (FMS). This federation defends the interests from both employed specialists and self-employed specialists. Further, two different hospitals were visited. The first interview in an hospital was conducted with a controller of the finance and control department. The controller is responsible for the financial management of the hospital and directly involved in the negotiations with the health insurers. The second hospital visit was a double interview with a senior advisor of the sales department, who negotiates with the health insurers and an advisor of the planning and control department with a background in information management.

From the health insurer stakeholder group, a health purchaser of one of the five largest Dutch health insurers was interviewed. This health purchaser was concerned with specialized medical care, that is purchased from the hospitals. Further, as it would be difficult to get in contact with the board of directors of a health insurer and each health insurer has different policies Zorgverzekeraars Nederland (ZN), an organisation that defends the interests of the Dutch health insurers, was interviewed.

The patient is the last group of stakeholders. It would not be representative to interview random patients, therefore a spokesman of the patient federation NPCF was approached for an interview. The patient federation NPCF represents 160 patient and consumer organisations and defends the interests of the Dutch patients and health consumers.

4.3.2 Interpretation of the data

Objective of the hospital funding system

The interviews show that the objective of the hospital funding system varies per stakeholder by their experience with the changes in regulations during the years. The health purchaser explains that from 2005 till 2012 the hospital funding was based on a lump sum agreement. This meant that a fixed amount of hospital funding was agreed upon with the health insurers, for instance a total of 100 million euros. The prices per DTC were negotiated and the hospitals could fill the fixed amount of hospital funding with the production of DTCs. With the introduction of the DOT-system in 2012 the hospital funding is based on P x Q agreements, with negotiations on both prices and quantities to stimulate the market competition. In 2012 and 2013 the hospitals were compensated for losses because of the changes in regulations. From 2014 on the hospitals will not be compensated any longer by the

government. According to the Dutch Healthcare Authority the transition is completed in 2015, which means the new system should be active then.

However, the health insurers use a budget ceiling at the P x Q agreements since 2012. The main reason was the new DTC-product structure of the DOT-system, which caused uncertainty in the prices as well as the quantities. The budget ceiling was based on the hospital spending of the year 2012, hence the P x Q agreements were based on this budget ceiling with volume ceilings per DTC. For example, when the hospital produces for 102 million euros, the hospital will only receive 100 million euros (their budget ceiling) and if the hospital produces 98 million euros, it will receive 98 million euros. This can be seen as the old system (the function-based budgeting system) with the guidelines of the new system. This was not the intention of the system, but by the introduction of the macro budget, which allows a national growth on healthcare spending of 1 percent in 2015, this budget ceiling is still a necessity for the health insurers to get a grip on the total hospital spending.

The future goal of the health insurers is to contract on the prices and to let go of the budget ceiling. With the transition to the maximum completion time of 120 days for DTCs, the DTC-product mix changed. More DTC products are being produced, but most of them will be less severe, as only some care activities will be included in the DTC product instead of all activities of the complete treatment. This leads to uncertainty on quantities and prices, which forced to maintain the budget ceiling instead of proper P x Q agreements. Health insurers allow the hospitals to increase production of a DTC product, but then the hospital will have to reduce the production of another DTC product. To summarize, the main objective of the health insurers is to deliver affordable high quality care that is accessible to everyone, within the budget ceiling.

The objective of the hospitals differs per hospital. The health insurers indicates that the hospitals try to achieve the volume ceilings. Both interviewed hospitals admit to achieve the volume ceilings. This is a necessity as the spending of the hospital are based on these volumes. One hospital indicated to stop producing when the ceilings are achieved. The other hospital indicated not minding overproduction with the precondition that the costs would stay the same. A hospital does not have the intention to make profit, but should have a stable financial position, according to the interviewed stakeholders.

According to the patient federation the objective of the patients is two folded. First, there is the individual patient. When the patient needs healthcare, he would like continuation of healthcare from his healthcare provider nearby. Second, there is the healthcare consumer, who would like a basic premium which is as low as possible. This healthcare consumer wants a steady financial management of hospitals, because bankruptcy of hospitals is expensive and will influence the basic premium he has to pay.

Information needs

Each health insurer is obligated to announce in which hospitals they will purchase care the upcoming year. This allows the insured to switch if they prefer a certain hospital. Around the month June the hospitals will deliver an offer to health insurers with quantities and prices. To make a good offer, a forecast is needed on the expected volumes. These forecasts have to be adjustable for the aforementioned national growth as well as the inflation rates. But there is also a need for a cost calculation per DTC. By having sharp prices the production of a certain DTC product may rise. This offer is the basis for the negotiations with the health insurers. The health purchaser of the health insurer will benchmark the prices with other hospitals and benchmark the quantities with previous years. The outliers and the total amount of hospital funding will be discussed in further detail with the hospitals.

The calculated prices of a DTC per hospital can vary widely. For this reason several stakeholders think a free market is not possible in healthcare. There are multiple reasons for this variety. There is no uniform method to allocate the costs to the products. Further, in the price of each DTC product a part of the overhead is allocated. The controller of the hospital illustrates that if a hospital produces a larger amount of less severe DTC products, like cataracts, more severe DTC products can be offered for a lower price, as the overhead costs of the hospital can be allocated over a larger amount of products. Independent treatment complexes can offer lower prices for less severe DTC products due to the lower overhead costs, because of the absence of an expensive IC. This results in, purchasing less severe DTC products at independent treatment complexes because they offer the DTC products cheaper, but higher prices for severe DTC products in hospitals as they have to cover their overhead over less DTC products.

After the agreements have been made on a P x Q basis with the budget ceiling, the stakeholders would like to see how the hospital is performing on the quantities as well as the total hospital funding. In order to achieve this the prices need to be available. Unfortunately,

in June 2015 still no DTC products have been reimbursed as the prices were still not available due to the conversion to the maximum completion time of 120 days.

There is a need for a proper production monitoring system. This system needs real time, or at least weekly, qualitative data to make correct decisions. A condition for this monitoring system is the work in progress status besides the finished production. The data of the WIP-grouper, mentioned in chapter 2.1, is not usable for the hospitals as this is only delivered on a monthly basis. The hospitals would like a hospital specific build-in grouper, so it is possible to monitor the status of the work in progress at any desired moment. This is only possible for patients that received care activities, so there is also a need for a forecast of patients that did not receive any care activity yet, but are on the agenda in the near future. To monitor the production effectively a planning is necessary to see the performance of the production. In the contracts between care providers and the health insurers it is stated the hospital is responsible for an even distribution of the care during the year. As the production is not distributed efficiently during the year, there is a need for a planning option with historical trends as it could fit the capacity much better.

Insured are free to switch once a year between health insurers. For these mutations the company Vektis designed a model that is budget neutral. In April the mutations are known and agreements with the hospitals are adjusted based on this model. Although in practice not many care-demanding insured switch between health insurers, the agreements in the application must be adjustable for these mutations.

