Improving managed competition by homogenizing the Dutch DBC

A study into cost variation in Dutch DBCs of patients treated for an inguinal hernia, appendicitis or cholecystitis

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Abstract

Background: In 2009, 12 percent of the annual gross domestic product was spent on health care in the Netherlands, which is more than most other OECD countries. Governmental budgets in the Netherlands had to be cut and cost containment in health care was inevitable. To create awareness of cost of treatment, the Diagnosis Treatment Combinations (DBC) system was introduced. To control costs, all health care players need to know which patients and their treatments are most expensive. Therefore, it is important that patients are classified by adequate classification variables which reflect differences between patient groups to predict high treatment costs. This study will examine whether it is necessary to increase the homogeneity of patient groups in DBCs and which (current) classification variables are able to create homogeneity of patient groups in DBCs to decrease cost variation.

Methods: In this study, patient level data of 2008 from the Dutch DBC database of inguinal hernia repair, appendectomy and cholecystectomy within the medical specialty Surgery were used for analyses. For each clinical pathway, the most relevant DBC codes and classification variables were selected. Classification variables concerned both care activities and patient core variables. Ordinary Least Squares (OLS) regression was used to examine the ability of DBC codes and classification variables to explain cost variation between patients.

Results: Although the predictive ability of appendectomy and cholecystectomy was very low, current DBC codes explained 30 percent of cost variation for inguinal hernia repair. Except for inguinal hernia repair, patient characteristics seemed to have a low predictive ability. However, age has a significant impact on cost variation and this is valid for all clinical pathways. As expected, care activities explained much cost variation. Although classification variables in general had a significant impact for inguinal hernia repair, care activities were most important for all clinical pathways particularly physiotherapy, CT scans, echoes, review ECG, daycare hours, laboratory- and microbiological services, open – and laparoscopic procedure, inpatient- and outpatient visit, pathological examination and emergency care visit.

Conclusions: The choice of a grouping algorithm is essential to increase homogeneity and consequently result in efficiency gains for hospitals. Together with care activities, age can serve as additional classification variable to increase homogeneity of patient groups. Although these results cannot be used to represent all Dutch patients and other important determinants should be taken into account, these results may help the decision-making process of improving the grouping algorithm of the new DOT (*DBC towards transparency*) system. Furthermore, these study results might have valuable implications for the relationships within the triangle in Dutch health care.

Keywords: DBC; health care provider; health Insurer; cost variation; homogeneity; patient classification

1. Introduction

Between 2008 and 2009, health care costs in the Netherlands increased with 2.1 percent (OECD, 2011). Due to ageing in Western countries, expansion of medical research, new technology, and economic growth, health care costs have risen in Western countries during the last decades (Newhouse, 1977; Oostenbrink, 2004; Thorpe, 2005; OECD, 2011). In 2009, 12 percent of the annual gross domestic product (GDP) was spent on health care in the Netherlands. Only the United States with its 17.4 percent of GDP spends more on health care compared to other Organisation for Economic Co-operation and Development – (OECD) countries (Schwarz et al., 1996; Groot, 1999; Evers et al., 2002; OECD, 2011). These reasons led to governmental cuts in the Netherlands and health care reform was inevitable. During the last decade, cost containment in the Netherlands was visible on the supply side by changing governmental regulations on reimbursement, which led to the system of managed competition. The idea behind this new system is competition on price and quality of care between health care providers and health insurers, while government sets the rules to guarantee public values. Ultimately, the new system should lead to increased efficiency in health care (Evers et al., 2002; Den Exter et al., 2004; Tan, Oostenbrink and Rutten, 2006; Van Kleef, 2012). The health care reform, introduced in 2005, in which cost containment and price competition were of major importance, brought new structure to the health care system. Necessary tools to implement managed competition and elaborate cost containment were the Diagnosis Treatment Combinations (DBCs, *Diagnose Behandel Combinaties*). A DBC contains care activities and this division of health care services in one package meant for the health insurers more comprehension and insight in the care delivery of health care providers. Consequently, the health insurers can act as care purchasers, because they would try to find the lowest price per care activity in order to offer their clients the best contract. For the patient this meant insight in prices of care activities and 'shopping' for the most attractive contract between health insurer and hospital (Oostenbrink and Rutten, 2006; NZa, 2006; Schäfer et al., 2010; DBC Onderhoud, 2011). This structure is shown in figure 1, in which agreements between the three parties in the Dutch health care system (the triangle) are illustrated. The consumer has the obligation to pay the premium to their choice of health insurance company and the health care provider is obliged to deliver care, which is specified in the contract between the health insurance company and the provider (Van Ginneken et al., 2011).

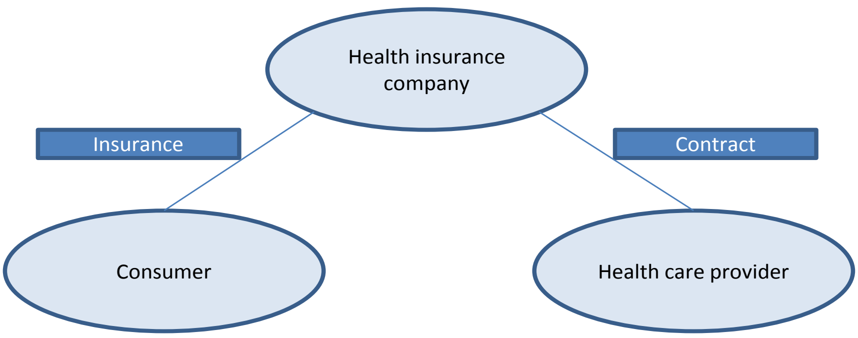

Figure 1. New structure in Dutch health care system since 2005

The new structure provides clarity about what the health care provider should deliver, specified in the contract, and what the consumer will receive, specified in the insurance contract. Specifically, the complete set of care activities a patient receives from the health care provider starting from the first consultation is summed in the DBC. The price of the DBC can be fixed (A segment DBCs) or negotiated upon (B segment DBCs) between a health insurer and a hospital or medical specialist, which will be further described in chapter 2. In addition, the negotiable DBC (B segment DBC) refers to the contract specified in figure 1 (Van Beek et al., 2005; Stolk and Rutten, 2005; DBC Onderhoud, 2011; Ginneken et al., 2011). Apart from the reason of increasing insight in care delivery of health insurers, cost calculation of DBCs changed with the new system. Although prices of fixed DBCs (A segment) are easier to calculate, the price of B segment DBCs are negotiated upon by health insurers and hospitals. The latter form is becoming more important in order to stimulate market forces in health care (Oostenbrink and Rutten, 2006; NZa, 2006; Schäfer et al., 2010). More information about the DBC system will be described in chapter 2. Negotiations within the B segment concern the number of DBCs, amount of care delivered and the price of the provided care. When the content of a DBC is clearly specified it is easier for all parties to negotiate the price of the DBC. Therefore, the rationale behind the introduction of the DBC system was the increase of transparency of health care provision, or better, creating awareness of all health care players regarding cost of treatment and to facilitate managed competition. In the past, the health care financing system was mainly focused on controlling costs and there were hardly any incentives which forced hospitals to produce efficiently. By means of this system, health insurers can negotiate prices with hospitals, try to find the lowest price per care activity and offer patients the most attractive contract.

In the Netherlands, the DBC is used for the implementation of the case-mix system, which defines the mix of patients present in the health care setting and aims to create homogeneous groups based on use of resources. Due to increased health care costs and the influence of managed competition in Dutch health care, the focus shifted more to the relationship between processes and associated costs of treatments inside a DBC. A DBC should combine the demand for specific care, the set diagnosis and the necessary treatment. This will lead to medically standardized DBCs and decreased cost variation. In order to make use of a DBC in the most effective way, homogeneity of patient groups regarding cost of treatment is required. If not, performance comparisons based on the number of DBCs do not control for differences between patients. As a result, reimbursement for large groups of patients is not adequate as it can either be very high or very low. To control costs, all health care players need to know which patients with their treatments are most expensive and this should be measured. It is therefore highly important that patients are classified by adequate classification variables which reflect differences between patient groups to predict high treatment costs. Ultimately, this would be the basis of negotiation between a health insurer and health care provider in order to control costs (Cheah et al., 1999; Lynk, 2001; Evers et al., 2002; Krabbe et al., 2012; Quentin et al., 2012). The choice of a grouping algorithm, used as a tool to increase homogeneity of groups, could consequently result in efficiency gains for hospitals. The goal of the grouping algorithm is to form groups of patients in order to increase (cost) homogeneity of patient classification (Kobel et al., 2011; Tan et al., 2012; Westerdijk et al., 2012).

This study will examine the necessity of increasing homogeneity of patient groups in Dutch DBCs. Therefore, homogeneity of groups needs to be defined to study potential predictive variables of cost variation. Hence, the aim of this study is to examine which of the variables (age, gender, type of hospital, region or care activities) could be a predictive variable of cost variation within DBCs. Therefore, the research question is:

"Which (current) variables in the Dutch DBC classification of health care activities could be used to increase homogeneity of patient classification and ultimately decrease cost variation to improve managed competition?"

In chapter 2 information about the DBC system will be given and the calculation of costs will be described. Furthermore, in chapter 3 the three clinical pathways, on which the analysis will be based, and its treatments will be explained. Then, in chapter 4 the methods followed by the results of the analyses in chapter 5 will be described. Finally, in chapter 6 the research question is discussed and implications for further research will be given.

2. The Dutch DBC system

As of the first of January 2005, the Dutch DBC was introduced. The DBC partly replaced the health care financing system based on budgeting and changed the underlying relations between the health insurer, health care provider and the patient. The use of DBCs in Dutch health care will be described in this chapter.

2.1 The Grouping Algorithm

As the health care provider registers an episode of care a patient receives, he needs to specify four dimensions; the medical specialty, the type of care, the diagnosis and the treatment axis (Stolk and Rutten, 2005; DBC Onderhoud, 2011). In addition, the type of care dimension further distinguishes regular care and follow-up care. First, regular care includes one year in which inpatient admissions, outpatient visits and follow-up care after discharge can take place. Secondly, follow-up care starts after regular care is finished (i.e. after one year). Furthermore, the treatment axis describes whether or not the patient is treated 'outpatient`, 'in day care` or with 'clinical episodes` and what the nature of the treatment is, e.g. open procedure outpatient (201) vs. laparoscopic procedure outpatient (301) (Folpmers and de Bruijn, 2004; Oostenbrink and Rutten, 2006; Steinbusch et al., 2007; Tan et al., 2010). An example of a DBC code for inguinal hernia repair is 0303.11.121.202. This means a DBC for a patient was opened within specialty Surgery, the patient received regular care and was treated for a hernia inguinalis by means of an open procedure inpatient.

Table 1. A DBC of an inguinal hernia repair

Medical specialty	Type of care	Diagnosis	Treatment axis
0303 Surgery	11 Regular care	121 Hernia inguinalis	201 Open procedure outpatient
	12 Follow-up care		202 Open procedure inpatient
			203 Open procedure clinical episode(s)
			301 Laparoscopic procedure outpatient
			302 Laparoscopic procedure inpatient
			303 Laparoscopic procedure clinical episode(s)

2.2 Calculation of costs

Within the DBC classification system, a difference exists between an A-segment DBC and a B-segment DBC. The A segment includes DBCs with fixed prices, which hospitals charge the health insurer and the patient. Within A segment DBCs, care activities have an average price and the price might be higher or lower for a specific treatment, which can differ between hospitals as some hospitals might execute more care activities compared to other hospitals. The fixed prices of the A segment DBC consist of two parts, the honorarium of the medical specialist and the hospital costs are set by the Dutch Health care Authority (*Nederlandse Zorgautoriteit*, NZa). In 2005, the calculation of the honorarium component was established. Since then, the honorarium consisted of the 'norm time' multiplied by the medical specialists' fixed fee per hour of €132 with a range of €6.50 (NZa, 2011g). The norm time (‘care profile`) includes the average number of medical procedures per DBC per hour, which hospitals register and an expert validates upon. However, due to development in health care delivery and DBCs, the calculation of the norm time was reexamined as the amount of time necessary per treatment changed. Currently, the honorarium component (euros per care activity) is the multiplication of norm time and the normative fee per hour (Tan et al., 2010; NZa, 2010; Canoy et al., 2011; NZa, 2011c). Moreover, the hospital costs are determined by DBC Maintenance, specifically the DBC Information System, DIS. This information system collects the hospital costs data, consisting of the resource-use information of all Dutch hospitals, the unit cost information of on average 20 front runner hospitals and the capital costs. After collecting all data from medical specialists and hospitals, the DIS gives feedback to medical specialists to achieve a standard of high quality information (Oostenbrink and Rutten, 2006; Tan et al., 2010). Whereas a cost accounting model is voluntary for most Dutch hospitals, the front runner hospitals are obliged to follow this model (Zuurbier and Krabbe-Alkemade, 2007). This accounting model helps the allocation of resources and costs, which is used by every cost center in the hospital. These hospitals allocate their hospital costs to individual hospital care services and their costs are financed by the DBC system. In addition, these costs relate to direct care services, for instance wages, equipment and overhead costs, and exclude not directly related costs (research, education and teaching). Furthermore, a distinction can be made between the final costs centers, which provide patient care, and the support cost center, which support the final costs centers and include overhead costs. By weighing these costs, the costs for individual hospital services are assigned based on their use of services. The distribution of costs to the emergency room (ER) of an angioplasty is an example of weighing total costs. Thereafter, the NZa calculates the unit cost by collecting all front runners’ weighted costs per hospital service. Then, the Authority determines a national unit price per hospital service which has an average time span of two years (Zuurbier and Krabbe-Alkemade, 2007; Tan et al., 2010).

