Explaining cost variation of hospital services in the Netherlands

A contribution to Work Packages 4 and 5 of the EU funded research project EuroDRG: Identification of factors explaining cost variation on the national level

Siok Swan Tan
Ken Redekop
Martin van Ineveld
Leona Hakkaart

Institute of Health Policy & Management

2011.02

Health Economics - iMTA

ERASMUS UNIVERSITEIT ROTTERDAM
iMTA

ERASMUS UNIVERSITEIT ROTTERDAM
INSTITUTE OF HEALTH POLICY & MANAGEMENT

Explaining cost variation of hospital services in the Netherlands

A contribution to Work Packages 4 and 5 of the EU funded research project EuroDRG:
Identification of factors explaining cost variation on the national level

Date of publication
October 2011

Authors
Siok Swan Tan
Ken Redekop
Martin van Ineveld
Leona Hakkaart

ERASMUS UNIVERSITEIT ROTTERDAM
iMTA

ERASMUS UNIVERSITEIT ROTTERDAM
INSTITUUT BELEID & MANAGEMENT GEZONDHEIDSZORG

Correspondence:
Siok Swan Tan, Erasmus University Rotterdam, institute for Medical Technology Assessment, P.O. Box 1738, 3000 DR Rotterdam, tan@bmg.eur.nl, +31 (0)10 408 8623.

Preface

This report describes the results of the regression analyses which aimed to identify the factors explaining cost variation of 10 episodes of care in the inpatient sector in the Netherlands. This report has been prepared by the institute for Medical Technology Assessment of the Erasmus Universiteit Rotterdam as part of work packages 4 and 5 of the EU funded research project ‘EuroDRG’ (full title: Diagnosis-Related Groups in Europe: towards Efficiency and Quality, contract no. FP7 2008-223300).

Content

Abbreviations

AMI | Acute Myocardial Infarction

CABG | Coronary Artery Bypass Graft

CM | Clinical Modification

DBC | Diagnose Behandel Combinatie (Diagnosis Treatment Combination)

DRG | Diagnosis Related Group

DV | Dummy Variable

df | degrees of freedom

EU | European Union

ICD | International Classification of Diseases

ICU | Intensive Care Unit

LOS | Length Of Stay

OLS | Ordinary Least Squares

PLL | Poisson Log-Linear

PTCA | Percutaneous Transluminal Coronary Angioplasty

ref | reference category

SD | Standard Deviation

SE | Standard Error

SI | Signal Intensity

Sig. | Significance

1. Introduction

Diagnosis Related Group (DRG)s have gradually become the principal means of reimbursing hospitals in most EU Member States. However, increased patient mobility will place growing pressure on the different, and often incompatible, DRG systems used by European countries. Any modifications to national DRG systems should thus be made with an eye towards the EU as a whole. Designed to address these challenges, the EuroDRG project analysed health systems in ten different countries: Austria, Estonia, Finland, France, Germany, the Netherlands, Poland, Spain, Sweden and the United Kingdom. The project focuses on [1]:
(1) identifying ways to calculate DRG tariffs in an adequate fashion,
(2) examining hospital efficiency within and across European countries and
(3) exploring the relationship between costs and the quality of inpatient care.

This report focuses on the second focus of examining hospital efficiency. DRG systems could support efforts to improve hospital efficiency, provided that their patient classification is of sufficient accuracy. Patients are generally classified by DRGs by primary diagnosis as well as by a selection of (usually no more than 10) partition variables [2]. An inaccurate patient classification may lead to over- or underestimated reimbursement of hospital services. When the patient classification leads to an overestimated reimbursement for a specific DRG, hospitals are disincentivized to reorganize treatment processes in order to improve efficiency for certain groups of patients. On the other hand, when the patient classification leads to an underestimated reimbursement for a specific DRG, hospitals are discouraged to provide high quality care as this may lead to costs above the reimbursement level. Hospitals may then start to compromise quality in order to reduce their costs [3]. Hence, the accuracy of the patient classification greatly determines the extent to which hospital efficiency is achieved [1,2].