The Dutch hospitals can negotiate with five large insurers namely, Menzis, CZ, Achmea, VGZ and DSW. There is a sixth party Multizorg, that will negotiate for the remaining four smaller health insurers. The hospitals need information on the current production per health insurer and would like this displayed compared to previous years and the norm. This should be possible per DTC, per specialism for the total hospital funding. Three stakeholders noted that the health insurer VGZ started with P x Q agreements in lots, which means that all DTCs that are in those lots can be settled with each other. The main reason for this is the poor predictability of the volume of these DTCs. Monitoring per lots is a necessity and it would be valuable if the division of lots per health insurer would be available in the application instead of selecting them individually by hand.

Control options

The stakeholders agree on the necessity of control options to get a grip on the financial position of the hospitals. One option is a treatment stop when the hospital achieves the volume ceiling of a DTC product. Two examples of this usage were appointed during the interviews. The first example regards the transgender care in the VUMC in Amsterdam. In 2014 this hospital announced to stop operating new patients as the hospital achieved the volume agreements. This is a unique case as the VUMC has a market share of 80 percent, which meant the transgender care would become unavailable for patients. The Dutch Healthcare Authority decided this was undesirable and therefore mediated between the hospital and the health insurers to come up with a solution.

The second example is more recognizable for other stakeholders. In December 2013 the Radboud UMC in Nijmegen announced a treatment stop till January 2014 for patients of the health insurer Achmea, as the hospital achieved the budget ceiling of this health insurer. This led to a lot of media coverage and the stakeholders agreed this was not desirable for anyone, especially the patient who would like continuation of healthcare in this hospital. A treatment stop when the hospital achieves the volume ceiling of a DTC product as a control option can also be made impossible by the contracts if the health insurers include an obligation of continuation of the care even in case of overproduction.

When the treatment stop is used as a control instrument, the norms for the waiting time per treatment in the Netherlands have to be taken into account. The waiting time for a treatment is not allowed to be longer than the norm as set by the Ministry of Health. The hospitals will aim for this norm, but for the health insurer this is a hard norm, as the health insurer must ensure that the insured will be treated within these time norms. That does not have to be at a specific hospital, but in any hospital within two hours of travelling. The Dutch Healthcare Authority observes increasing waiting times and believes it is primarily the responsibility of the health insurer to reduce these waiting times as they are obliged to comply with the norms.

The hospitals will have to add extra waiting time if an increase in demand occurs, however the health insurer will only notice this increase in demand and waiting times at a much later stage when they receive the claims for the patients. The government is aiming for more transparency in this field. This is manifested by the statement in law that forces hospitals to publish the actual waiting times per treatment on a monthly basis. These waiting times are the average of the waiting times of all health insurers, so it can occur that for one health insurer

the waiting time is six weeks and for all other health insurers only one week. As the health insurer has no real time insight in the waiting times per treatment per hospital, there is a responsibility for the patient, to inform the health insurer when the waiting time becomes too long.

If the waiting time for a treatment in a specific hospital is known, the health insurer can suggest the patient to go to another contracted hospital with shorter waiting times. The patient has the freedom of choice to stay on the waiting list or to go to the suggested hospital. According to the Dutch Healthcare Authority there is a need for a system in which the production agreements are controlled on a quarterly basis. The authority argues that healthcare is controlled by rewarding the hospitals that do well and give the hospitals that do worse the opportunity to do better. This is in line with the aim of the health insurers to reduce waiting times and this way it also becomes the responsibility of the hospitals as the health insurers do not have current information on waiting times. Determinative for adjustments in agreements between hospitals and health insurers should be the price and quality of the delivered care.

Key figures

The BI application is intended for hospitals, so the stakeholders agree that within the hospital at least the board of directors, financial management and sales management need direct information on the status of the hospital funding. But also quality management should have access to the production volumes. In the Netherlands the quality standards for certain treatments are set in terms of volumes. If a hospital does not meet these volumes in a year, the hospital will not be allowed to perform that treatment any longer. To prevent the loss of treatments in a certain region, hospitals can decide to merge.

Besides the board of directors, financial management, sales management and quality management, specialists who execute the DTC production should have accurate information on this performance. The health insurers have no indications that the specialists have this information need. One of the interviewed hospitals confirms this view, but indicates that the specialists should ask for this information. In the other hospital the specialists are more demanding for information, one surgeon even explicitly asked for the production rates. The Federation of Medical Specialists indicates that the need for information on the production is the same for specialists who are self-employed as for specialists who are employed by the hospital. Both specialists have an interest in a financial stable hospital, as it provides them

work. An increasing demand for production information is detected by the interviewees. The inclusion of the fees of the self-employed specialists in the tariff of the DTCs contributes to the awareness, as the aim of the specialist will be more in line with the aim of the hospital in terms of production. Hospitals will include agreements on compensation by overproduction in the contracts with the self-employed specialists.

The health purchaser also would like to have access to the BI production information. However, the supervisor will not allow this, as it would deteriorate the negotiation position of the hospitals. Also, the government would not like access to the production information, because it would move the responsibility of healthcare continuation from the health insurers back to the government and this not the purpose of this system.

This chapter was about the stakeholder analysis regarding the control of hospital production. The interview method, stakeholders and topics have been discussed. The interviews made clear; the objective of the hospital funding system, information needs, control options and the key figures. The results provided an insight on the negotiations between health insurers and hospitals, and the information needs regarding hospital funding of the stakeholders. Together with the results of the literature study a BI application for management decisions regarding hospital funding will be designed in the next chapter.

5. Design of the BI application

In this chapter the BI application will be designed based on the literature study and the stakeholder analysis. It will start with the theory of the design. Subsequently, the components of the application including the preconditions for implementation and use, and the options to control the hospital productions will be discussed.

5.1 Theory of the design

In the literature study forward citations yielded the term performance management. This was initially not included in the literature study, as it made the scope too broad. However, for the design of the BI application performance management cannot be disregarded. Performance management is a continuous process of measuring the main activities of an organization to ensure the strategic goals can be met in an effective and efficient manner. This performance management life cycle is represented in figure 14.

A quick literature search on performance management in healthcare in the three aforementioned databases yielded only 180 articles. According to Mettler and Rohner (2009) this could be explained by the differentiation between public organizations and private organizations. In healthcare there is no profit maximising focus, little potential for income generation and generally speaking, no criteria against which performance can ultimately be measured [46]. With the introduction of the regulated free market in the Netherlands criteria for optimization of hospital funding are defined in terms of production agreements per DTC. This makes it possible to measure the performance of the hospital funding. And due to the possibility of bankruptcy this measurement is even a necessity.