Although still the largest part of the DBCs have fixed prices, the share of the B segment DBCs is increasing. This is a necessity for the DBC to function as a tool for managed competition, because B segment DBCs are negotiable between health insurer and the health care provider and health insurers want to lower costs. When the share of this segment increases, this will result in more negotiations between hospitals and health insurers. Consequently, competition among hospitals and health insurers takes place to increase efficiency and lower the costs. Ultimately, the most attractive contract will be offered to the patient. The B segment grew from 10 percent since the introduction of the DBC to 70 percent in 2012. The slow increase in the share of the negotiable B-segment is due to the fact that health insurers have to get used to their role as negotiator. As of 2009, capital investments became part of the negotiation process, which beforehand were established by the NZa by means of a normative compensation. Although the B segment DBCs increase in share, the honorarium component is still determined by the NZa. Before 2012, examples of A-segment DBCs were appendectomy, hip fracture, COPD, pneumonia and examples of B-segment DBC were inguinal hernia repair, knee replacement, cholecystectomy, cataract and heart failure (Oostenbrink and Rutten, 2006; Schäfer et al., 2010; NZa, 2011a; CvZ, 2012).

2.3 Division of the budget

As A segment and B segment differ substantially, the funding mechanism differs as well. For A segment DBCs, costs are determined by average unit cost prices, based on resource-use and costs which hospitals provide to the NZa (Schäfer et al., 2010). In addition, the total revenue of each hospital is calculated. In case the revenue exceeds the functional budget for the A list DBCs, the hospital has to pay the difference to the NZa. In case the revenue is lower than the threshold, set by the budget, the hospital is reimbursed by the NZa. This functional budget system, introduced in 1988, consisted of four components on which the budget was based; infrastructure (costs defined per hospital), availability (size of the necessary clinical area), capacity (number of beds, personnel), and productivity (number of hospital admissions, inpatient – and outpatient days). For the B-segment, the NZa does not set a budget limit as these DBCs are fully negotiable. Since the functional budget applies to total production of health care services, the system does not make a distinction between the A- and B-segment even though the budget is only applicable to the A segment. Before 2009, the NZa made the distinction in order to calculate the budget for the A-segment and after this year the distinction was subject to negotiations between health insurers and health care providers. Regarding B segment DBCs; the Dutch Association of Health Insurers annually publishes a directive in which it specifies the hospital performance indicators to guide their hospitals (Schäfer et al., 2012; Tan et al., 2010; NZa, 2011e). However, as of 2012 the budget system will disappear and a hospital will be paid based on the hospitals' performance, which will be described in detail below. Although the largest part of the care activities will be performance based as of 2012, on specific care functions (e.g. emergency care) a separate funding mechanism will apply (Evers et al., 2002; NVZ, 2011).

2.4 Decrease costs, but increase quality

After completion of a DBC, the hospital sends the invoice to the health insurer in order to reimburse. Depending on the sort of DBC, the hospital is paid based on fixed A segment prices or based on negotiated B segment prices (Tan et al., 2010; NZa, 2010). However, the calculation of these prices is based on factual information, while the quality of a hospital is not taken into account. In general, this is applicable to both A segment as B segment DBCs, because both the NZa and the health insurers look at prices and production volume instead of quality (Tan et al., 2010). Even though the focus of the Authority is mainly on prices and production volumes, the prices of A segment DBCs increased at a higher rate than the B segment DBCs, which are the responsibility of health insurers. Therefore, awareness is created on the purchasing side and the discussion on the quality of care is moving from health care providers towards health insurers and public purchasers. Health insurers are pushed to stabilize the health care expenditures and new initiatives have been created. For instance, in the United States and the United Kingdom quality-based purchasing initiatives take place by means of pay-for-performance programs. Driven by health care cost reduction, OECD countries struggle with their design to control health expenditures and stabilize (or even increase) quality of care simultaneously. Additionally, the quality has to meet societal standards of effectiveness, responsiveness, equity, efficiency, and safety, which increases the complexity of the design further (Custers et al., 2007; Van de Ven and Schut, 2009).

3. Three clinical pathways

To study the predictive impact of current DBC codes, care activities and core patient variables on total costs per patient, data from three clinical pathways are used in the analyses. These three clinical pathways are inguinal hernia repair, appendectomy and cholecystectomy. Below these clinical pathways accompanied by their characteristics are described in detail.

3.1 Inguinal hernia repair

An inguinal hernia (medical term: hernia inguinalis) is a protrusion of the peritoneum in the inguinal area, which is the area between the thighs and abdomen. This protrusion appears as a result of a weak spot in the abdominal wall, called a hernia and an edema of the inguinal is the result. Surgical repair of an inguinal hernia is the most common procedure in general surgery (Jenkins and O'Dwyer, 2008; O'Reilly et al., 2011). In the Netherlands, 28,000 people are treated for an inguinal hernia of which 95 percent is man. Furthermore, the chance of an inguinal hernia is 30 percent for men and 3 percent for women (Flich, 1992; Neumayer et al., 2004; Burgmans, 2008; CBS, 2009; Liesbreukcentrum Nederland, 2011; Castorina et al., 2012). Several types of inguinal hernia exist, for example the normal hernia inguinal hernia, the femoral hernia and incarcerated hernia. The femoral hernia occurs below the inguinal ligament, a bluge in the upper part of the thigh. This type accounts for only 3 percent of all hernias and develops mostly in women, because of the wider bone structure of the female pelvis. The other type, incarcerated hernia, is used to describe an obstructed hernia, which cannot be reduced and may lead to bowel obstruction. The incidence of an incarcerated hernia varies between 6.5 and 30 percent, ten years after the occurrence of a hernia inguinalis (Stoppa et al., 1998; Mikkelsen et al., 2002; Dutch Association of Surgery, 2003; Matthews and Neumayer, 2008; Medline Plus, 2012). Patients can be treated by means of an open procedure via inguinal incision or via a laparoscopic/endoscopic repair. One major difference between the open and laparoscopic repair are the total costs, which could differ at least 100 dollars per patient. Although this treatment is costlier, potential benefits of laparoscopic repair are less postoperative pain and a shortened recovery period after surgery (Jacobs et al., 2008; Kulacoglu, 2011). Previous studies have shown the incidence of an inguinal hernia with a mean age of 55 years old and a normal distribution. In addition, the incidence of an inguinal hernia increases with age, especially among men. Also, in 15 percent of the cases, the inguinal hernia reoccurred (Cahlin et al., 1980; Flich, 1992; Ruhl et al., 2006; Castorina et al., 2012). In 2008, the DBC of a patient treated for inguinal hernia was situated in the B segment.

3.2 Appendectomy

Appendicitis is an inflammation of the appendix, which can appear spontaneously. At some point in life, on average 7 percent of the world population suffers from this disease. Most studies show an average age of suffering from appendicitis between 25 and 35 years old and incidence rates are regardless of gender (Adolph et al., 1996; Lunca, 2004; CBS, 2009; Harbrecht et al., 2011). Acute appendicitis is the most common acute surgical abdominal condition and difficult to diagnose. Although, much progress has been made in reducing mortality rates among patients with appendicitis, the same progress has not yet been made on morbidity rates.

For instance, the risk of perforation, especially among elderly is still high. This has an impact on health care costs among patients treated with appendicitis (Margenthaler et al., 2003; Lunca, 2004). The morbidity rate, associated with abdominal pain, increases with age. Whereas the rate is 15 percent for patients over the age of 50, more than 70 percent perceives pain over the age of 80 years old (Telfer, 1988; Lunca, 2004). An appendectomy is the surgical intervention in which the appendix is removed; it is a common and relatively simple procedure (Addiss et al., 1990; Margenthaler et al., 2003; Schreyögg, 2008). Equal to treatment for inguinal hernia repair, the appendectomy can be treated by means of an open procedure or a laparoscopic procedure. The laparoscopic procedure appeared to result in a shorter recovery time compared to open procedures and patients can return to a full diet sooner. Furthermore, this procedure leads to a shorter length of stay in the hospital. However, the laparoscopic procedure leads to higher costs, which prevents it from replacing the open procedure (Wei et al., 2010; Mason et al., 2011; Yeh et al., 2011). In the Netherlands, the procedure appendectomy is performed on 16,000 people every year. This accounts for around 6 percent of all surgical interventions performed each year (Kazemier, 1997; NVGIC, 2010). In 2008, the appendectomy DBC was situated in the A segment.

3.3 Cholecystectomy

The third episode of care is the cholecystectomy, which is the surgical removal of the gallbladder due to gallstones, consisting of cholesterol. Around 10 to 15 percent of the adult population in Western countries has gallstones and the incidence of gallstones annually is 1 in 200 people (Wauben et al., 2008; Gurusamy et al., 2009). One of the major risk factors is gender, because women are much more likely to develop gallstones than men. The average age of receiving cholecystectomy treatment is 52 years old (Simopoulos et al., 2005; Yetkin et al., 2009). In general, symptoms are not likely to occur. Gender is a risk factor, because of stimulation by estrogen on the liver to remove more cholesterol from blood and divert this into the bile. One other major risk factor is overweight. Although losing weight would decrease the chance of gallstones, rapid weight loss or dieting and putting weight back on further increases the production of cholesterol by the liver, which causes an increased risk for gallstones. In addition, genetics and pregnancy increase the chance of gallstones. Whereas gallstones among elderly people are common, gallstones rarely occur among children (Dray et al., 2007; Liu et al., 2008; Gurusamy et al., 2009). Surgical options of the removal include the standard procedure, laparoscopic cholecystectomy and the older more invasive procedure, open cholecystectomy. Although the open procedure has been the gold standard for more than 100 years, this changed in the 1980s when the laparoscopic procedure was introduced (Kues et al., 2006; Rooh-uh-Muqim, 2008; Aaviksoo et al., 2011). Laparoscopic cholecystectomy is regarded as standard treatment as it results in lower morbidity, less pain after surgery and shorter hospital stay compared to the open cholecystectomy. Although this procedure is seen as the gold standard treatment for gallstones, conversion after surgery might still occur. For instance, age, diabetes and previous surgery are preoperative risk factors for conversion. In the Netherlands, the cholecystectomy is executed 24,000 times each year and the most acknowledged minimally invasive operation in the Netherlands (Simopoulos et al., 2005; NVGIC, 2007; Wauben et al., 2008; CBS, 2009). In 2008, the DBC for patients treated for cholecystitis was situated in the B segment.

4. Methods

In this section the collection of data, the statistical tests used and the regression analyses per model for each of the clinical pathways are described.

4.1 Data collection

In this study, patient level data in the Netherlands of three clinical pathways within the medical specialty Surgery were used for analyses. This data was provided by the Dutch Information System (DIS), which contains the information of all Dutch patients. A large amount of data was requested for the subsidized project EuroDRG – Diagnosis-Related Groups in Europe: towards Efficiency and Quality (Tan et al., 2011). Specifically for this study representative data was used providing information about patients treated for inguinal hernia, appendicitis or cholecystitis. For each clinical pathway, data was provided concerning patient number, country of origin, date of birth, age, the start date and end of treatment, gender, type of hospital treated in, region, care activities, number of days hospitalized, DBC code, number of care activities and costs per cost category. The most relevant current DBC codes and potential future classification variables were identified to use in this study. Current DBC codes relate to the treatment axis and classification variables are variables which might function as a tool to homogenize patient groups. These classification variables consist of both patient characteristics (i.e. age, gender, type of hospital and region) and care activities. All Dutch patients receiving one of the current DBC codes in 2008 were eligible for this study. Patients one year of age and below and patients without the Dutch nationality were excluded from analysis, as well as patients who were admitted for follow-up care (type of care equals 12, table 1). Furthermore, for all clinical pathways those patients were excluded who did not receive an open or laparoscopic procedure. In case more than one appendectomy was recorded in the database (recording errors), these patients were excluded from further analyses. And last, those patients whose total costs where greater than three standard deviations from the mean were also considered outliers and additionally excluded from analyses as these observations most likely have a large impact on cost variation. The classification variables for the remaining patients were acquired from the database of the Dutch DBC case-mix system. Below is described what the inclusion criteria were for both DBC codes and classification variables in order to build a database per clinical pathway.

4.2 Methods

Firstly, an ANOVA-test and t-test were performed to examine differences between categories of patient characteristics. This was necessary because there might be intergroup differences, for instance differences between age groups and their relation to total costs. The ANOVA test is used to analyze variances between two or more groups of averages, while the t-test is only suitable for one or two groups of averages. Then, Ordinary Least Squares (OLS) were used to examine the ability of DBC codes and classification variables to explain cost variation between patients. OLS is a statistical technique, which in this study uses patient sample data to estimate the relationship between the outcome variable (total costs) and predictor variables (DBC codes or classification variables). Regressions were either run by means of a forward method or a backward method. A model, which is run by the forward method starts with no variables and adds variables in order of significance. Thus, the variable with the lowest p-value will be added first. This type of analysis normally results in a small number of predictive variables as only those variables are added which substantially impact the R-square. The backward method includes all variables and only those variables are eliminated, which least increase the R-square of the outcome, total costs (Field, 2009). Except for the sensitivity analysis, all models were run by means of the backward method since this type of analysis will result in the largest number of predictive variables. Furthermore, the regression analysis of Model 3 and 4 is performed by excluding the constant (intercept) in the model. The rationale is that patients will most probably not start with a basic level of costs as care activities will determine total costs, which means the intercept might be zero and is therefore excluded.