Rather than defining DRGs, some European countries decided to introduce their own unit of analysis to classify patients. Austria, England and Poland have introduced casemix systems that do not originate from the DRG system. However, the patient classification of these systems is very similar to those of DRG systems. In contrast, the Dutch patient classification differs substantially from the DRG approach [2,4]. Specifically because the DRG system was not believed to lead to sufficiently accurate DRGs for the increasing share of outpatient care, diagnosis treatment combination (DBC)s were introduced in the Netherlands for the patient classification, resource allocation and reimbursement of hospital services [5,6]. Patients are classified by DBCs by medical specialty, diagnosis and treatment variables (i.e. treatment setting (inpatient/ outpatient/ in daycare) and medical specialty-specific procedures) [4].

DRGs aim to classify patients into mutually exclusive groups of patients, with the patients in each group having the same expected resource requirements (and ultimately costs). An accurate patient classification is thus characterized by distinct cost variation *between* DRGs on the one side and limited cost variation *within* DRGs on the other side. However, the partition variables used in DRG systems cannot account for all cost variation among patients – there will be patient characteristics other than their DRG which could serve as adjustment factors for the patient classification and explain cost variation [7]. Other characteristics often recorded in DRG systems include core variables (e.g. age, gender, total diagnoses and procedures, transfers, emergency, mortality and intensive care unit (ICU) admissions), Charlson co-morbidities, global quality (e.g. Patient Safety Indicators, adverse events, urinary tract infection, wound infection) and/or treatment variables (e.g. treatment setting (inpatient/ in daycare) and episode specific procedures) [1,2]. In the Netherlands, however, no Charlson co-morbidities and global quality variables are collected. The current DBC system allows for separate DBCs for co-morbidities. For global quality, some variables are collected to serve as a benchmarking tool for hospital performance, e.g. malnutrition and mortality after Percutaneous Transluminal Coronary Angioplasty (PTCA) [8]. However, these variables are only collected for subsets of patients and at an aggregated level. The absence of Charlson co-morbidities and global quality variables at the patient level prevents the comparison of their ability to explain cost variation with that in DRG systems.

Instead of recording Charlson co-morbidities and global quality variables, it was decided to focus the collection of data in the Netherlands primarily on detailed resource quantities and unit costs. Since the introduction of the DBC system, the resource quantities of all patients admitted to any hospital in the Netherlands have been collected in the database of the DBC system [4,6]. The available literature has demonstrated that resource quantities are able to explain cost variation between groups of patients (see for instance [9-11]). Therefore, it seems justified to examine the ability of the resource quantities in the national database to explain cost variation between DBCs.

This report describes the methodology and results of the regression analyses which aimed to examine the accuracy of the patient classification for 10 episodes of care in the Netherlands. An accurate patient classification is characterized by distinct cost variation *between* DBCs on the one side and limited cost variation *within* DBCs on the other side [1,7]. Section 2 describes the methodology and section 3 the primary outcomes of the regression analyses. In section 4, the findings for the Netherlands are discussed and related to the research question.

2. Methods

2.1 Design of the study

The aim of the present study was to examine the accuracy of the patient classification for 10 episodes of care in the Netherlands. Although reimbursement fees and charges are available, no actual costs are recorded in the database of the DBC system. Therefore, length of stay (LOS) was taken as a proxy to actual costs. Hence, we examined the degree of association between the LOS of the first inpatient admission and 3 routinely collected groups of variables: DBC codes, core variables and resource quantities. Regression models were used to identify suitable variables which could serve as adjustment factors for the patient classification and explain cost/LOS variation. The results may serve as a basis to examine hospital efficiency within the Netherlands and across European countries and to explore the relationship between costs and the quality of inpatient care.

2.2 Episodes of care

The 10 episodes of care have been defined in the *inpatient sector* as part of the EuroDRG project and are presented in table 2.1. In order to find appropriate episodes of care in national databases, the project did not rely on DRG codes (as their definition may vary between countries) but mainly used diagnoses (defined by ICD-10) and common procedure codes (defined by ICD-9-Clinical Modification (CM)) if necessary. The preliminary selection of the episodes of care was based on those which proved to be successful in the HealthBASKET project [12,13]. These were based on collections of community health indicators, such as the ones used in the 'Health for All 21' data base and in the 'European Community Health Indicators'-Project. The episodes of care represent a large burden of disease (measured as number of people affected or costs related) or are related to preventive measures and are valid and sensitive to assess the achieving of targets formulated in health policies. In addition, the selection of episodes of care covers:

- different medical specialties
- elective as well as emergency procedures
- diagnostic as well as therapeutic procedures
- episodes of care with important treatment variation (e.g. open surgery versus laparoscopic procedures)
- episodes of care particularly requiring innovative procedures (e.g. PTCA).