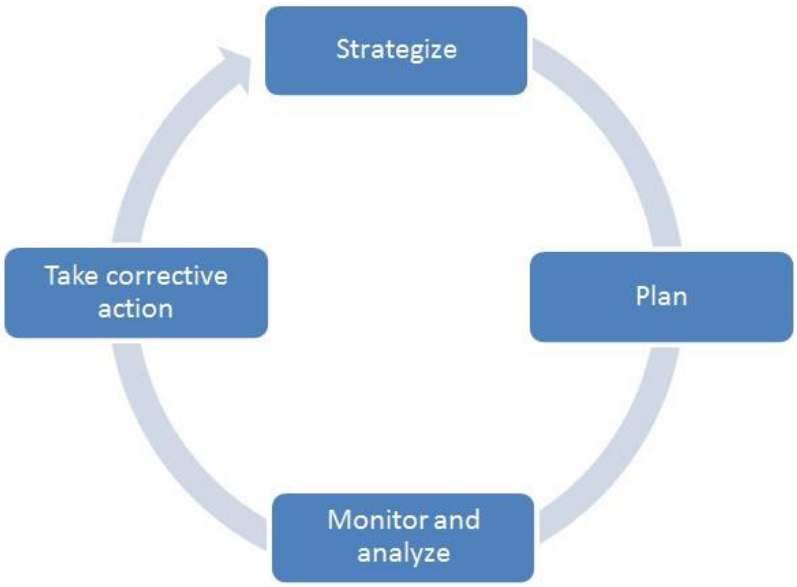

Figure 14: The performance management life cycle.

Performance management in healthcare is not only aiming at the systematic generation and control of the hospital funding, but also at the optimization of the efficiency of the care delivery. Therefore performance management, like other management approaches, only can be implemented successfully, if strategic planning is closely linked to operational execution and control [46]. This corresponds to what is expressed in the article of Datz et al. (2012) on a model for workforce planning [39]. And it meets the need for planning mentioned by the stakeholders.

For the design of the BI application the steps displayed in table 9 were used. At the strategic level the business goal and the key performance indicators for the optimization of the hospital funding are defined (strategize) as well as the process performance design and operationalization are initiated (plan). On the tactical level the process performance is measured and analysed (monitor and analyse) and is the process reported and optimized by adjustments (take corrective action).

Strategize
1. Business goal definition
2. Key performance indicator definition
Plan
3. Process performance design
4. Process performance operationalization
Monitor and analyse
5. Process performance measurement
6. Process performance analysis
Take corrective action
7. Performance reporting
8. Plan and process adjustment

Table 9: The steps in performance management derived from Mettler and Rohner (2009).

5.2 The application

Strategize

For an effective use of any BI application it is a necessity to provide information which meets the aim of the organization. This aim of the organization has to be translated into clear measurable outcomes that define success and which have to be shared throughout the organization and with stakeholders [47].

In the previous three chapters the business goal of the Dutch hospitals is elaborated. The Dutch hospitals aim for an optimization of the hospital funding to maintain financial stability. However, the definition of this optimization can depend on the agreements with the health insurers. The intention of the current healthcare system was making agreements on a P x Q basis per DTC. Due to uncertainty in quantities and prices by transitions in the system like the

DOT-system, a maximum growth of the macro-budget and the reduction of the maximum completion time of DTCs to 120 days the health insurers were forced to make agreements using budget ceilings.

The optimization of the hospital funding can therefore be addressed as achieving the agreed quantities of DTCs per year or the budget ceiling of the hospital. However, this budget ceiling is made up by the formula $TR = \sum P_i \text{ X } Q_i$ which indicates the quantities of DTC products have the greatest influence on the hospital funding as the prices tend to be fixed during a year. A key performance indicator helps the hospital define and measure progress towards the business goal. The key performance indicator has to be a quantifiable measurement that reflects the critical success factors of the hospital. This makes the key performance indicator of this application the quantity of DTCs produced per year. Which is in line with the finding of the literature study which indicates that in a hospital setting the performance could be expressed as the amount of patients that are treated within the budget boundaries [34, 36].

In designing and the use of an effective performance management system leadership involvement is crucial. Also effective and open communication between employees, stakeholders and customers is a necessity to improve the performance [47]. This corresponds to the findings of the literature study that the establishment of clear and defined ideas about the information needs is the basis of trust in BI. Without trust there will be little user acceptance and therefore, strong support and leadership from the top management is a key success factor for implementing a BI application in healthcare [31, 32]. But BI has also the ability to eliminate information asymmetry by open and effective communication and to respond to the environmental changes. This need for transparency between all stakeholders is also reflected in the stakeholder analysis. The specialists have a key position in the performance of the hospital as the hospital management has limited possibilities to control hospital production processes [34]. Through the inclusion of the fees of the self-employed specialists in the tariff of the DTCs the aim of the specialist will be more in line with the aim of the hospital in terms of production.

Plan

In the stakeholder analysis the negotiation process between hospitals and health insurers is elaborated. In June of every year the hospital will provide an offer to each of the health insurers that announced to purchase care in the upcoming year. This offer consists of prices and quantities. In the stakeholder analysis the hospitals indicated a need for cost calculations

per DTC and a forecast on the expected quantities. In this process performance design stage a forecast for the upcoming year will have to be provided first.

As it is the year 2015, there is a need for a forecast for the year 2016. This forecast will have to provide insight in the total of the expected production per DTC. These forecasts will have to provide a trend in comparison to the previous year, as the strategic planning decisions in which direction the hospital is heading the couple of years concern product range, target mix and volumes of patients [35].

This research was conducted in the first half of 2015, with the result there is no useful data available to perform accurate forecasts for the years 2015 and 2016. To demonstrate the complexity of the forecasting process an anonymized dataset from the Geniq data warehouse is used. The data of the care-product-group 040201 is used as an example and this production is displayed in Appendix B. There is chosen for this care-product-group, as diabetes mellitus is well-known and the demand should be quite predictable. The reference date of the data is May 2014 and it only shows the completed DTCs. As the maximum completion time between 2012 and 2015 in the DOT-system was 365 days the historical data from January 2012 till May 2013 should be accurate. As displayed in Appendix B some DTC-care products are hardly or not at all being produced during the year. For this reason it has been decided to use the complete production of the care-product-group in this example. The progress of the production of the completed DTCs over the years 2012-2014 is displayed in figure 15.