The first model (Model 1) included current DBC codes, presuming to have a high impact on total costs and function as predictors for total cost variation. In order to only include those variables which occur regularly, DBC codes which include 5 percent or more of the sample, were appointed a dummy variable (DV). Those DBC codes, which were executed less than 5 percent, were summed and captured in a residual DV ('other DBC codes'). Furthermore, the reference category concerned the DBC code, which relates to the majority of the patients.

The second model (Model 2) includes a set of patient core variables, which are age, gender, type of hospital and region. Patient core variables are split in homogenous groups to study the (significant) differences within each characteristic and compare this to the other characteristics. These variables were the only available variables in the Dutch database regarding patient characteristics. The core variables are selected based on the assumption to have a significant impact on the outcome, total costs. Age categories were constructed based on five quintiles chosen according to the observed age distribution in the DBC database of each clinical pathway with the reference category being the largest category. Furthermore, the groups of hospitals are split into general-, medium sized general-, large general-, non-university- and university teaching hospital, with the largest category being the reference category. The final variable, region, was categorized by zip code starting ranging from one to nine. The nine regions relate to the first number of a Dutch zip code, with the largest category being the reference category.

In model 3, the impact of care activities on total costs is analyzed. For each patient, the available care activities were categorized in a specific cost category. These cost categories and how they are valued are shown below in table 2. Unit costs per cost category are based on reference prices of the Dutch Manual for Costing or by tariffs provided by the Dutch Healthcare Authority, which was described in chapter 2.2. All costs were based on Euro 2008 cost data (CVZ, 2010; DBC Onderhoud, 2011; NZa, 2011c; Tan et al., 2011).

Table 2. Cost categories used in the Netherlands

Reference prices (Dutch Manual for Costing)	**Tariffs (Dutch Healthcare Authority)**
Inpatient days	Medical imaging services
Intensive care days	Medical devices
Daycare hours	Surgical procedures
Outpatient and emergency room visits	Diagnostic activities
Laboratory services	Microbiological and parasitological services
Blood products	Pathological services
Paramedical and supportive services	
Rehabilitation services	

The criteria of including care activities were based on the number of times they were executed or the most expensive care activities. The two inclusion criteria were both the costs of the care activity exceeding five percent of the average costs per patient and care activities which have been performed on more than one percent of the patients. The executions below this percentage have not been taken into account in the analysis. In order to include a great number of care activities, some activities, which are similar (i.e. CT-scans, echoes and laboratory services) were summed. In this model, total costs of most important care activities are taken as independent variables to analyze their impact on total costs per patient.

Firstly, the impact of care activities on total costs per clinical pathway was examined. Secondly, a sensitivity analysis was performed. Predictors having the highest univariate correlation with the outcome were selected. Thirdly, variables explaining the largest share of variance were added to the model. Additionally, variables which were of significant impact on total costs were also added to the model.

The final model (Model 4) includes the set of (significant) patient variables and important care activities, which were the result of the analyses of Model 2 and 3. These core variables were selected based on the precondition to have a significant impact on total costs of each of the clinical pathways and explain cost variation. Model 4 is run until only significant patient core variables and important care activities remain.

All analyses are based on 2008 patient data from the Dutch DBC database. Statistical analyses were conducted with the statistical software program SPSS for Windows version 20.0. Cases with p-value<0.05 were considered statistically significant.

5. Results

In this chapter, the results per clinical pathway will be described. Firstly, the ability of DBC codes to predict total costs is analyzed. Then, patient variables are chosen in order to analyze their impact on the outcome and parallel to this analysis, the explanatory factor of care activities on cost variation is analyzed. Finally, the impact of the significant patient variables and care activities on total costs will be analyzed in order to make assumptions on the prediction of costs per clinical pathway.

5.1 Model 1 – Impact current DBC codes on total costs

Table 3 shows the average and standard deviation of total costs per clinical pathway. Furthermore, table 4 presents the frequencies of patients per treatment axis treated for all clinical pathways. However, the frequencies are much lower than stated in previous mentioned literature (Kazemier, 1997; CBS, 2009; NVGIC, 2010; Liesbreukcentrum Nederland, 2011; Castorina et al., 2012). Although approximately five percent of the patients per database were outliers and therefore excluded from further analyses based on criteria mentioned in Methods, the final database varies by the average number of performed inguinal hernia repairs, appendectomies and cholecystectomies each year. For inguinal hernia repair, mainly DBC code 202 (open inpatient surgery) was opened, whereas for appendectomy DBC code 203 (surgery with clinical episodes) was mainly opened and for cholecystectomy mostly DBC code 303 (laparoscopic surgery with clinical episodes) was opened. These frequencies correspond to literature as the open procedure is mostly performed for both appendectomy and inguinal hernia repair (Jacobs et al., 2008; Kulacoglu, 2011; Mason et al., 2011; Yeh et al., 2011). However, for cholecystectomy most patients are treated by means of the laparoscopic procedure, which corresponds to literature as the laparoscopic procedure for cholecystectomy is seen as the gold standard (Rooh-uh-Muqim, 2008; Aaviksoo et al., 2011). The first regression model, Model 1, is shown in table 5. This model examines the ability of current classification variables (DBC codes) to explain cost variation between DBCs for inguinal hernia repair, appendectomy and cholecystectomy. The number of DBC codes, which have been identified per clinical pathway, ranged from one for appendectomy to two for cholecystectomy and three for inguinal hernia repair. This can be explained as patients receiving an appendectomy or cholecystectomy are treated within specialty surgery with clinical episodes instead of treatment inpatient or outpatient. This, however, is possible among patients treated for an inguinal hernia repair. The inclusion criterion for DBC codes was to reach a share of 5 percent of all used DBC codes. The DBC codes opened less than in 5 percent of the patients were not included in analysis and summed in 'other DBC codes'. Furthermore, the DBC code valid for the largest number of patients is chosen as reference DBC code.

Inguinal hernia repair

The first DBC code of inguinal hernia (203, surgery with clinical episode(s)) resulted in a total costs increase of €973 and the last DBC code (302, laparoscopic inpatient surgery) resulted in an increase of €251 compared to the reference group (202, open inpatient surgery). All DBC codes in inguinal hernia repair have a significant impact on the outcome, total costs. The absolute difference in total costs between the cheapest and most expensive DBC code (DBC code 2 vs. DBC code 1) for inguinal hernia repair was €973. Furthermore, the relative difference in total costs between the mean (presented in table 3) and the most expensive DBC code was an increase of 50 percent (€1,929 vs. €2,902). 30 Percent of cost variation can be explained by DBC codes for inguinal hernia repair. Thus, quite a large share of variation in costs can be allocated to the treatment axis.

Appendectomy

As the patient sample of appendicitis only represents two DBC codes, the largest DBC code, 203, is chosen as reference DBC code and DBC code 303 (laparoscopic surgery with clinical episode(s)) as independent variable. DBC code 303 resulted in a total costs increase of €320 and has a significant impact on total costs. The absolute difference in total costs between the DBCs (DBC code 4 vs. DBC code 2) was €320. The relative difference in total costs between the mean (presented in table 3) and most expensive DBC code was an increase of 8 percent (€3,965 vs. €4,285). Furthermore, one percent of cost variation can be explained by one DBC code for appendectomy, which means hardly no share of cost variation can be explained by the type of treatment axis.

Cholecystectomy

The database of patients treated for gall stones represents three DBC codes with the largest DBC code, 303, chosen as reference DBC and DBC code 203 and 'other DBC codes' as independent variables. Furthermore, treatment within DBC code 203 resulted in an increase of €1,744, while 'other DBC codes' resulted in a reduction of total costs of €1,598. Both variables have a significant impact on total costs. The absolute difference in total costs between the DBCs (DBC code 2 vs. DBC code 4) was €1,744. Furthermore, the relative difference in total costs between the mean (presented in table 3) and the most expensive DBC code was an increase of 73 percent €2,391 vs. €4,135). Finally, 15 percent of cost variation can be explained by DBC codes for cholecystectomy meaning a small share of variation in costs can be allocated to the type of treatment axis.

Comparison between clinical pathways

When comparing all three clinical pathways, DBCs with a laparoscopic procedure leads to lower significant costs compared to the DBCs with an open procedure for cholecystectomy. This does not correspond to literature as the laparoscopic procedure for cholecystectomy usually leads to higher costs (Tiwari et al., 2011). The opposite is true for appendectomy and inguinal hernia repair treatment. Regarding these clinical pathways, laparoscopic DBCs resulted in significantly higher costs compared to the open DBCs, which is in agreement to literature (Jacobs et al., 2008; Wei et al., 2010; Kulacoglu, 2011; Mason et al., 2011). As outpatient DBCs rarely appear for these three clinical pathways, a comparison between inpatient and outpatient DBCs could not be made. Regarding inguinal hernia repair, daycare treatment leads to significantly higher costs compared to inpatient treatment regardless of the type of treatment (open vs. laparoscopic treatment). For appendectomy and cholecystectomy a comparison could not be made.

Table 3. Mean total costs and standard deviation per clinical pathway

In euro (€)	Inguinal hernia repair	Appendectomy	Cholecystectomy
Mean (SD)	1,929 (796)	3,965 (1,304)	2,391 (1,537)

Table 4. Deviation of patients per treatment axis of inguinal hernia repair, appendectomy and cholecystectomy

		Inguinal hernia repair		Appendectomy		Cholecystectomy	
		N = 16,001		*N = 8,489*		*N = 17,181*	
Code	**Treatment axis**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
201	Open outpatient surgery	58	0.4			4	0.0
202	Open inpatient surgery	9655	60.3			2	0.0
203	Open surgery with clinical episode(s)	3706	23.2	5239	61.7	1537	9.0
301	Laparoscopic outpatient surgery	3	0.0			10	0.1
302	Laparoscopic inpatient surgery	1918	12			654	3.8
303	Laparoscopic surgery with clinical episode(s)	661	4.1	3250	38.3	14974	87.1

Table 5. Model 1 – Regression analyses examining ability of current DBC codes to explain cost variation between DBCs for the three clinical pathways (*p<0.05 and these codes are significant)

	Inguinal hernia repair		Appendectomy		Cholecystectomy	
	$R^2 = 0.300$		$R^2 = 0.014$		$R^2 = 0.154$	
	β	SE	B	SE	β	SE
Constant	1,623*	7	3,843*	18	2,297*	12
DBC code 1 (202)	reference group					
DBC code 2 (203)	973*	13	reference group		1,744*	38
DBC code 3 (302)	251*	17				
DBC code 4 (303)			320*	29	reference group	
Other DBC codes	1,127*	26			-1,598*	56

5.2 Model 2 – Impact patient characteristics on total costs

Table 6 presents the average age per clinical pathway and the standard deviation. For inguinal hernia repair, the average age is 52 years old (SD 22), which is younger than the average age of 57 stated in literature (Neumayer et al., 2004; Castorina et al., 2012). For appendectomy, the average age is much lower (30 years old; SD 18), which corresponds to literature (Lunca, 2004; Harbrecht et al., 2011). And for cholecystectomy, patients are on average 49 years old (SD 18), which is slightly higher than stated in literature (Simopoulos et al., 2005; Yetkin et al., 2009). In addition, table 7 presents patient characteristics per clinical pathway with the total number of patients per category and their share of the total number of patients per variable. The total number of patients treated for inguinal hernia after correction for outliers and other preconditions for inclusion into analysis, is 16,001, which is much lower than the number mentioned in literature (Liesbreukcentrum Nederland, 2011). The total number of patients treated for appendicitis is 8,489, which is much lower than stated in literature (CBS, 2009; NVGIC, 2010). And the number of cholecystectomy treatments is also much lower (17,181) than stated in literature (CBS, 2009). Although many patients were considered outliers due to inclusion criteria, large differences in frequencies can, however, not be declared. The age categories were chosen based on quintiles according to the age distribution in the patient databases. For inguinal hernia, the quintiles were 2 to 36 years, 37 to 51 years, 52 to 61 years, 62 to 70 years and 71 to 96 years. For appendicitis these quintiles differed, i.e. 2 to 13 years, 14 to 20 years, 21 to 32 years, 33 to 47 years and 48 to 95 years and the final clinical pathway with its quintiles 8 to 34 years, 35 to 45 years, 46 to 55 years, 56 to 65 and 66 to 95 years. With respect to gender 90 percent of patients treated with an inguinal hernia repair are male, 54 percent treated with appendectomy are male and 29 percent treated with cholecystectomy are male. These percentages correspond to literature as inguinal hernia mainly occurs in men, cholecystitis occurs mainly in women and appendicitis occurs regardless of gender. The database for each clinical pathway contained several missing values. For inguinal hernia repair, 572 patients did not show information regarding the type of hospital they were treated in. For appendectomy, 432 patients did not show information regarding type of hospital and one patient did not contain a category for region. Finally, for cholecystectomy, 672 patients did not contain information regarding type of hospital and 226 patients did not contain information regarding their region.