Table 2.1: Episodes of care defined to support the EuroDRG project and this report

Episode of care	Defined by	Diagnosis (ICD-10)	Procedure (ICD-9-CM)	Episode specific exclusion criteria
Breast cancer	main diagnosis + procedure	C50, D05	85.20-85.23, 85.33-85.36, 85.4	Age <1, outpatients, male cases, benign tumours
Acute myocardial infarction	main diagnosis	I21 -I22		Age <1, outpatients; procedure 36.1 cases
Coronary artery bypass graft	all diagnoses + procedure		36.1	Age <1, outpatients
Stroke	main diagnosis	I61, I63, I64		Age <1, outpatients
Inguinal hernia surgery	main diagnosis + procedure	K40	17.1, 17.2, 53.0, 53.1	Age <1, outpatients
Appendectomy	main diagnosis + procedure	K35-K38	47	Age <1, outpatients
Cholecystectomy	main diagnosis + procedure	K80 (incl. K80.0-K80.8)	51.2	Age <1, outpatients
Hip replacement	all diagnoses + procedure		00.85-00.87 81.51 – 81.53	Age <1, outpatients
Knee replacement	all diagnoses + procedure		00.80 - 00.84, 81.54, 81.55	Age <1, outpatients
Childbirth	main diagnosis	Z37.0 to 37.9		Age <1, male cases

2.3 Regression analyses

Patients are generally classified into DRGs by primary diagnosis as well as by a selection of (usually no more than 10) partition variables. These partition variables, though, cannot account for all cost/LOS variation among patients. In support of the EuroDRG project, other characteristics of patients other than their DRG which explain variation in the participating countries were identified. These include core variables (e.g. age, gender, total diagnoses and procedures, transfers, emergency, mortality and ICU admissions), Charlson co-morbidities and global quality variables (e.g. Patient Safety Indicators, adverse events, urinary tract infection, wound infection) [1,2]. As Charlson co-morbidities and global quality variables are not available in the Netherlands, 3 routinely collected groups of variables were collected from the database of the DBC system instead: DBC codes, core variables and resource quantities. For each episode of care, the relevant DBC codes were identified and the core variables and resource quantities for patients receiving these DBC codes in 2008 were acquired. DBCs referring to follow up care were discarded (type of care: code 21). Patients whose LOS was greater than 3 standard deviations (SD) from the mean were considered outliers and excluded from the analyses (7). Additionally, some episode specific exclusion criteria were applied (table 2.1).

Regression models were used to identify suitable variables which could serve as adjustment factors for the patient classification and explain cost/LOS variation. Hence, LOS was the dependent variable. Patients receiving treatment *in daycare* were appointed a LOS of 0 (zero). For the EuroDRG analyses, Poisson Log-Linear (PLL) regression was taken as the standard model (7). However, patients in the Netherlands are classified by treatment setting (inpatient/ in daycare). As a result, DBC codes relating to treatments in daycare caused the Hessian matrix to be singular in PLL regression (i.e. convergence criteria are not satisfied). Therefore, we applied Ordinary Least Squares (OLS) regression for the main analyses. To be able to make comparisons possible across countries, we additionally conducted PLL regression on the subsets of patients receiving treatments in the inpatient setting.

The initial specification of our model included DBC codes only (model 1). The DBC codes are ordered and labelled with the least resource intensive appearing first: e.g. the DBC1 variable usually represents the shortest LOS among an episode of care. The DBC codes are identified as dummy variables (DV) when they include at least 1% of the sample to avoid marginal cases over-influencing the results of the models. As all patients are assigned to one DBC code or another, in all specifications, we omit the DBC code in which the majority of the patients in that episode of care are assigned. This means that coefficients for all variables are to be interpreted in relation to this omitted reference DBC code. A residual DV captures all other patients in the episode of care that are not assigned to the identified DBC codes (7).