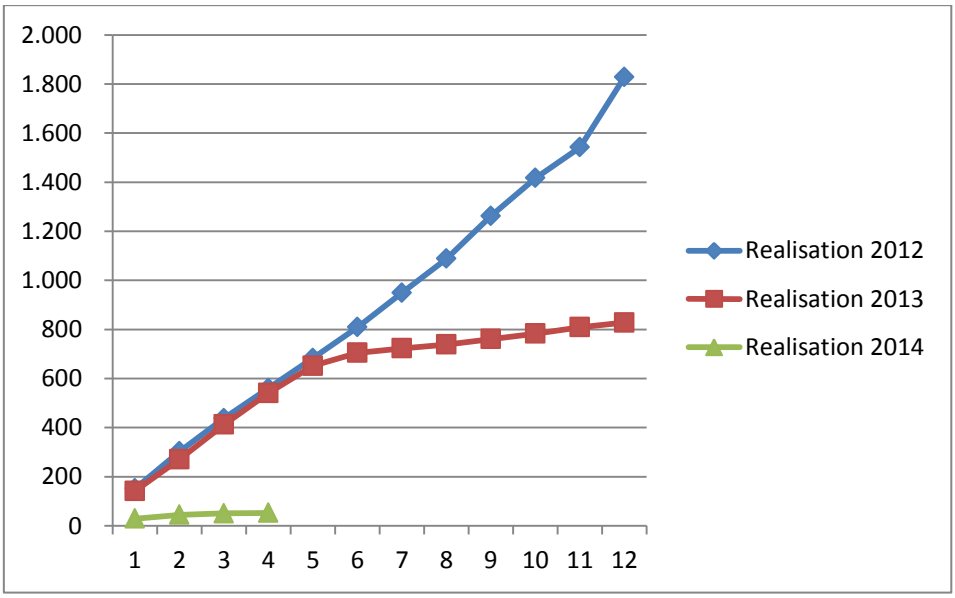

Figure 15: The production of completed DTCs of the care-product-group 040201.

Winter's forecasting method is used in this example as it takes the trends as well as the seasonal changes into account. For accurate forecasts Winter's method needs two full seasons of historical data to initialize a set of seasonal factors. Also Pasupathy appointed that for forecasts at least two years and ideally six years of historical data should be available[37]. Although only 1.5 year of historical data was available this method was used as these trends and seasonal changes were highlighted in the literature study as well as the stakeholder analysis. The year 2012 is used to calculate the seasonal factors and the first 5 months of 2012 and 2013 are used to calculate a trend line. The forecasts for 2013 and 2014 are displayed in figure 16. These show a downward trend.

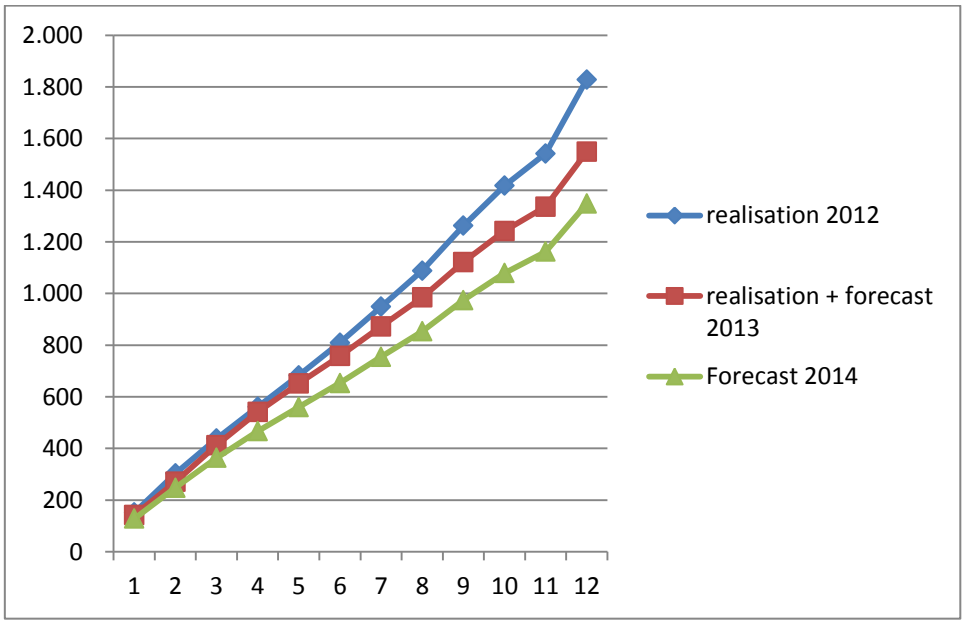

Figure 15: Forecasts production of completed DTCs of the care-product-group 040201.

When forecasts for the upcoming year are available a cost analysis will have to be performed with the forecasted quantities. Historical data on the costs of DTCs is available in the data warehouse of Geniq. An example of such a cost analysis is displayed in figure 17. The cost analysis shows the fixed costs and the variable costs. These costs are displayed against the expected revenue, which enables an analysis if the current prices can or should be adjusted. The precise cost analyses are not taken into account in this research as it will make the scope too broad. However, inflation rates and other changes that could influence the costs of the DTCs should be taken into account.

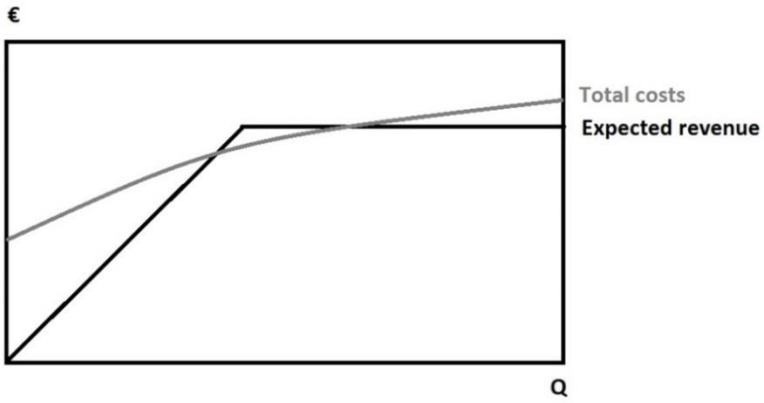

Figure 17: Example of a cost analysis with the expected total revenue.

When the quantities and prices are established by the financial management, the negotiations will take place between health purchaser and the sales management. As the health purchaser is restricted to use budget ceilings it is unavoidable certain quantities or prices will need to be adjusted. When the agreements for the upcoming year are made, new cost calculations will have to be made in order to be sure the correct performance will be achieved. An example of this DTC performance design is displayed in figure 18. The quantities of produced DTCs displayed in the red fields will cause losses, as the costs are not covered, this can be expressed as negative performance. The quantities produced in the orange fields will cover the costs, but there is little room for adversities, like a more severe patient mix. The quantities in the green field is the performance to achieve, as it provides a healthy profit to maintain financial stability.