Table 6. Average age per clinical pathway

	Inguinal hernia repair		**Appendectomy**		**Cholecystectomy**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age	52	22	30	18	49	18

Table 7. Patient characteristics per clinical pathway

	Inguinal hernia repair		Appendectomy		Cholecystectomy	
	Number	Share	Number	Share	Number	Share
Age quintile 1	3281	20	1612	19	3363	20
Age quintile 2	3227	20	1736	20	3702	22
Age quintile 3	3145	19	1740	20	3391	20
Age quintile 4	3074	19	1751	21	3342	19
Age quintile 5	3274	20	1650	19	3383	20
Male	14367	90	4552	54	5056	29
Female	1634	10	3937	46	12125	71
Small hospital	4263	26	1846	22	4381	25
Medium-sized hospital	4679	29	2466	29	4637	27
Large general hospital	2215	14	1439	17	2654	15
Non-university teaching hospital	3819	24	1800	21	4382	26
University teaching hospital	452	3	505	6	500	3
Unknown	572	4	432	5	672	4
Region 1	2172	13	1129	13	2831	16
Region 2	2209	14	1324	16	2324	14
Region 3	2880	18	1690	20	2987	17
Region 4	1551	10	603	7	1551	9
Region 5	2083	13	1128	13	1929	11
Region 6	1482	9	787	9	1402	8
Region 7	1510	9	840	10	1615	9
Region 8	1106	7	347	4	1068	7
Region 9	1008	7	640	8	1248	7
Unknown			1	0	226	2

In table 8 the average costs of patients treated with inguinal hernia repair, appendectomy and cholecystectomy are presented. In order to assess significant differences between categories, first an ANOVA-test and independent samples t-test were performed per clinical pathway to analyze variances between averages of categories. Both tests show that categories within variables age (divided by quintiles), gender, type of hospital and type of region do not differ significantly from each other. However, assumed was variances would exist within gender and type of hospital as the number of patients per category differed substantially. The mean total costs per episode of care is €1,929 (SD €796) for inguinal hernia repair, €3,965 (SD €1,304) for appendectomy and €2,391 (SD €1,537) for cholecystectomy.

Table 8. Cost characteristics of the patient samples

In euro (€)	Inguinal hernia repair		Appendectomy		Cholecystectomy	
	N = 16,001		*N = 8,489*		*N = 17,181*	
	Mean	SD	Mean	SD	Mean	SD
Total costs	1,929	796	3,965	1,304	2,391	1,537
Age quintile 1	1,730	711	3,827	1,298	2,228	1,324
Age quintile 2	1,855	759	3,806	1,195	2,111	1,208
Age quintile 3	1,892	776	3,800	1,146	2,191	1,323
Age quintile 4	1,956	797	3,981	1,267	2,369	1,507
Age quintile 5	2,212	850	4,425	1,495	3,080	2,011
Male	1,932	791	3,913	1,338	2,640	1,733
Female	1,907	840	4,016	1,337	2,287	1,436
Small hospital	2,131	903	4,016	1,337	2,420	1,548
Medium-sized hospital	1,825	698	3,891	1,283	2,433	1,574
Large general hospital	1,738	663	3,907	1,246	2,286	1,458
Non-university teaching hospital	1,999	823	3,991	1,246	2,419	1,506
University teaching hospital	1,726	755	4,240	1,320	2,763	1,818
Region 1	1,899	756	3,862	1,150	2,396	1,563
Region 2	1,846	822	3,785	1,245	2,332	1,581
Region 3	1,879	844	3,937	1,299	2,267	1,481
Region 4	2,149	804	4,070	1,338	2,317	1,389
Region 5	1,942	789	3,915	1,251	2,518	1,574
Region 6	1,915	734	4,136	1,394	2,366	1,540
Region 7	1,921	777	4,040	1,449	2,459	1,598
Region 8	2,127	804	4,166	1,417	2,370	1,369
Region 9	1,772	682	4,168	1,304	2,530	1,573

Table 9 presents Model 2, which examines the ability of patient characteristics to explain cost variation between DBCs for inguinal hernia repair, appendectomy and cholecystectomy. As discussed in chapter Methods, the patient characteristics are age, gender, hospital type and region. For inguinal hernia repair, the first quintile is chosen as reference category because this category represents the largest part of the patient sample. The fourth quintile is chosen as reference category for appendectomy being the largest category. For cholecystectomy, quintile two is chosen as reference category being the largest category. As gender-category 'Male' is larger than category 'Female' for both inguinal hernia repair and appendectomy, this category is chosen as reference category. As cholecystectomy is executed mostly on women, this category is chosen as reference. Furthermore, medium sized hospital type is chosen as reference category as is Region 3 for all clinical pathways.

Inguinal hernia repair

The predictability of patient variables on total costs is much lower than the prediction by DBC codes (Model 1) for inguinal hernia repair with 9 percent. Age has quite a large impact on cost variation ($p<0.05$). However, the magnitude of the effect differs per clinical pathway. Patients of age in quintile 1 for inguinal hernia repair led to the lowest costs. However, patients in quintile 5 led to the highest total costs (+€487). This, however, is plausible as surgery among elderly might lead to more complications, more precautions are needed and their recovery period might take longer. Regarding type of hospital, treatment in a large general hospital resulted in significantly lowest costs for inguinal hernia repair and treatment in a small general hospital resulted in significantly highest total costs (+€296). Regarding geographical area, patients treated for inguinal hernia and living in Region 4 resulted in highest costs ($p<0.05$) compared to the reference category, region 3 (+€163) and treatment in region 9 resulted in significantly lowest costs (-€351).

Appendectomy

The predictability of patient variables on total costs was almost as low as the prediction by DBC codes (Model 1) with 5 percent. Patients of age in quintile 3 resulted in the lowest total costs (-€193). Furthermore, gender explained cost variation both for appendectomy and cholecystectomy although the impact differed between these clinical pathways. Females treated for appendectomy led to significantly higher costs (+€106). Although not true for inguinal hernia repair, treatment for appendicitis resulted in significantly highest costs (+€396) when patients were treated in a university teaching hospital. Regarding geographical area, the highest extra costs ($p<0.05$) were accounted on patients living in region 8 when treated for appendectomy as the costs increased by €195.

Cholecystectomy

The predictability of patient variables on total costs was comparable to the prediction by DBC codes (Model 1) with 6 percent. Patients in quintile 2 led to the lowest total costs and quintile 5 to significantly highest total costs (+€914). Whereas women treated for appendectomy led to significantly higher costs, women treated for cholecystectomy led to significantly lower costs (-€257). This could have been caused by the fact treatment of women is more of a routine treatment, whereas men are not treated regularly and therefore, costlier. Receiving treatment in a large general hospital resulted in the lowest significant costs. Comparable to appendectomy treatment, cholecystectomy also resulted in highest costs (+€302) ($p<0.05$) when patients were treated in a university teaching hospital. Regarding region, patients treated for cholecystitis and living in region 9 resulted in highest total costs compared to the reference category (+€111).

A range of potential future explanatory variables were available in the database of the DBC system. Although not complete, this set of variables offered an opportunity to research their ability of explaining cost variation. The new chosen classification variables, patient characteristics, seemed to have a low predictive ability with the largest predictive value for inguinal hernia repair. Age, particularly elderly, has a significant impact on cost variation and this is valid for all clinical pathways. However, the magnitude of the effect differs per clinical pathway. Furthermore, both type of hospital and region are important predictors for cost variation when patients are diagnosed with inguinal hernia. The opposite is true for treatments appendectomy and cholecystectomy, as gender is here of significant and substantial impact on cost variation. In addition, gender does have an opposite effect on each of these clinical pathways. Although the net result differs substantially between a large general hospital and a small general hospital and is represented as a significant, explanatory factor for cost variation for inguinal hernia repair, the impact is smaller and non-significant for both appendectomy and cholecystectomy. Differences between these types of hospitals could be explained by the fact large hospitals produce at lower costs due to economies of scale and division of labor compared to smaller hospitals. These hospitals experience lower costs per produced output as volume increases. Thus, large hospitals perceive lower costs of treatment when the number of beds increases. Although this could be a reason for inguinal hernia repair, differences between small and large hospitals are non-significant for appendectomy and cholecystectomy. This, however, could be explained by the fact these treatments are routine treatments which could be performed in any given hospital. Regarding appendectomy and cholecystectomy teaching hospitals are shown as significant predictors of cost variation compared to non-teaching hospitals, although the latter is shown as a non-significant predictor. High costs of treatment in a teaching hospital could be caused by heterogeneity of patients treated, because the more severe (less efficient) patients are often sent to teaching hospitals. Additionally, due to the delay of teaching medical students, costs per patient increase. However, when hospitals are paid extra for these students, costs should be equalized (Posnett, 2002; Dormont et al., 2004; Street et al., 2010). However, due to the increasing market share of B segment DBCs, these hospital differences will decrease further as health insurers can now negotiate about care products and their prices. Consequently, hospitals will evaluate their costs of treatment in order to compete (NZa, 2011f; Westerdijk et al., 2012). Additionally, geographical area seemed to predict cost variation significantly well for inguinal hernia repair, but results for appendectomy and cholecystectomy are less convincing.

Table 9. Model 2 – Inguinal hernia repair, appendectomy and cholecystectomy; backward regression analyses examining ability of core patient characteristics to explain cost variation between DBCs (*p<0.05 and these codes are significant)

	Inguinal hernia repair		Appendectomy		Cholecystectomy	
	R^2 = 0.093		R^2 = 0.049		R^2 = 0.061	
	β	SE	β	SE	β	SE
Constant	1,658.90	21.95	3,892.18	50.05	2,086.83	41.54
Age quintile 1	reference group		-143.00*	45.31	109.37*	37.35
Age quintile 2	137.53*	19.64	-179.11*	44.29	reference group	
Age quintile 3	165.51*	19.86	-193.42*	44.51	70.95	36.42
Age quintile 4	228.33*	19.98	reference group		224.46*	36.65
Age quintile 5	487.18*	19.61	447.49*	45.07	913.80*	36.68
Male	reference group		reference group		257.38*	26.08
Female	38.00	20.93	105.87*	28.59	reference group	
Small hospital	295.95*	17.19	83.68*	41.47	-32.54	33.58
Medium hospital	reference group		reference group		reference group	
Large hospital	-143.96*	20.98	-41.98	46.26	-142.55*	38.34
Non-teaching hospital	220.31*	17.60	73.80	41.94	-33.74	32.90
Teaching hospital	-12.61	38.27	396.08*	64.44	302.20*	71.23
Region 1	-80.20*	24.08	-129.47*	56.23	76.57	44.03
Region 2	-127.41*	22.62	-223.47*	49.45	-60.01	43.28
Region 3	reference group		reference group		reference group	
Region 4	163.25*	25.27	121.87	62.88	-52.53	48.98
Region 5	-56.40*	24.24	-37.08	53.46	99.71*	47.94
Region 6	-58.27*	26.17	91.80	59.33	-108.00*	51.54
Region 7	-2.40	25.04	112.69*	57.06	54.84	47.48
Region 8	67.84*	28.70	195.48*	77.45	-10.95	55.82
Region 9	-350.54*	30.23	121.59	65.08	111.37*	54.26

5.3 Model 3 – Impact important care activities on total costs

Tables A, B and C in the appendix show the most important care activities, which satisfy the inclusion criteria of respectively inguinal hernia repair, appendectomy and cholecystectomy. Additionally, the explanation of each care activity is given per table, the number of patients who received the care activity, the average number of times patients receive the care activity during treatment and the unit costs per care activity are presented. For the summed care activities a weighted average of the costs is used. In table D, E and F Model 3 is presented with the predictive power of the most important care activities per clinical pathway. The criteria of inclusion were based on the number of times they were performed or the most expensive care activities as described earlier. The number of most important care activities differs between the clinical pathways. Below, results per clinical pathway will be described.

Inguinal hernia repair

In total 13 care activities were identified of which all had a significant impact on total costs. The R-square of the predictive important care activities was 90 percent for inguinal hernia repair, which means they have substantial predictive power on total costs. The regression analysis showed an increased predictive ability compared to current DBC codes. In agreement to literature, the database of inguinal hernia repair consisted of several types of hernias, such as hernia inguinalis, hernia incarcinata and the hernia femoralis, which were often performed as open procedures. Although this distinction was made, both the hernia incarcinata and hernia femoralis were performed rarely according to the database. This is also in agreement to literature. Therefore, all three types of hernias were summed and defined as open procedures. Regarding recurrence of the hernia inguinalis, literature states in 15 percent of Dutch population the hernia inguinalis reoccurs. This, however, is not fully in agreement to this study as 9 percent of Dutch population in 2008 was treated for a recurrence of the hernia inguinalis of which the largest part was treated by means of an open procedure. Physiotherapy showed the largest increase in total costs (+€25.81). This number means for every Euro spend on Physiotherapy, €24.81 Euro is spend on other care activities. Only one percent of the patients treated received this care activity, but cost variation could be explained by the fact this small number of patients treated with physiotherapy could have received many other care activities as they are treated for a longer amount of time. Ultimately, costs increase for those patients and as a result variation in costs increases. Furthermore, Daycare resulted in the largest decrease of total costs (-€6.07). This means for every extra Euro spend on Daycare hours (extra Daycare hours) less other care activities are needed. An explanation could be as a patient's stay is extended by several hours, chances of a recurrence are lower as patients are under supervision and less other health care services are needed. This, however, was not examined.

Appendectomy

For appendectomy, in total 20 care activities were identified of which 19 were of significant impact on total costs. The predictive power of care activities for appendectomy increased even more compared to inguinal hernia repair by 99 percent and are much better predictors compared to current DBC codes. The largest cost increase is caused by Daycare hours (+€2.41). This means for every Euro spend on Daycare, €1.41 is spend on other care activities. An explanation could be more tests are performed as the patient is still present and might have complaints. As a result, variance in total costs rise. Microbiological and parasitological services led to the lowest cost increase by €0.68. This means, for every Euro spend on these care activities, less health care services are needed (-€0.32) elsewhere. Both the open as the laparoscopic procedure resulted in no extra cost increase elsewhere. Thus, regardless of the type of procedure, performing surgery does not lead to extra costs elsewhere.

Cholecystectomy
For cholecystectomy, 23 most important care activities explained 99 percent of cost variation. Thus, care activities are much better cost predictors compared to current DBC codes. Examination and screening resulted in the largest increase in costs (+€3.11). The large increase in costs could be declared by the fact performing this care activity could lead to performance of other care activities. This procedure is rarely performed in 2008 according to data, but variation of performing this procedure could have been high. However, this is not examined. The largest decrease in costs was caused by performing laboratory services, although not significantly. Furthermore, performing an echo also led to decreasing total costs by -€0.78. This means, spending extra money on Echoes might lead to less use of other care activities and therefore, lowers total costs.

Comparison between clinical pathways
When comparing model 3 of each clinical pathway only care activity Laboratory services resulted in an increase of total costs for every clinical pathway. This means performing these services led to the performance of other services and therefore increased costs, consistently for all clinical pathways. Whereas Daycare hours resulted in decreased total costs for inguinal hernia repair, this care activity increased total costs for both appendectomy and cholecystectomy. This means, for inguinal hernia repair extension of patient stay led to less performance of other care activities, whereas the opposite is true for both appendectomy and cholecystectomy. Furthermore, the performance of an open inguinal hernia repair procedure resulted in the performance of more other care activities compared to the laparoscopic procedure. For appendectomy, total costs remained unchanged independent of the type of procedure. Additionally, performing an open cholecystectomy led to less performance of other care activities compared to the laparoscopic procedure, although the difference is minor. This model overall shows that important care activities have a significant and substantial impact on all clinical pathways. Furthermore, the analysis shows which variables might lead to extra costs by executing other variables.

5.4 Model 4 – Significant impact of core variables on total costs

Model 4 in tables 10, 11 and 12 shows the classification variables, which have a significant impact on total costs per clinical pathway. Table 10 shows the variables, which have an impact on the total costs of inguinal hernia repair, table 11 the variables on total costs of appendectomy and table 12 the impact variables on total costs of cholecystectomy. In order to assess which core variables classify patients into mutually exclusive groups of patients, variables are chosen which have a significant impact on total costs in previous performed analyses (Model 2 and 3). These tables show the results of the regression analyses assessing the ability to predict total costs per patient with first the regression with all significant variables from model 2 and 3. The final analysis showed the remaining core variables having a significant impact on total costs per clinical pathway.

Inguinal hernia repair

Regarding table 10, 14 patient classification variables and 12 care activities were the variables having a significant impact on total costs of inguinal hernia repair and were therefore core variables. The significant patient variables were all the classified patient characteristics (age, type of hospital and type of region). The significant care activities were physiotherapy treatment, daycare, clinical chemistry and hematology, CT scans, echoes, inpatient days, microbiology and parasitology, hernia (open and laparoscopic procedure), pathological examination, outpatient visit and emergency care visit. Thus, these variables, together with the significant patient classification variables, predict cost variation on treatment inguinal hernia repair best. The predictive power of these variables is 92 percent on the outcome, which is slightly more than the predictive power of separate models 2 and 3.

Appendectomy

Regarding table 11, six patient classification variables and 19 care activities have a significant impact on total costs of an appendectomy. The significant patient variables were age, gender, type of hospital and region. Except for diagnostic laparoscopy, all care activities were significant. Furthermore, the predictive power of these variables is 99 percent on total costs. This percentage is much larger than the predictive power of Model 2, but equal to the predictive power of Model 3 for appendectomy.

Cholecystectomy

For cholecystectomy, two patient classification variables and 23 important care activities have a significant impact on total costs of treatment. The two significant patient core variables were age (quintile 5) and region (region 9). Whereas patient variables did not seem to impact total costs of cholecystectomy significantly, 23 care activities had a significant impact on total costs. Except for laboratory services, all care activities were significant. These, in total 25, significant variables led to a predictive power of 99 percent on total costs of cholecystectomy, which is larger than the R square of Model 2, but equal to Model 3.

Model 4 in general shows the greatest predictive ability with the R-square ranging between 0.90 for inguinal hernia repair and 0.99 for appendectomy and cholecystectomy. When comparing the three clinical pathways, only age and region had consistent significant impact on total costs. When comparing only inguinal hernia repair and appendectomy, age, type of hospital and region had significant impact on total costs for both clinical pathways. Although many patient core variables had significant impact for all clinical pathways in Model 2, adding care activities led to insignificance of several patient core variables, especially for cholecystectomy. Furthermore, except for one care activity in every clinical pathway, care activities had significant impact on total costs and were therefore important cost predictors. Physiotherapy treatment, laboratory services, CT scans, echoes, daycare, inpatient days, microbiological and parasitological services, open surgical procedure and laparoscopic surgical procedure, pathological examination, outpatient visit and emergency room visit were the twelve care activities which were significant for all clinical pathways. In addition, only care activities laboratory services and emergency care visits led to a positive association with total costs (but higher costs) consistently all clinical pathways.

5.5 Sensitivity analysis

A sensitivity analysis is performed after the original analysis for all clinical pathways. After stepwise addition of important care activities for inguinal hernia repair and appendectomy, the results were equal to the original analysis and there were no differences in significance of patient variables after the addition of care activities. However, the sensitivity analysis for cholecystectomy showed different results. These results are shown in table G in the appendix. This analysis, however, resulted in no significant patient core variables and the R-square did not change. Furthermore, only eleven of the in total 24 important care activities seemed to impact total costs such that it had an impact on the R-square. Model 3 is used as the model for cholecystectomy for further discussion, in order to compare all three clinical pathways. The outcome of less significant care activities by the forward analysis for cholecystectomy could be declared by the fact only variables which actually improve the model by having a significant impact on the R-square are added whereas the backward analysis eliminate variables which improve the model by being eliminated. The backward analysis, however, did not discard any variables as no variable would improve the model by deletion.

After the addition of most important care activities, the predictive ability of inguinal hernia repair, appendectomy and cholecystectomy increases substantially compared to model 2, which only analyses the impact of patient classification variables on costs. Although the difference between the predictive power of model 3 and the final model is quite small for appendectomy and cholecystectomy, patient classification variables did have an impact on costs of inguinal hernia repair. Moreover, in the final model of inguinal hernia repair and appendectomy several patient classification variables have a significant impact on costs. This, however, is not the case for cholecystectomy, which only includes age quintile 5 and region 9 as patient classification variables. Consistently for all clinical pathways, both laparoscopic and open procedure are nearly 1, which means for every Euro spend on these types of surgery, no extra money is spend on other care activities. As a footnote can be mentioned, applicable to all models analyzed in this study, costs of care activities are based on costs per care activity multiplied by the number of times performed. This causes small differences in cost variation. However, practice based data is used this way.

Table 10. Model 4 – Inguinal hernia repair; backward regression analyses examining ability of core variables to explain cost variation between DBCs (first and final analysis) (*p>0.05 and these are significant)

Inguinal hernia repair	**R^2 = 0.91**		**R^2 = 0.91**	
	β	SD	β	SD
Age quintile 2	108.23*	15.79	108.52*	15.78
Age quintile 3	136.51*	16.02	137.88*	15.92
Age quintile 4	134.59*	16.49	137.11*	16.18
Age quintile 5	194.42*	16.95	197.11*	16.61
Small general hospital	325.05*	13.94	325.28*	13.94
Large general hospital	-52.59*	16.83	-51.64*	16.79
Non-university hospital	308.33*	14.15	308.63*	14.14
Region 1	-97.74*	18.30	-97.19*	18.29
Region 2	-66.30*	16.97	-65.51*	16.94
Region 4	213.16*	19.67	215.66*	19.41
Region 5	101.68*	18.36	102.01*	18.35
Region 6	-94.09*	20.27	-93.63*	20.26
Region 8	177.04*	22.27	177.48*	22.26
Region 9	-279.71*	23.46	-278.87*	23.44
CA 1 – Physiotherapy treatment	25.61*	1.04	25.59*	1.04
CA 2 – Daycare hours	-6.28*	0.32	-6.28*	0.32
CA 3 – Laboratory services	1.74*	0.38	1.81*	0.37
CA 4 – CT scans	1.14*	0.30	1.14*	0.30
CA 5 – Echoes	1.58*	0.24	1.58*	0.24
CA 6 – Review ECG	0.63	0.80		
CA 7 – Inpatient days	0.81*	0.02	0.81*	0.02
CA 8 – Microbiological and parasitological services	4.11*	0.72	4.10*	0.72
CA 9 – Hernia, open procedure	1.01*	0.02	1.01*	0.02
CA 10 – Laparoscopic surgery	0.95*	0.02	0.95*	0.02
CA 11 – Pathological examination	3.72*	0.63	3.72*	0.63
CA 12 – Outpatient visit	3.66*	0.12	3.65*	0.12
CA 13 – Emergency room visit	2.09*	0.14	2.08*	0.14

Table 11. Model 4 – Appendectomy; backward regression analyses examining ability of core variables to explain cost variation between DBCs (first and final analysis) (*p>0.05 and these are significant)

Appendectomy	**R^2 = 1.00**		**R^2 = 1.00**	
	β	SD	β	SD
Age quintile 1	-10.97*	5.85	-8.87*	4.89
Age quintile 2	-13.76*	5.63	-11.89*	4.64
Age quintile 3	-6.13	5.63		
Age quintile 5	0.15	5.87		
Female	16.28*	3.75	16.05*	3.72
Small general hospital	20.19*	4.46	19.30*	4.37
Teaching hospital	11.01*	7.84		
Region 1	18.06*	5.81	20.23*	5.70
Region 2	21.10*	5.19	23.82*	5.02
Region 7	-7.11	6.26		
Region 8	-8.99	9.16		
CA 1 – Physiotherapy treatment	0.91*	0.08	0.91*	0.08
CA 2 – Echoes	1.01*	0.28	1.05*	0.28
CA 3 – CT scans	0.84*	0.04	0.84*	0.04
CA 4 – Examination and screening	1.23*	0.06	1.23*	0.07
CA 5 – Daycare hours	2.24*	0.41	2.26*	0.41
CA 6 – Diagnostic laparoscopy	-0.03	0.42		
CA 7 – Review ECG	1.97*	0.37	1.98*	0.35
CA 8 – Intensive care days	1.03*	0.01	1.03*	0.01
CA 9 – Laboratory services	1.25*	0.03	1.24*	0.03
CA 10 – Inpatient days	1.02*	0.00	1.02*	0.00
CA 11 – Microbiological and parasitological services	0.69*	0.03	0.69*	0.03
CA 12 – Appendectomy	0.99*	0.01	0.99*	0.01
CA 13 – Laparoscopic appendectomy	0.99*	0.00	0.99*	0.00
CA 14 – Test laparotomy	1.34*	0.14	1.35*	0.14
CA 15 – Wounds treatment	1.43*	0.12	1.43*	0.12
CA 16 – Pathological examination	0.54*	0.03	0.54*	0.03
CA 17 – Outpatient visit	1.22*	0.03	1.07*	0.03
CA 18 – Emergency room visit	1.08*	0.03	0.99*	0.02

CA 19 – Rehabilitation services	1.14*	0.10	1.12*	0.10
CA 20 – Other laboratory services	2.21*	0.41	2.23*	0.41

Table 12. Model 4 – Cholecystectomy; backward regression analyses examining ability of core variables to explain cost variation between DBCs (first and final analysis) (*p>0.05 and these are significant)

Cholecystectomy	**R^2 = 0.99**		**R^2 = 0.99**	
	β	SD	β	SD
Age quintile 1	1.11	5.36		
Age quintile 4	8.86	5.34		
Age quintile 5	13.75*	5.61	14.55*	5.36
Male	4.78	4.37		
Large general hospital	7.74	5.40		
Teaching hospital	22.12	11.96		
Region 5	0.56	6.24		
Region 6	13.20	7.13		
Region 9	20.32*	7.53	19.47*	7.45
CA 1 – Physiotherapy treatment	1.21*	0.06	1.21*	0.06
CA 2 – CT scans	0.99*	0.03	0.98*	0.03
CA 3 – Echoes	-0.75*	0.07	-0.76*	0.07
CA 4 – ERCP	0.84*	0.12	0.84*	0.12
CA 5 – Examination and screening	3.09*	0.13	3.09*	0.13
CA 6 – Daycare hours	1.27*	0.22	1.27*	0.22
CA 7 – Diagnostic duodenoscopy	1.18*	0.05	1.18*	0.05
CA 8 – Diagnostic laparoscopy	2.32*	0.47	2.32*	0.47
CA 9 – Review ECG	0.81*	0.24	0.83*	0.24
CA 10 – Intensive care says	0.86*	0.01	0.86*	0.01
CA 11 – Laboratory services	1.12*	0.03	1.12*	0.03
CA 12 – Inpatient days	0.99*	0.00	0.99*	0.00
CA 13 – Microbiological and parasitological services	1.03*	0.07	1.03*	0.07
CA 14 – Endoscopic gallbladder drainage	1.31*	0.15	1.32*	0.15
CA 15 – Cholecystectomy, open procedure	0.95*	0.03	0.95*	0.03
CA 16 – Laparoscopic cholecystectomy	0.97*	0.01	0.98*	0.01

CA 17 – Test laparotomy	1.61*	0.12	1.61*	0.12
CA 18 – Therapeutic laparoscopy	0.96*	0.12	0.96*	0.12
CA 19 – Hernia umbilicalis	0.72*	0.13	0.73*	0.13
CA 20 – Pathological examination	1.16*	0.07	1.18*	0.07
CA 21 – Outpatient visit	0.96*	0.02	0.96*	0.02
CA 22 – Emergency room visit	1.04*	0.03	1.04*	0.03
CA 23 – Rehabilitation services	0.91*	0.04	0.91*	0.04
CA 24 – Laboratory services	-1.31	1.00		

6. Discussion

6.1 Main findings

This study presents the results of the analysis of currently used classification variables (DBC codes) and potential new classification variables (patient characteristics and care activities) in order to improve the grouping algorithm used in the Dutch DBC system. Overall, current DBC codes do not seem to explain much cost variation for these clinical pathways and are therefore not suitable enough to increase homogeneity of patient classification. This is in accordance with literature as previous studies showed that current DBC codes as classification variables do not explain all cost variation between DBCs of clinical pathways (Busse et al., 2008; Street et al., 2010; Tan et al., 2012). Results of this study suggest patient classification variables function as insufficient predictive variables to define mutually exclusive patient groups with the exception of inguinal hernia repair. The most important classification variables are care activities as these variables describe almost all cost variation. Furthermore, the analyses show which variables might lead to extra costs by executing other variables. Specifically laboratory services and emergency care visits have an equal impact on all three clinical pathways. Although care activities are most important, adding patient characteristics, at least for inguinal hernia repair treatment, has a positive impact on cost prediction. Specifically age, together with care activities, can serve as additional classification variable to improve the Dutch grouping algorithm. Even though patient variables do have a significant impact, the variables explaining the largest share of cost variation for these three clinical pathways are care activities. Thus, care activities are valuable explanatory predictors for cost variation and might increase homogeneity of patient groups.