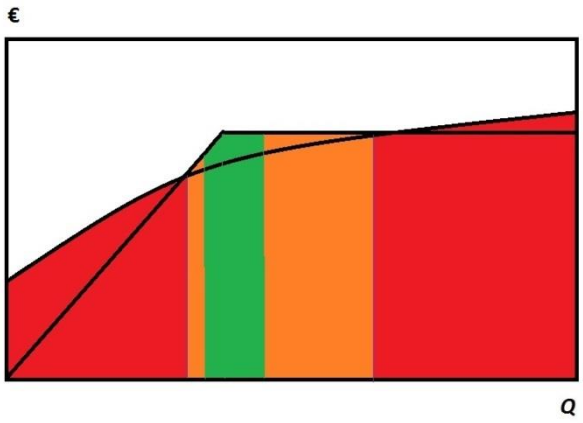

Figure 18: Example of DTC performance design.

The next step is performance operationalization, which consists of the planning of the quantities during the year. A simple method for planning could be an even distribution of the total quantities of DTC over the months. However, as the stakeholder analysis indicated there is a need for a more seasonal distribution as the care to patient is not distributed evenly

throughout the year. This could be incorporated by using the Winter's seasonal factors. This planning must be adjustable during the year. In particular, for the mutation of insured in the month April and to take corrective action during the year if necessary.

Monitor and analyse

The performance is monitored by measuring the actual production. As shown in figure 15 the completed DTCs do not represent the actual performance. To get insights in the actual performance also the production of uncompleted DTCs needs to be taken into account. However, all care-products during the complete treatment of a patient will lead to a specific DTC. This causes that the uncompleted DTC can change if a care-product is added to the treatment. Nevertheless there is an information need regarding these uncompleted DTCs. The use of a build-in WIP-grouper could provide information on the value of the delivered care products of the uncompleted DTCs as it derives the actual DTCs automatically. The advantage of a build-in WIP-grouper over the WIP-grouper of the Dutch Healthcare Authority is the ability of delivering instant information instead of requesting this data through external activities. This ensures actionable information is available when requested, at the right location, and in the right form in order to make timely and fact based decisions, which is the basis of BI.

The build-in WIP-grouper will deliver information on the production of actual DTCs, which provides more accurate information than only the completed DTC production. As described the uncompleted DTCs can change if a care product is added to the treatment. Therefore, there is also a demand for the estimated final DTCs. These could be derived by analysing care pathways. Care pathways can be seen as the description of successive steps, decision points and criteria in the healthcare process for a patient group with a specific demand for care. In other words, the average care processes which are included in a completed DTC. In uncompleted DTCs a part of the care pathway is known. By comparing the care pathway of the incomplete DTC with care pathways of completed DTCs an estimate of the final DTC can be made. However, the phase of treatment process will have an effect on this estimate. This was illustrated in figure 12 and by Vissers et al (2001) in the literature study. The more historical data on the care pathways of DTCs, the better an estimate can be made.

When this data is available the actual monthly production per DTC can be measured by sum up the completed DTCs with the uncompleted DTCs or estimated final DTCs. In which the starting date of the DTC, and the date the patient requested for care, will determine the month

of the performance. Measurement is not an end goal in itself, but a tool for more effective management. Therefore, the results of the performance measurement indicate what happened, not why it happened, or what to do about it [47]. In order to make effective use of the performance measurement outcomes a transition from measurement to management have to be made. This performance analysis consists of comparing this actual production with the planned production per month.

Take corrective action

In performance reporting it should be immediately clear how the hospital is performing with respect to the strategic goals. To give an example of a performance report the data used in the planning phase was updated during this research. The reference date of this data is February 2015 and it still only shows the completed DTCs. As the maximum completion time between 2012 and 2015 in the DOT-system was 365 days the historical data from January 2012 till February 2014 should be accurate. Which implies that the production over 2013 is available. In figure 19 the forecast for 2013 and the realised production of 2013 are displayed. It can be concluded that there would be overproduction if the forecast should be the agreed upon production. And it shows directly how difficult it is to make accurate forecasts. This forecast has an accuracy of only 67% and a forecast accuracy of 85% or more is seen as useful for management decisions.

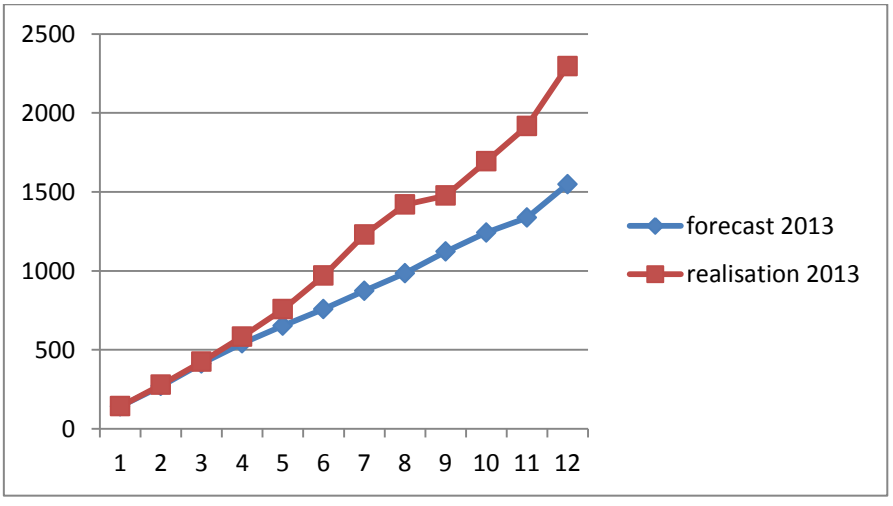

Figure 19: The forecasted and realised production of completed DTCs of the care-product-group 040201 in 2013.

The extensive framework of Karami et al. (2013) indicates a data warehouse, an analytical tool and a dashboard as possible BI tools for decision support [33]. The data warehouse is used to obtain the data and predictive analytic tools are used to strategize and to obtain actual performance. In performance reporting a dashboard is useful. A dashboard provides at a

glance views of the performance with respect to strategic goals. An example of such a dashboard is displayed in figure 20, this gauge shows the performance of the year 2013 as shown in figure 19. The BI dashboard should include two gauges. One which indicates the performance of the chosen month and one for the forecasted performance of the complete year. This makes it possible to quickly see if corrective action is necessary.

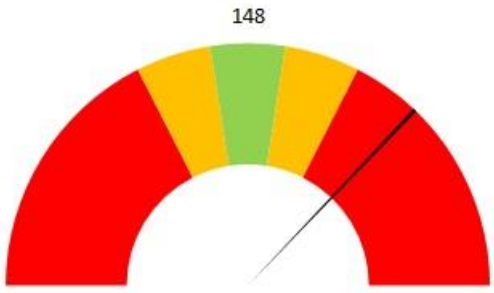

Figure 20: Example of a dashboard which shows the performance of the realised production in 2013.