As hospitals have to invoice all DBCs in the B-segment in order to have the care delivered reimbursed, evaluating the Dutch grouping algorithm is necessary. This way of reimbursing gives health insurers a grip on negotiating health care costs based on information about treatment, volume and quality of care in favor of the patient (Schäfer et al., 2010; NZa, 2011e). In 2008, inguinal hernia repair and cholecystectomy were both treatments situated in the B segment, whereas appendectomy was situated in the A segment. This meant both inguinal hernia repair and cholecystectomy treatment were negotiable clinical pathways. For the health care provider this meant competition with other hospitals concerning the amount of care delivered in a DBC and the price of the provided care. Then, health insurers would try to find the cheapest DBC and contract the hospital offering the lowest price. Negotiating DBCs, specifically for inguinal hernia repair and cholecystectomy, took place among hospitals and health insurers in order to increase efficiency. This, however, is not true for appendectomy treatment as this clinical pathway had its cost of treatment fixed in 2008. Due to this, health care providers performing an appendectomy might be less willing to offer efficient and low cost care. Since 2012, these three clinical pathways are all B segment treatments, which means competition between hospitals and health insurers takes place for all treatments examined in this study. This type of DBC is most important to implement managed competition and elaborate cost containment. As these treatments are all B segment treatments and increasing efficiency is beneficial to all of them, the outcomes of this study could be of value to the grouping algorithm. It is, however, not possible to use these hospital samples to represent all treatments as the clinical pathways used are routine treatments of which cost variation might be lower than average. Even though cost variations still appear, these treatments are standard and more diverse treatments should be examined in order to generalize these study results and to draw conclusions for the Dutch population.

6.2 Transition phase

In order to identify efficiency in hospitals, costs of hospital services were calculated with respect to a best practice hospital. By the examination of several treatments, hospitals and health care providers have insight in the hospital resource utilization in relation to DBCs which can be compared to the gold standard. Consequently, it measures the extent to which efficiency within DBCs, but more general within hospitals, is achieved. Due to these intra DBC differences and differences in costs, specialties and hospitals are either underpaid or overpaid per patient. When a hospital is overpaid for several DBCs, they would be less willing to evaluate their treatments whereas underpaid hospitals would want to evaluate their treatments. Consequently, the overpaid hospitals would not be motivated to optimize their cash flows to improve efficiency, while the underpaid hospitals would want to decrease costs per DBC. It is exactly this effect which, together with managed competition and the demand-led system, led to the increased importance of the B segment system of reimbursement (Quentin et al., 2012; Westerdijk et al., 2012). As of the 1st of January 2012, the DBC system moved to the 'DBC towards Transparency` system (*DBC Op weg naar Transparantie*, DOT). This system is developed by the Ministry of Health, the Dutch Health care Authority (NZa), health insurers, health care providers, and DBC Maintenance. The purpose of DOT, together with payments based on health care provider's performance, is the further increase of transparency in costs. For this system to function optimally, health insurers have to take up an active role as care purchasers. The introduction of the new system causes major changes for both hospitals and health insurers. First of all, the number of DBCs, which are now called DBC care products, decreased from 30,000 DBCs to 4,400 care products (NZa, 2011b, c). With these 4,400 care products, the NZa hopes to cover all care. Another purpose of the DOT system was to decrease differences in efficiency between specialties. This should be accomplished by the fact the DOT system works cross-specialties, which will lead to uniformity. Specialties who deliver the same (amount of) care, are reimbursed for equal care products. Furthermore, the part of care in which hospitals face financial risk (B segment) will increase to 70 percent. Especially this change will be of major impact on financial processes within hospitals. Hospitals work towards pay-for-performance schemes and will not receive a budget, but are paid, based on their performance, by health insurers. More specifically, hospitals and health care providers are paid based on care products. Therefore, hospitals have to register all delivered care as thoroughly and as understandable as possible for health insurers to have all delivered care reimbursed and to cover all expenses. Consequently, transparency of resource-use and costs will be achieved. This new transition model will be fully implemented after two years. In 2012, hospitals will receive 95 percent of the difference in turnover, while in 2013 this will not exceed 70 percent. Thus, health care institutions are given time to transpose A segment to B segment (NZa, 2011d, e).

6.3 Impact DOT system on findings

One of the biggest changes after the introduction of the DOT system is the reimbursement of a care product instead of a DBC. Whereas a DBC was started by the health care provider and validated upon, a care product is derived automatically from the diagnosis and the care activities registered. The derivation of the care product happens via a national grouper. Prior to the DOT system, reimbursement of care delivery was based on the DBC code without using the information (content of care delivery and its costs) stored in the DBC. Since January 2012, care activities form the basis of registration of care delivery. Additionally, the care product is derived from these activities and the care product is what health insurers reimburse. Ultimately, the financial health of a hospital depends on this registration. The new system also works cross-specialties, which will lead to more cost- and medically homogenized care products. As medical recognition of care products increases, so does the homogeneity of costs and resource-use (DBC Onderhoud, 2011b; NZa, 2011b-f). This study showed care activities would be sufficient classification variables as they explained nearly all cost variation. Therefore, they could contribute to the new DOT system to increase homogeneity of patient groups treated for inguinal hernia, appendicitis and cholecystitis. However, patient level data from 2008 is used. Further research is necessary to examine the impact of the new DOT system on the (frequency of) performance of care activities and ultimately, cost variation between patient groups.

6.4 Implications for the triangle in Dutch health care

The new DOT system and the findings of this study might have an impact on the relationships between the three involved parties in Dutch health care (patient, health care provider and health insurer). Due to the increasing share of B segment DBCs, negotiating price and quality of care are becoming increasingly important. By means of care activities, homogeneity of patient groups can be increased. For health care providers and hospitals this means the cheapest and most expensive treatments (and patients) are identified. Consequently, they can focus more on the expensive patients, optimize the care process and improve efficiency. Furthermore, hospitals might want to search for other hospitals to cooperate with in order to improve their process of care delivery. This could mean splitting expensive treatments in segments in order to excel in a part of the clinical pathway instead of perform average on the whole treatment process. For inguinal hernia repair this could mean hospital A only performs the regular form of surgical repair of the inguinal hernia whereas hospital B only performs the incarcerated hernia treatment or the laparoscopic procedure. A disadvantage of specializing hospitals for patients is they cannot be treated everywhere and might have to travel to find the best treatment. For health insurers this means focused purchasing of specific care negotiating a certain level of quality. A precondition for this is that enough hospitals offer a basic package of treatments in order to maintain competition between hospitals and keep prices low. Increasing homogeneity by means of care activities for health insurers means target group offering of contracts to patients. Furthermore, as health insurers can negotiate both price and quality, a complete package can be offered to the patient. Although risk equalization is maintained in the Netherlands concerning the basic benefit package, health insurers are free to choose whether or not they want to offer elective care to the patient. Consequently, health insurers might want to offer contracts to the healthiest patients who might not need additional care. Increasing homogeneity of patient groups might result in either more or less acceptance of (expensive) patients and could ultimately lower the costs. A drawback, however, is that offering this extra information to health insurers (resulting from increased homogeneity) could lead to cream skimming although only for elective care. Instead of cream skimming, health insurance companies might also want to look at raising the insurance premium for those patients, which result in highest costs. This way, health insurers increase homogeneity of their contracted patients. As a result they could either differentiate in premium or allocate the extra costs to the patient.

6.5 Implications for further research

Several limitations must be considered while the results of this study are interpreted. Other important patient characteristics, which might explain cost variation further, should be added, although this was impossible due to the lack of data. Factors as mortality rate of hospitals, insurance type, socio-economic status, morbidities, discharge status, risk level (i.e. weight and height), level of functions and physician characteristics would make the model more accurate. Additionally, information about presence of elective care would be valuable. Although almost every individual in the Netherlands is insured for health care expenses, the addition of elective care (i.e. physiotherapy, psychological support) might lead to variation in total costs. Secondly, a variety of treatments should be analyzed in future research to give more valuable suggestions. Due to the fact only three clinical pathways were analyzed, no generalizations can be made. As three routine treatments are chosen, these results are not representative for most other treatments. Thirdly, by including all care activities or using different inclusion criteria, the outcomes might have differed. Furthermore, apart from exclusion of recording errors in the database of appendectomy, more recording errors in the databases of each clinical pathway could be present. More information about hospitals (i.e. total production, capital and equipment) would be valuable to make valid assumptions about type of hospital. And last, correlations between care activities may be present as performing care activities might have led to the performance of other care activities.

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8. References

Aaviksoo, A., Paat-Ahi, G., Sakoswki, P., Saluse, J., Swiderek, M. (2011). DRGs in Europe: a cross country analysis for cholecystectomy *(draft version)*

Addiss, D.G., Shaffer, N., Fowler, B.S. Tauxe, R.V. (1990). The epidemiology of appendicitis and appendectomy in the United States. American Journal of Epidemiology, Vol. 132, issue 5, pp. 910 – 925

Adoplh, V.R., Falterman, K.W. (1996). Appendicitis in children in the managed care era. Journal of pediatric surgery, Vol. 31, pp. 1035 – 1037

Beek, L., Goossen, W.T., van der Kloot, W.A. (2005). Linking nursing care to medical diagnoses: heterogeneity of patient groups. International Journal of Medical Information, Vol. 74, pp. 926 – 936

Brown, L.M., Rogers, S.J., Cello, J.P., Brasel, K.J., Inadomi, J.M. (2011). Cost-effective treatment of patients with symptomatic cholelithiasis and possible common bile duct stones. Journal of the American College of Surgeons, Vol. 212, issue 6, pp. 1049 – 1060

Burgmans, J.P.J., Clevers, G.J., Verbeek, E.J.M.M., Verleisdonk, E.J.M.M. and Davids, P.H.P. (2008). From the clinic: Endoscopic inguinal hernia surgery: less chronic pain and a faster reintegration into the workforce. Journal of Care and Management, Vol. 16, issue 9, pp. 393 – 395

Busse, R., Schreyogg, J., Smith, P.C. (2008). Variability of healthcare treatment costs amongst nine EU countries – results from the HealthBASKET project. Health Economics, Vol. 17, pp. 29 – 53

Cahlin, E. and Weiss, L. (1980). Results of postoperative clinical examination of inguinal hernia after three years. Acta Chirurgica Scandinavica, Vol. 146, pp. 421 – 426

Canoy, M.F.M., ten Have, A.G.M., Oortwijn, W.J., Romme, M.C.J. (2011). Annual book Governmental spending 2011. Chapter 4: Health care expenditures under control? [Jaarboek Overheidsuitgaven 2011. Hoofdstuk 4: Zorgkosten onder controle?]

Castorina, S., Luca, T., Privitera, G., El-Bernawi, H. (2012). An evidence-based approach for laparoscopic inguinal hernia repair: lessons learned from over 1,000 repairs. Clinical anatomy, doi: 10.1002, ca.22022

Centraal Bureau voor Statistiek (CBS) (2009). Operaties in het ziekenhuis; soort opname, leeftijd en geslacht. Accessed on http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=80386NED&LA=NL on the 30th of June 2012

Cheah, J., Chee, Y.C. (1999). Case Mix-for better or worse? Singapore Medical Journal, Vol. 40, issue 1, pp. 9-12

College van Zorgverzekeringen (CvZ). (2010). Handleiding voor kostenonderzoek: Methoden en standaard kostprijzen voor economische evaluaties in de gezondheidszorg.

College van Zorgverzekeringen (CvZ). (2012). Rapport 6e Monitor Regeling financiering zorg onverzekerbare vreemdelingen

Custers, T., Arah, O.A., Klazinga, N.S. (2007). Is there a business case for quality in The Netherlands? A critical analysis of the recent reforms of the health care system. Health Policy, Vol. 82, pp. 226 – 239

DBC Onderhoud. (2011a). Website of the organization of DBC maintenance. Accessed on http://www.dbconderhoud.nl on the 7th of December 2011

DBC Onderhoud. (2011b). DOT RSAD Document: Beschrijving van het RSAD-model, de basis van DOT, de nieuwe DBC systematiek voor de ziekenhuiszorg, v20111001

Dormont, B., Milcent, C. (2004). The sources of hospital cost variability. Health Economics, Vol. 13, issue 10, pp. 927 – 939

Dray, X., Joy, F., Reijasse, D. (2007). Incidence, risk factors and complications of cholelithiasis in patients with home parenteral nutrition. Journal of American College of Surgeons, Vol. 204, issue 2, pp. 13 – 21

Dutch Association of Hospitals (NVZ). Website Dutch Association of Hospitals. Theme site pay for performance 2012. Accessed on http://www.prestatiebekostiging2012.nl/functioneel-budget-fb on the 12th of December 2011

Dutch Association of Surgery *[Nederlandse Vereniging voor Heelkunde].* (2003). Treatment of Hernia Inguinalis

Dutch Association of Gastrointestinal Surgery [*Nederlandse Vereniging voor GastroIntestinale Chirurgie,* NVGIC]. (2010). Guidelines for diagnosis and treatment of acute appendicitis.

Dutch Association of Gastrointestinal Surgery [*Nederlandse Vereniging voor GastroIntestinale Chirurgie,* NVGIC]. (2007). Guidelines suffering from gallstones.

Dutch Health care Authority (NZa) (2006). Document and assessment criteria for development DBC system

Dutch Health care Authority (NZa) (2010). Report rates medical specialists 2011. Rapport tarieven medisch specialisten 2011. Explanation of rate decisions

Dutch Health care Authority (NZa) (2011a). Website Nederlandse Zorgautoriteit: Zorgonderwerpen. Accessed on http://www.nza.nl/zorgonderwerpen on the 11th of December 2011

Dutch Health care Authority (NZa) (2011b). Rapport Doorontwikkelagenda DOT. Doorontwikkeling prestaties en tarieven medisch specialistische zorg

Dutch Health care Authority (NZa) (2011c). Consultatiedocument Honorarium medisch specialisten DOT 2012. Berekening honorariumcomponent per zorgproduct

Dutch Health care Authority (NZa) (2011d). Website Nederlandse Zorgautoriteit: Artikel 'NZa: verbeterd declaratiesystem ziekenhuizen' d.d. 7 juni 2011. Accessed on http://www.nza.nl/publicaties/nieuws/NZa-verbeterd-declaratiesysteem-ziekenhuizen on the 14th of February 2012

Dutch Health care Authority (NZa) (2011e). Consultatiedocument Invoering prestatiebekostiging medisch specialistische zorg. Uitwerking van implementatie per 2012

Dutch Health care Authority (NZa) (2011f). Eindrapport Impactanalyse DOT ziekenhuiskostendeel. De impact van DOT onder prestatiebekostiging

Dutch Health care Authority (NZa) (2011g). Beleidsregel BR/CU-2031. Honorariumbedragen DBC's medisch specialistische zorg

Evers, S., Voss, G., Nieman, F., Ament, A., Groot, T., Lodder, J., Boreas, A., Blaauw, G. (2002). Predicting the cost of hospital stay for stroke patients: the use of diagnosis related groups. Health Policy, pp. 21 – 42

Everhart, J.E. (1994). Abdominal wall hernia. In: Everhart, J.E. et al. Digestive diseases in the United States: epidemiology and impact. National Institute of Diabetes and Digestive and Kidney Diseases, pp. 471 – 507

Field, A. (2009). Discovering statistics using SPSS. Third edition: Oriental Press, Dubai

Flich, J., Alfonso, J.L., Delgado, F., Prado, M.J., Cortina, P. (1992). Inguinal hernia and certain risk factors. European Journal of Epidemiology, Vol. 8, issue 2, pp. 277 – 282

Folpmers, M., de Bruijn, J. (2004). Honorering in de zorg: Overgang naar de nieuwe landelijke DBC-systematiek. MCA Tijdschrift voor organisaties in control, Vol. 6, pp. 18 – 25

Van Ginneken, E., Schäfer, W., Kroneman, M. (2011). Managed competition in the Netherlands: an example for others? Eurohealth, Vol. 16, issue 4

Groot T.L.C.M. (1999). Budgetary reforms in the non-profit sector: a comparative analysis of experiences in health care and higher education in the Netherlands. Financial Accountability and Management, pp. 353 – 376

Gurusamy, K.S., Samraj, K. (2009). Cholecystectomy for patients with silent gallstones. The Cochrane Library, issue 1, pp. 1 – 13

Harbrecht, B.G., Franklin, G.A., Miller, F.B., Smith, J.W., Richardson, D.J. (2011). Acute appendicitis – not just for the young. The American Journal of Surgery, Vol. 202, issue 3, 00. 286 – 290

International Classification of Diseases, 10th version. Accessed on http://www.icd10.nl/ on the 7th of May, 2012

Jacobs, V.R., Morrison, J.E. (2008). Comparison of institutional costs for laparoscopic preperitoneal inguinal hernia versus open repair and its reimbursement in an ambulatory surgery center. Surgical laparoscopy, endoscopy & percutaneous techniques, Vol. 18, issue 1, pp. 70 – 74

Jenkins, J.T. and O'Dwyer, P.J. (2008). Inguinal hernias. British Medical Journal, Vol. 336, pp. 269 – 272

Kazemier, G., de Zeeuw, G.R., Lange, J.F., Hop, W.C.J., Bonjer, H.J. (1997). Laparoscopic vs. open appendectomy. A randomized clinical trial. Surgical Endoscopy, Vol. 11, pp. 336 – 340

Van Kleef, R.C. (2012). Managed competition in the Dutch health care system: preconditions and experiences so far. Public policy review, Vol. 8, issue 2, pp. 171 – 190

Kobel, C., Thuilliez, J., Bellanger, M.M., Pfeiffer, K.P. (2011). DRG systems and similar patient classification systems in Europe. In: Diagnosis-related groups in Europe: moving towards transparency, efficiency and quality in hospitals, first edition, Open Press and WHO Regional Office for Europe, Buckingham

Krabbe, Y., Groot, T., Lindeboom, M. (2012). Marktwerking in ziekenhuizen. Gezondheidszorg Economisch Statistische Berichten (ESB). Jaargang 97, pp. 121 – 124

Kues, J, de Jong, J.A., Gooszen, H.G., van-Laarhoven, C.J. (2006). Laparoscopic versus open cholecystectomy for patients with symtomatic cholecystolithiasis. Cochrane Database Systematic Review, Vol. 4

Kulacoglu, H. (2011). Current options in inguinal hernia repair in adult patients. Hippokratia, 15, 3, pp. 223-231

Liesbreukcentrum Nederland (2011). Website Diakonessenhuis Liesbreukcentrum Nederland. Accessed on http://www.liesbreukcentrumnederland.nl on the 5th of January 2012

Liu, B., Beral, V., Balkwill, A., Green, J., Sweetland, S., Reeves, G. (2008). Galbladder disease and use of transdermal versus oral hormone resplacement therapy in postmenopausal women: prospective cohort study. BMJ, Vol. 337, pp. 1 – 9

Lunca, S., Bouras, G., Romedea, N.S. (2004). Acute appendicitis in the elderly patient: diagnostic problems, prognostic factors and outcomes. Romanian Journal of Gastroenterology, Vol. 14, issue 4, pp. 299 – 303

Lynk, W.J. (2001). One DRG, one price? The effect of patient condition on price variation within DRGs and across hospitals. International Journal of Health Care Finance and Economics, pp. 111 - 137

Margenthaler, J.A., Longo, W.E., Virgo, K.S., Johnson, F.E., Oprian, C.A., Henderson, W.G., Daley, J., Khuri, S.F. (2003). Annals of Surgery, Vol. 238, issue, 1, pp. 59 – 66

Mason, A., Or, Z., Renaud, T., Street, A., Thuilliez,J., Ward, P. (2011). How well do DRGs for appendectomy explain variations in resource use? An analysis of patient level data from ten European countries *(draft version)*

Matthews, R.D., Neumayer, L. (2008). Inguinal hernia in the 21st century: an evidence-based review. Current Problems in Surgery, Vol. 45, pp. 261 – 312

Medline Plus (2012). Femoral hernia. Accessed on http://www.nlm.nih.gov/medlineplus/ency/article/001136.htm on the 8th of April, 2012

Mikkelsen, T., Bay-Nielsen, M., Kehlet, H. (2002). Risk of femoral hernia after inguinal herniorrhaphy. British Journal of Surgery, Vol. 89, pp. 486 – 488

Neumayer, L., Giobbie-Hurder, A., Jonasson, O., Fitzgibbons, R., Dunlop, D., Gibbs, J., Reda, D., and Henderson, W. (2004). Open mesh versus laparoscopic mesh repair of inguinal hernia. The New England Journal of Medicine, Vol. 350, issue 15, pp. 1819 – 1827

Newhouse, J.P. (1977). Medical care expenditure: A cross-national survey. The Journal of Human Resources, Vol. 12, issue 1, pp. 115 – 125

OECD (2011). OECD Health Data 2011. Accessed on http://stats.oecd.org on the 4th of December 2011

Oostenbrink, J.B. (2004). Principles and progress in healthcare cost analysis. Applications to economic evaluations in COPD (PhD thesis). Erasmus University Rotterdam

Oostenbrink, J.B. and Rutten, F.F.H. (2006). Cost assessment and price setting of inpatient care in the Netherlands. The DBC case-mix system. Health Care Management Science, Vol. 9, pp. 287 – 294

O'Reilly, J., Serdén, L., Talbäck, M., McCarthy, B., Wiley, M. (2011). DRGs in Europe – Performance of ten European DRG systems in explaining variation in resource utilization in inguinal hernia repair (*draft version)*

Quentin, W., Scheller – Kreinsen, D., Geissler, A., Busse, R. (2012). Appendectomy and diagnosis-related groups (DRGs): patient classification and hospital reimbursement in 11 European countries. Langenbeck's Archives of Surgery, Vol. 397, pp. 317 – 326

Reid, B. and Sutch, S. (2008). Comparing diagnosis-related group systems to identify design improvements. Health Policy, Vol. 87, pp. 82 – 91

Rijksinstituut Volksgezondheid en Milieu (RIVM) (2011). Zorgbalans: Prices B-segment. Accessed on http://www.gezondheidszorgbalans.nl/kosten/doelmatigheid/prijzen_bsegment on the 14th of February, 2012

Rooh-ul-Muqim, F.H. (2008). Comparison in terms of postoperative morbidity and hospital stay between open cholecystectomy and laparoscopic cholecystectomy. World Journal of Laparoscopic Surgery, Vol. 1, 3, 17 – 21

Ruhl., C.E., Everhart, J.E. (2006). Risk factors for inguinal hernia among adults in the US population. American Journal of Epidemiology, Vol. 165, issue 10, pp. 1154 – 1161

Schäfer, W., Kroneman, M., Boerma, W., Van den Berg, M., Westert, G., Devillé, W., Van Ginneken, W. (2010). The Netherlands – Health system review. Health systems in transition, Vol. 12 No. 1: Chapter 3. Financing

Schreyögg, J. (2008). A micro-costing approach to estimating hospital costs for appendectomy in a cross-European context. Health Economics, Vol. 17, issue 1, pp. 59 – 69

Schwarz, F.W., Glennester, H., Saltman, R.B. (1996). Fixing health budgets: experience from Europe and North America. Chichester: Wiley, pp. 75 – 92

Simopoulos, C., Botaitis, S., Polychronidis, A., Tripsianis, G., Karayiannakis, A.J. (2005). Risk factors for conversion of laparoscopic cholecystectomy to open cholecystectomy. Surgical Endoscopy, Vol. 19, pp. 905 – 909

Steinbusch, P.J.M., Oostenbrink, J.B., Zuurbier, J.J., Schaepkens, F.J.M. (2007). The risk of upcoding in casemix systems: A comparative study. Health Policy, Vol. 81, issues 2-3, pp. 289 – 299

Stolk, E.A. and Rutten, F.H. (2005). The "Health Benefit Basket" in the Netherlands. European Journal of Health Economics, Vol. 1, 6, pp. 53 – 57

Stoppa, R., Wantz, G.E., Munegato, G. and Pluchinotta, A. (1998). Hernia Healers: An Illustrated History. Arnette: Velizy Villacounlay, France

Street, A., Scheller-Kreinsen, D., Geissler, A., Busse, R. (2010). Determinants of hospital costs and performance variation: methods, models and variables for EuroDRG project. Working papers in Health Policy and Management

Tan, S.S. (2009). Microcosting in economic evaluations. Issues of accuracy, feasibility, consistency and generalisability. Dissertation, Erasmus University Rotterdam

Tan, S.S., Oostenbrink, J.B., Rutten, F.F.H. (2006). Costs and prices of healthcare services in the Netherlands: a microcosting approach based on case-vignettes. Rotterdam, Erasmus University