From the literature study as well as the stakeholder analysis it can be concluded waiting times are the most acceptable control option for all stakeholders. A certain amount of waiting time would even be desirable. Vissers et al. (2001) argue buffers of waiting patients can help using a resource more efficiently. By creating buffers the demand uncertainty can be reduced [35]. The BI application should make a distinction in the production of the DTC per health insurer. The agreements with the health insurers can make a difference if corrective action is necessary. The data used in the example of this chapter provides the complete production of the DTCs, in which no distinction is made per health insurer. If only the production agreements with one health insurer are exceeded in the example and subsequently it is decided to increase the waiting times for all patients, there is the chance the agreements with the other health insurers are not met. This may even lead to greater financial problems. Therefore, proper performance analysis is important to get insight in the reason why there is a deviation. If there is insufficient production to meet the planned quantities it can be decided to reduce waiting times. As Vrangbæk and Bech (2004) mention; if waiting lists are too long, patients will seek treatment in hospital with shorter waiting lists [40].

After each corrective action, whether it will be an increase or a reduction of the waiting time, the performance management life cycle will have to be run through again as performance management is an iterative and ongoing process. This ensures the strategic goals can be met in an effective and efficient manner. Also a gap between demand and supply could be solved on the strategize level by negotiating with the health insurers on an increase of the resource.

6. Policy recommendations

This chapter provides policy recommendations on the implementation of the proposed BI application. These recommendations can be seen as advices and have to be taken into account when developing and implementing the BI application.

6.1 recommendations

If a service providing company like PinkRoccade Healthcare will launch a new application it must be sure the application will deliver valid information. Validity of information is the degree to which it delivers what it is supposed to deliver. The example in the design of the application showed that it is very hard to forecast the production of DTCs. A forecast with 1.5 year of historical data did not provide a valid forecast. Pasupathy (2010) argued that at least two years and ideally six years of historical data should be available for these forecasts [37]. Due to the change in maximum completion time of 120 days per January 2015 currently not enough historical data is available. The historical data of previous years could be converted with an available conversion table. However, the stakeholder analysis indicated the hospitals did not have confidence in the quality of this data. Therefore it is recommended to introduce the application not earlier than April 2017, as this will make sure enough data is gathered.

As described in the previous paragraph a consistent supply of qualitative data is necessary to provide in the need for valid information. Major changes in the Dutch healthcare system cause that hospitals and health insurers are continuously resolving transition problems. When there is the chance new major changes in the healthcare system will emerge it must be considered whether it is worth to invest in the development of the application, as the service life will not be long enough to recover the investments. The interviewed stakeholders indicated they would like a period without major changes. In July 2015 the Dutch Healthcare Authority announced no major changes will be executed in 2016. The main reasons for this are the reduction of administrative burden for hospitals and to facilitate proper negotiations between hospitals and health insurers.

As it is not recommended to introduce the application before April 2017 there is time available to develop the build-in WIP grouper and an analytical tool which can derive the final DTCs throughout care pathways, so hospitals can get real-time insight in their work in progress. Especially these care pathways are recommended to focus on as they also have the ability to deliver clinical decision support. Although, by the top five sought BI applications mentioned by Ashrafi et al. (2014) it can be concluded there is a higher need for management

decision support than clinical decision support, there is a demand for care pathways from the health insurers to benchmark the quality of care.

In the design of the application is described that in case corrective action is necessary adjusting the waiting time per DTC per health insurer will be the most acceptable control option. To be able to use adjusting the waiting times per health insurer as an effective control mechanism, this tactical decision making has to be closely linked to the operational execution. Hence, there should be a direct connection between the BI application and the planning module of the concerning departments as this link enables optimizing the resources (like operating rooms, equipment and devices, staff and supplies) in all individual departments of the hospital.

However, this does not yet take into account the health insurer will only notice this change in demand and waiting times at a much later stage when they receive the claims for the patients. Therefore, it is recommended to invest in a website which displays current waiting times of hospitals per department. These current waiting times could be measured using BI. Besides calculating the time between the date the patient requests for care and the date of the treatment, there must be compensated for the fact patients can choose for a later date of treatment for example by a planned holiday. When patients consult this website they have the ability to choose for a hospital which is contracted by their health insurer with the lowest waiting time. If the trends of the waiting times are meaningfully displayed, for example in a dashboard, the health insurer can see at a glance which waiting times are increasing to undesirable lengths. This is an early warning system for the health insurer which enables them to contact the hospitals to analyse the cause of increasing waiting times. For instance, facility problems could be solved by suggesting the patients to go to another contracted hospital and an increase in demand, for instance, by a new treatment could be solved by making new agreements for this DTC. Determinative for adjustments in agreements between hospitals and health insurers should be the price and quality of the delivered care. This website could eliminate information asymmetry between hospital and health insurer and hence fits the quest for transparency in healthcare of the Dutch Healthcare Authority.

The performance management process develops participation, awareness, a decentralised decision making process, and responsibility for achieving the strategic goals which have been formulated [47]. As a consequence, there is a need for guidance on which the hospital will have to draw conclusions about what it is doing well, what it is not doing so well, and what

can be improved. So one of the main challenges of the proposed BI application is to develop a learning organisation culture. In addition to the development of the BI application there is a crucial role for consultancy with background knowledge on the primary processes and hospital funding.

7. Conclusion

This chapter includes the conclusions, limitations and recommendations of this study. The first subchapter provides an overview of the final conclusions. Subsequently, the limitations of this study will be discussed and the chapter will end with recommendations for further research.

7.1 Conclusion

The research objective of this study was as follows:

What is the potential of applying a BI application to Dutch hospitals in order to optimize strategic and tactical management decisions on hospital funding.

In order to reach the research objective it was important to gain insight in the Dutch healthcare system and BI in healthcare. This background knowledge was necessary to make decisions on how to the design the BI application to control hospital funding in the Netherlands.

It can be concluded that the regulated free market in the Netherlands with competition between hospitals in quality and price does not work as intended at this moment. The purchased quantities should reflect the quality of care, as if the quality of care does not meet the requirements of the health insurers, they should not purchase care in this hospital. However, the stakeholder analysis showed that in the negotiations between hospitals and health insurers the quality of the care is not included. Also competition on prices is currently not possible as there is no uniform procedure on how the prices have to be calculated. The main reason the negotiations are not conducted on the level of quality and price are the changes in the Dutch healthcare system every few years. Changes as the maximum completion time of a DTC and the introduction of a macro budget caused health insurers to hold on to budgets per hospital and fill these budgets with P x Q agreements. Only abnormalities on quantities and prices in the offer made by the hospitals will be negotiated.

The objective of the hospital as well as the health insurers on the hospital funding is meeting the negotiated financial agreements. In which the hospital will choose for financial stability instead of the continuation of providing care to patients. However, an advantage of the P x Q agreements with production ceilings for DTCs is the ability to plan the provided care better. As it can be seen as a manufacturing organization, where you would like to maximize the available resource.

There is a demand for production forecasts in the negotiations phase and the monitoring phase. In these forecasts it must be able to be make a distinction per DTC, lot, department, health insurer and complete hospital. Winter's forecasting method is recommended as forecasting tool as it provides a trend line for the data as well as seasonal indices. These seasonal indices are particular useful in healthcare as there is no constant demand per DTC during a year. For proper use of the forecasts these quantities of DTCs must be able to be displayed against the agreed upon quantities and the production of previous years.

However, forecasts on the years 2015 and 2016 are almost not possible. With the transition to the maximum completion time of 120 days for DTCs, the DTC product mix changed. More DTC products are being produced in comparison to the year 2014, but most of these products will be less severe as only some care activities will be included in the DTC product instead of all activities of the complete treatment. At the moment of this research the transition models are not approved which causes uncertainty on quantities and prices. Besides this uncertainty on quantities and prices, there is a need for at least two years of historical data to make accurate forecasts. As this historical data will not be available before April 2017 also accurate forecasts for 2016 will not be possible.

In the monitoring phase there is a demand for accurate and up-to-date production data. To obtain this data there is a need for a build-in WIP-grouper which derives DTCs of the delivered care products. An estimate of the final DTCs could be made available by analysing care pathways. But a precondition for accurate and up-to-date data is accurate registration at the source, in which improvement is possible.

In both the literature study and the stakeholder analysis it emerged that there is a need for knowledge on data collection and need for the information BI will deliver. Preconditions for effective use of BI are the quality of the data, and the end users must be capable to interpret the supplied information and hence determine what is relevant. Which both can be improved by more knowledge on BI. This can be accomplished by more education on BI in study programs or by a more advanced consultancy role of the BI service providing company.

The provided management information of the BI application should not only be available for the board of directors of the hospital. Even more than the board of directors, the financial management and the specialists will need the information the BI application will provide. The financial management will make the strategic planning decisions by negotiating on the quantities and prices with the health insurers for the upcoming year. In this stage access to

forecasts is essential. For the decision making on the tactical level there is a key role for the specialist as they have the ability to control the production on the operational level.

Waiting times are the best control option when it is likely the hospital will achieve the production ceiling. Production stops have occurred in the Netherlands what is seen as undesirable. Therefore, there is a need for a better planning per health insurer which will regulate that when the demand rises the waiting time will increase. BI can help calculate the accurate waiting times per health insurer. It also has the ability to make these waiting times transparent, so the health insurers as well as the patient can make proactive decisions.

All these conclusions help to answer the research objective in one final paragraph.

BI has the potential to improve the financial performance of the Dutch hospitals by delivering actionable management information by using a data warehouse, analytical tools and dashboards. Together with performance management, as identified in the design of the application, it is the basis for a hospital to assess how well it is progressing towards its predetermined strategic objectives, helps to identify areas of strengths and weaknesses, helps to decide on future directions, and enables taking corrective action for tactical decisions.

7.2 Discussion

This subchapter consists of discussion topics regarding the conducted research

The subject of this thesis, the control of hospital funding in the Netherlands, is very complex. This resulted in a quite broad scope for this research. Many components of the Dutch healthcare system and Hospital Information Technology are elaborated extensively and were necessary to understand decisions made in the design of the BI application. Hence, some components like care pathways could have been elaborated in more detail to broaden the understanding. For instance, current research and applications of the care pathways. However, this has not been done as it would distract from the research objective.

This broad scope of the thesis resulted in a literature study which was divided into two parts. Both parts deliver meaningful information for the design of the BI application. Especially the literature study on BI in healthcare is an enrichment for the literature, as this is a relatively unexplored field of research. It provides a review on the preconditions and applications of BI in healthcare. The literature study on the management of hospital production also provided meaningful information, however it could have been more specific, by narrowing it to the research objective.

The sample size of stakeholders interviewed in the stakeholder analysis can be seen as relatively small. However, it must be taken into account this is a qualitative research method in which the average interview took one hour. During these interviews a lot of information was provided which had to be processed. Furthermore, from each stakeholder group at least one spokesman was interviewed, and in the main stakeholder groups of hospitals and health insurers even at least two spokesmen.

The interpretation of the data in the stakeholder analysis can be seen as rather superficial. This is due to the guarantee of confidentiality of the stakeholders. To reduce the risk of unanticipated harm anonymity was guaranteed and potential sensitive information was excluded from the analysis which caused quotes could not been included in this thesis. Even without these quotes the interpretation of the data provided a clear view on the research.

Performance management was chosen as the method to design the BI application, as this emerged from the literature study. Other possible methods for the design of BI applications are not yet considered. Although, the chosen method is sufficient other possibilities could have been taken into account.

The use of only one forecast as an example in the design of the BI application, gives a limited idea of the possibilities. It satisfies for the example, but when more data would have been analysed, better results could have come to surface. Unfortunately, the updated data with reference date February 2015 came too late to be able to compare forecasts with 1.5 year of historical data to forecasts with 2 years of historical data. Also, Winter's forecasting method could have been elaborated more in detail.

The build-in WIP-grouper and the method to derive final DTCs through care pathways have not yet been elaborated into a working model. Unfortunately, also no data of the WIP-grouper of DBC-Onderhoud was available in the data-warehouse of Geniq to show how it ideally would work.

In this thesis no ethical discussion is included concerning whether the BI application is desirable for patients. At some point in time it may occur there is no medical treatment available for the patient. This shows the necessity for BI in healthcare. For the health consumer BI in healthcare can ultimately lead to a basic premium which is as low as possible.

Overall this thesis is an enrichment to literature as it describes a relatively new problem in the Dutch healthcare system. The design of a BI application for the control of hospital funding using performance management is new in this market. There are more countries in the world who will face similar problems which can use the approach provided in this thesis as an guidance to overcome or avoid similar issues.

7.3 Recommendations for further research

This subchapter consists of recommendations for further research

In this research the implementation of a build-in WIP-grouper is discussed to generate insight in actual performance information of hospitals . Further research is necessary to determine how the WIP-grouper can be built into the BI application. Future research can also focus on if it is worth to invest in adjusting such a build-in WIP grouper to the yearly changes in regulations.

Care pathways are also mentioned in the design of the BI application. More background knowledge and use of applications on this topic is recommended. Research on best practice statistical approaches is necessary to obtain valuable forecasts of the uncompleted DTCs to the final DTCs.

In this thesis there is only one forecasting method being carried out, namely Winter's forecasting method. In further research it can be helpful to forecast with other methods as well, for instance double exponential smoothing.