Tan, S.S., van Ineveld, M., Redekop, W. K., Hakkaart-van Roijen, L. (2011). The Netherlands: The Diagnose-Behandel Combinaties (DBCs). In: *Diagnosis-Related Groups in Europe: moving towards transparency, efficiency and quality in hospitals.* First edition, Open University Press and WHO Regional Office for Europe: Buckingham

Tan, S.S., Hakkaart – van Roijen, L., Van Ineveld, M., Redekop, K. (2012). Explaining cost variation of clinical pathways in the Netherlands *(draft version)*

Telfer, S., Fenyo, G., Holt, P.R., deDombal, F.T. (1988). Acute abdominal pain in patients over 50 years of age. Scandinavian Journal of Gastroenterology, Vol. 144, pp. 47 – 50

Thorpe, K.E. (2005). Rising health care spending and what to do about it. Health Affairs, Vol. 24, Issue 6, pp. 1436 – 1445

Tiwari, M.M., Reynoso, J.F., High, R., Tsang, A.W., Oleynikov, D. (2011). Safety, efficacy and cost-effectiveness of common laparoscopic procedures. Surgical endoscopy, Vol. 25, issue 4, pp. 1127 – 1135

Vandermeulen, L.J.R., Lommers, M.H.F., Dohmen, P.J.G., Pieter, D. (2009). Volledigheid nieuwe productstructuur. Onderzoek naar de verschillen tussen FB, DBC en DOT per specialisme and ziekenhuiscategorie. Prismant

Van de Ven, W.P.M.M. and Schut, F.T. (2009). Managed competition in the Netherlands: still work-in-progress. Health Economics, Vol. 18, pp. 253 – 255

Wauben, L.S.G.L., Goossens, R.H.M., van Eijk, D.J., Lange, J.F. (2008). Evaluation of protocol uniformity concerning laparoscopic cholecystectomy in the Netherlands. World Journal of Surgery

Wei, H.B., Huang, J.L., Zheng, Z.H., Wei, B., Zheng, F., Qiu, W.S., Guo, W.P., Chen, T.F., Wang, T.B. (2010). Laparoscopic versus open appendectomy: a prospective randomized comparison. Surgical Endoscopy, Vol. 24, pp. 266 – 269

Westerdijk, M., Zuurbier, J., Ludwig, M., Prins, S. (2012). Defining care products to finance health care in the Netherlands. European Journal of Health Economics, Vol. 13, pp. 203 – 221

Yeh, C.C., Wu, S.C., Liao, C.C., Su, L.T., Hsieh, C.H., Li, T.C. (2011). Laparoscopic appendectomy for acute appendicitis is more favorable for patients with comorbidities, the elderly, and those with complicated appendicitis: a nationwide population-based study. Surgical Endoscopy, Vol. 25, pp. 2932 – 2942

Yetkin, G., Uludag, M., Citgez, B., Akgun, I., Karakoc, S. (2009). Predictive factors for conversion of laparoscopic cholecystectomy in patients with acute cholecystitis. Bratislavské lekárske listy, Vol.110, issue 11, pp. 688 – 691

Zuurbier, J. and Krabbe-Alkemade, Y. (2007). Onderhandelen over DBC's. Second edition. Maarssen: Elsevier Gezondheidszorg

9. Appendix

Table A. Most important care activities (CA); explanation and costs for inguinal hernia repair

Cost category	Code	Explanation care activity	Number of patients receiving this CA	Average number of times executed	Average costs per CA (in €)
CA 1 Paramedical and support services	193001	Physiotherapy treatment	156	1.51	36.00
CA 2 Medical imaging services		CT scans	96	1.04	218.13
CA 3		Echoes	1,215	1.05	77.84
CA 4 Dagcare hours	190035 190055	Daycare	14,131	1.21	31.38
CA 5 Diagnostic activities	39757	Review ECG, Holter, exercise testing etc.	2,292	1.00	19.97
CA 6 Clinical chemistry and hematology		Sum of weighted care activities	31,420	7.23	4.36
CA 7 Inpatient days	190204, 190205, 190206	Inpatient days	5,742	1.31	457.00
CA 8 Microbiological and parisitological services		Sum of weighted care activities	1,832	1.76	8.96
CA 9 Surgical procedures	35700, 35702, 35703	Hernia, open procedure	13,517	1.00	1,045.32
CA 10	35710, 35713	Laparoscopic surgery	2,685	1.02	1,393.07
CA 11 Pathological services	50501	Pathological examination	334	1.00	55.85
CA 12 Outpatient and emergency room visits	190011, 190012, 190013, 190014, 411000	Outpatient visit	30,552	1.93	72.00
CA 13	190015, 190016	Emergency care visit	1,078	1.00	151.00

Table B. Most important care activities (CA); explanation and costs for appendectomy

Cost category	Code	Explanation care activity	Number of patients receiving this CA	Average number of times executed	Average costs per CA (in €)
CA 1 *Paramedical and support functions*	193001	Physiotherapy treatment	369	4.45	36.00
CA 2 *Medical imaging services*		CT scans	1,221	1.34	221.48
CA 3		Echoes	5,451	1.34	77.35
CA 4		Examinations with screening	1,728	1.91	50.97
CA 5 *Dagcare hours*	190035, 190055	Daycare	106	1.28	31.38
CA 6 *Diagnostic activities*	35584	Diagnostic laparoscopy (keyhole surgery)	402	1.01	19.97
CA 7	39757	Review ECG, Holter, exercise testing etc.	513	1.08	19.97
CA 8 *Intensive care days*		IC products	153	3.19	695.76
CA 9 *Clinical chemistry and hematology*		Sum of weighted care activities	179,542	23.00	4
CA 10 *Inpatient days*	190204, 190205	Inpatient days	31,480	3.76	457.00
CA 11 *Microbiological and parisitological services*		Sum of weighted care activities	21,366	4.33	9.50
CA 12 *Surgical procedures*	34910	Appendectomy, open procedure	5,423	1.00	1,500.17
CA 13	34911	Laparoscopic appendectomy	3,066	1.00	1,999.25
CA 14 *Pathological services*	50501, 50503	Pathological examination	6,801	1.03	57.93
CA 15 *Outpatient and emergency visits*	190011, 190012, 190013, 190014, 411000	Outpatient visit	19,754	2.34	72.00
CA 16 *Outpatient and emergency room visits*	190015, 190016	Emergency care visit	8,581	1.17	151.00
CA 17 *Other therapeutic services*		Sum of weighted care activities	888	1.11	53.38
CA 18 *Other laboratory services*		Sum of weighted care activities	494	2.00	11.31

Table C. Most important care activities (CA); explanation and costs for cholecystectomy

Cost category	Code	Explanation care activity	Number of patients receiving this CA	Average number of times executed	Average costs per CA (in €)
CA 1 Paramedical and support functions	193001	Physiotherapy treatment	1,847	3.87	36.00
CA 2 Medical imaging services		CT scans	1,784	1.28	221.18
CA 3		Echoes	5,201	1.18	77.75
CA 4		ERCP (Endoscopic retrograde Cholangiopancreatography)	109	1.00	252.77
CA 5		Abdominal and thorax examination and screening	5,503	1.00	50.97
CA 6 Dagcare hours	190035, 190055	Daycare	1,284	1.33	31.38
CA 7 Diagnostic activities	34686	Diagnostic duodenoscopy with fiber coop	130	1.05	391.05
CA 8	35584	Diagnostic laparoscopy (keyhole surgery)	713	1.28	19.97
CA 9	39757	Review ECG, Holter, exercise testing etc.	2,821	1.11	19.97
CA 10 Intensive care days		IC products	176	2.71	899.93
CA 11 Clinical chemistry and hematology		Sum of weighted care activities	404,630	27.54	4
CA 12 Inpatient days	190204, 190205, 190206	Inpatient days	57,638	3.52	457.00
CA 13 Microbiological and parisitological services		Sum of weighted care activities	36,696	3.57	6.99
CA 14 Surgical procedures	35342	Laparoscopic gallbladder drainage	99	1.05	160.47
CA 15	35350	Cholecystectomy	2,028	1.26	215.01
CA 16	35355	Laparoscopic surgery	19,416	1.24	286.54
CA 17	35512	Test laparotomy	149	1.16	160.47
CA 18	35588	Therapeutic laparoscopy (surgery)	100	1.56	160.47
CA 19	35760	Hernia umbilicalis, open procedure	107	1.27	160.47
CA 20 Pathological services	50501, 50503	Pathological examination	14,169	1.03	58.01
CA 21 Outpatient and emergency room visits	190011, 190012, 190013, 190014, 411000	Outpatient visit	47,504	2.79	72.00
CA 22 Outpatient and emergency visits	190015, 190016	Emergency care visit	5,937	1.25	151.00
CA 23 Other therapeutic services		Sum of weighted care activities	2,122	1.42	103.76
CA 24 Other laboratory services		Sum of weighted care activities	305	1.80	10.10

Table D. Model 3 – Inguinal hernia repair; backward regression analyses examining ability of most important care activities (CA) to explain cost variation between DBCs (*p<0.05 and these are significant)

	Inguinal hernia repair	
	R^2 = 0.90	
	β	SD
CA 1 - Physiotherapy treatment *	25.81	1.09
CA 2 – Daycare hours*	-6.07	0.31
CA 3 – Laboratory services*	3.05	0.37
CA 4 – CT scans*	1.06	0.30
CA 5 – Echoes*	1.48	0.24
CA 6 – Review ECG*	4.18	0.78
CA 7 – Inpatient days*	0.84	0.02
CA 8 – Microbiological and parasitological services*	3.73	0.74
CA 9 – Hernia, open procedure*	1.27	0.02
CA 10 – Laparoscopic surgery*	1.11	0.02
CA 11 – Pathological examination*	3.68	0.65
CA 12 – Outpatient visit*	3.47	0.12
CA 13 – Emergency room visit*	1.92	0.14

Table E. Model 3 – Appendectomy; backward regression analyses examining ability of most important care activities to explain cost variation between DBCs (*p<0.05 and these are significant)

	Appendectomy	
	R^2 = 0.99	
	β	SD
CA 1 - Physiotherapy treatment*	0.93	0.08
CA 2 – Echoes*	1.04	0.27
CA 3 – CT scans*	0.84	0.04
CA 4 – Examination and screening*	1.20	0.07
CA 5 – Daycare hours*	2.41	0.40
CA 6 – Diagnostic laparoscopy	0.00	0.41
CA 7 - Review ECG*	1.81	0.35
CA 8 – Intensive care days*	1.03	0.01
CA 9 – Laboratory services*	1.29	0.03
CA 10 – Inpatient days*	1.02	0.00
CA 11 – Microbiological and parasitological services*	0.68	0.03
CA 12 – Appendectomy, open procedure*	1.00	0.00
CA 13 – Laparoscopic appendectomy*	1.00	0.00
CA 14 – Test laparotomy*	1.30	0.13
CA 15 – Wounds treatment*	1.41	0.12
CA 16 – Pathological examination*	0.51	0.03
CA 17 – Outpatient visit*	1.08	0.03
CA 18 – Emergency room visit*	0.97	0.02
CA 19 – Rehabilitation services*	1.12	0.10
CA 20 – Other laboratory services*	2.14	0.40

Table F. Model 3 – Cholecystectomy; backward regression analyses examining ability of most important care activities to explain cost variation between DBCs (*p<0.05 and these are significant)

	Cholecystectomy	
	R^2 = 0.99	
	β	SD
CA 1 – Physiotherapy treatment*	1.19	0.06
CA 2 – CT scans*	0.97	0.03
CA 3 – Echoes*	-0.78	0.07
CA 4 – ERCP*	0.85	0.12
CA 5 – Examination and screening*	3.11	0.13
CA 6 – Daycare hours*	1.12	0.19
CA 7 – Diagnostic duodenoscopy*	1.18	0.05
CA 8 – Diagnostic laparoscopy*	2.27	0.45
CA 9 – Review ECG*	0.97	0.22
CA 10 – Intensive care days*	0.86	0.01
CA 11 – Laboratory services*	1.10	0.03
CA 12 - Inpatient days*	0.99	0.00
CA 13 – Microbiological and parasitological services*	1.08	0.07
CA 14 – Endoscopic gallbladder drainage*	1.41	0.15
CA 15 – Cholecystectomy, open procedure*	0.97	0.03
CA 16 – Laparoscopic cholecystectomy*	0.98	0.01
CA 17 – Test laparotomy*	1.63	0.11
CA 18 – Therapeutic laparoscopy*	0.96	0.12
CA 19 – Hernia umbilicalis*	0.75	0.12
CA 20 – Pathological examination*	1.22	0.07
CA 21 – Outpatient visit*	0.97	0.02
CA 22 – Emergency room visit*	1.03	0.03
CA 23 – Rehabilitation services*	0.89	0.04
CA 24 – Other laboratory services	-1.16	0.95

Table G. Model 3 – Sensitivity analysis; impact of care activities on total costs for cholecystectomy

	R^2 = 0.97	
	β	SD
CA 1 – Physiotherapy treatment	1.33	0.06
CA 2 – CT scans	1.12	0.03
CA 5 – Examination and screening	2.24	0.11
CA 7 – Diagnostic duodenoscopy	1.23	0.06
CA 10 – Intensive care days	0.87	0.01
CA 11 – Laboratory services	1.25	0.03
CA 12 – Inpatient days	1.00	0.00
CA 15 – Cholecystectomy, open procedure	1.19	0.03
CA 16 – Laparoscopic cholecystectomy	1.10	0.01
CA 21 – Outpatient visit	1.06	0.02
CA 22 – Emergency room visit	1.00	0.02