More information on the cost calculation of the DTCs is recommended. However, the agreements between health insurers and health providers are made on P x Q agreements, this research mainly concerns the quantities. Therefore, a focus on costs can generate meaningful new insights. It can also be helpful to provide an uniform method of cost calculation which will insure the health insurers can benchmark on accurate prices.

In the policy recommendation the use of a website which provides accurate waiting times is discussed. Research on the potential of BI in obtaining the waiting times is recommended as well as research on the effect of the use of accurate waiting times by patients and health insurers.

Finally, future research may focus on the validity and use of the BI application when the proposed BI application is being developed and in production.

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Appendix A: History of the Dutch hospital funding from start till 2001

The history of hospital funding in the Netherlands starts in the beginning of the 20th century. Some employers started to set up their own sickness fund for their employees. This was a new phenomenon, as in the 19th century it was common practice to charge fees according to the patient's income [48]. The adoption of the Sickness Act (Ziektewet) in 1913 was the start of government interference in the health insurance domain. Due to political conflicts it took until 1930 before the system of health insurance became operational. This system did not cover medical expenses and attempts to make the system compulsory failed. This changed in 1941 by the German occupier. The compulsory insurance through sickness funds was introduced for employees earning less than a certain income ceiling. Also, the relatives of the employees were covered and it included ambulatory and inpatient specialist care. By this policy the population coverage extended from 45% to 60% [8]. The other 40% relied on one of the private health insurers or health services were paid out-of-the-pocket. Till the 1970's the primary goal of the Dutch government was to guarantee access to basic health services and to promote public health insurance. Specialists were free to start practices and to set their own prices. Together with equal access to healthcare this made the healthcare costs rise rapidly [6].

From the 1970's till 1983 there was an output-based financing system for hospitals. This was a fee-for-service agreement where revenues were directly related to the scale of production. This production consisted of surgical procedures, laboratory tests and the number of nursing days. The maximum number of staff per department was directly related to the expected production of this department. As the government controlled the costs of all services by setting fixed tariffs, using historical nominal amounts, nurses were set a maximum salary per nursing day. In general all costs of the provided care were compensated by the insurers and the volume of production was no issue, making it attractive for hospitals and specialists to maximize the production and therefor provide more treatments [49]. Resulting in a growth of the GDP of the Netherlands spent on healthcare from 6.9% in 1972 to 7.4% in 1980 [50].

In 1983 a global budgeting model was introduced for all hospitals to counter this growth. From this time on the production was not reimbursed afterwards, but each hospital received a prospective global budget to cover the production of that year. The year 1982 was used as a baseline year to calculate the hospital budgets. Every year the budgets were adjusted for the forecasted growth in demand for healthcare and the reduction of spending. If the budget was not reached at the end of the year, the hospital was allowed to keep the remaining budget. On the other hand, if the hospital exceeded the budget it had to find a way to cover these extra

costs. The goal of this system was that the budgeting would enforce hospitals to control their costs effectively and to work more efficiently [7]. A flaw in the system was that 70% of the specialist were self-employed and were still paid on a fee-for-service basis. This meant that it was attractive for the specialist to raise production, while the management wanted to control costs. This led to struggles within the hospital. There also was no relation between the functions in the hospitals and the budget, resulting that deficits were compensated by profitable departments.

In 1988 a function-based budgeting model was introduced to counteract this last problem. The budgets were no longer calculated on historical base, but on four components. These components consisted of an availability component (depending on the size of the population in the service area of the hospital), a capacity component (depending on the number of hospital beds and the number of medical specialists and their capacity), a location-based component (depending on the assigned capacity) and a production component (depending on production agreements with health insurers on the number of hospitalizations, day care visits, inpatient days, and outpatient visits). The availability, capacity, and the location-based component had to cover the fixed part of the hospital costs and the production component the variable part. Because the larger hospitals were supposed to treat the more severe patients, they received a higher compensation for variable parameters like nursing days and outpatient visits. This made it profitable for smaller hospitals to merge to one larger hospital. The main flaw of the function-based model was that it did not kept pace with the growth in healthcare demand. The individual budgets of the hospital were derived from the available macro-budget set by the government. But this macro-budget was set too tight due to government cuts. Together with the growing demand for healthcare, the number of training places for specialists were reduced, leading to the occurrence of waiting lists for patients [2, 7].

The so called cash-on-the-nail system was introduced in 2001, because many hospitals exceeded their budget set by the government, and the waiting lists increased rapidly. To reduce the waiting lists the Dutch government reimbursed the costs of all extra performed production. Which meant that the system basically returned to the time of the output-based financing system. This seemed a logical step as one thought the waiting lists were caused by the tight budget, but instead they were caused by inefficiency [50]. Because the production agreements were no longer binding, the influence of the health insurers became smaller. With the result that between 2000 and 2002 the annual growth in healthcare expenditures increased from 4% to 7% [1].

Appendix B: DTC production of care-product group 040201 Diabetes Mellitus May 2014

040201 Endocrine/nutrition/metabolism - Diabetes mellitus	jan-12	feb-12	mrt-12	apr-12	mei-12	jun-12	jul-12	aug-12	sep-12	okt-12	nov-12	dec-12	jan-13	feb-13	mrt-13	apr-13	mei-13	jun-13	jul-13	aug-13	sep-13	okt-13	nov-13	dec-13	jan-14	feb-14	mrt-14	apr-14
	152	**151**	**135**	**123**	**122**	**126**	**140**	**139**	**174**	**155**	**125**	**286**	**142**	**129**	**142**	**128**	**111**	**53**	**18**	**16**	**22**	**22**	**26**	**19**	**29**	**16**	**6**	**2**
040201004	11	10	6	12	14	10	6	10	10	6	5	20	7	8	8	10	4	2	0	0	0	1	0	2	0	2	0	0
040201005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
040201006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
040201007	3	4	5	2	3	2	1	2	3	0	0	0	3	1	1	6	2	0	3	2	1	1	0	3	1	0	0	1
040201008	3	1	1	2	2	3	1	3	3	0	1	7	2	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0
040201009	3	4	1	1	1	3	6	1	1	2	1	5	6	4	3	1	2	1	0	0	0	0	0	0	0	0	0	0
040201010	7	9	13	10	16	8	17	6	19	14	13	12	9	13	15	9	12	1	1	0	1	0	2	1	3	0	0	0
040201011	0	0	1	0	1	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
040201013	109	111	92	81	73	86	94	90	112	101	82	200	96	92	100	84	72	31	11	9	13	16	21	6	17	9	3	0
040201014	0	0	0	3	0	2	1	4	4	1	1	6	1	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0
040201016	10	7	9	8	7	9	10	18	17	26	16	25	7	10	6	13	10	12	1	0	1	0	0	1	1	2	0	0
040201019	6	5	7	4	5	3	3	5	5	5	6	10	9	1	7	4	4	6	2	5	5	4	3	6	7	3	3	1