A second model considered a set of core variables other than DBC codes to explain variation in resource use among patients (model 2). These core variables include age, gender, emergency admission (yes/no), ICU admission (yes/no), hospital type (small general hospital, medium-sized general hospital, large general hospital, non-university teaching hospital or university teaching hospital) and a selection of episode-specific treatment variables. We constructed age categories based on quintiles chosen according to the observed distribution of age for the episode of care in question, with the second age category generally being the reference category. A DV identified whether the patient was male, whether the patient was admitted through the emergency department, whether the patient required an ICU admission and whether patients were treated at a certain hospital type [7].

Subsequent specifications of our model included the same set of core variables as defined in model 2 supplemented with variables of resource quantities. In the database of the DBC system, resource quantities are organized within the following cost categories: inpatient days, ICU days, outpatient and emergency room visits, daycare admissions, surgical procedures, medical devices, diagnostic procedures, medical imaging services, laboratory services, microbiology/ parasitology services, pathology services, blood products, paramedical services and rehabilitation services [4]. Model 3 includes these cost categories, where model 4 includes numbers of resource quantities per cost category.

2.4 Presentation of results

Chapter 3 presents one table per episode of care. The table contains an overview of the DBC codes, core variables and descriptive statistics relating to the episodes of care as well as OLS regression results. Additional information is included in the appendices. Histograms showing LOS distributions are provided in Appendix A. Logistic regression examining the impact of our set of core variables on the allocation to treatments in daycare (as opposed to treatments in the inpatient setting) are provided in Appendix B. For the subsets of patients receiving treatment in the inpatient setting, PLL regression results are presented in Appendix C. All analyses are based on 2008 data. Statistical analyses were conducted with the statistical software programmes SPSS for Windows version 17.0 and SAS version 9.0.

3. Results

3.1 Breast cancer

In the Netherlands, breast cancer is the most prevalent cancer in women. In 2002, the total number of breast cancer patients was estimated at 76,000 (930 cases per 100,000 women). The incidence amounted to 11,687 (143 cases per 100,000 women). The mean age at diagnosis was about 60 years. Breast cancer hardly occurs in women up to 25 years. The incidence increases with age in women up to 65 years, while the incidence is quite constant in women older than 65 years [(14)].

Costs for breast cancer care amounted to € 247.2 million in 2005. Breast cancer was responsible for 9.3% of the total costs for cancer and 0.4% of the national health expenditures. More than a half of the costs for breast cancer are attributable to hospital care (54.4%). Besides, a great share of public health care costs is attributable to breast cancer screening, especially for patients aged 50 to 74 years as these women are invited for breast cancer screening every two years [(15)]. The absolute number of hospital admissions for breast cancer increased from 13,053 in 1995 to 14,459 in 2005. This was fully attributable to the increase in daycare treatments (from 2,037 in 1995 to 12,986 in 2005). The number of inpatient days in 2005 was two times lower than in 1995 [(14)].

An amputation or a breast saving operation is a treatment option for patients with non-invasive tumours, depending on the size of the tumour. In 2008, a total number of 13,439 females with mean age 57 (SD 17) years received an excision or destruction of breast tissue, not otherwise specified (ICD-9-CM procedure code 85.20), local excision of lesion of breast (85.21), resection of quadrant of breast (85.22), subtotal mastectomy (85.23), unilateral subcutaneous mammectomy with synchronous implant (85.33), other unilateral subcutaneous mammectomy (85.34), bilateral subcutaneous mammectomy with synchronous implant (85.35), other bilateral subcutaneous mammectomy (85.36) or mastectomy (85.4) and met all the inclusion criteria (cf section 2). Table 3.1 presents the DBC codes, core variables and descriptive statistics relating to these females as well as OLS regression results. The mean LOS of the first inpatient admission was 1.7 (SD 1.5) days (Appendix A-1). Of the patients, 88% was appointed to the reference DBC code 110003180203 (one-sided surgical inpatient). DBC code 110003180202 (one-sided surgical in daycare) resulted in a LOS reduction of 1.4 days and DBC code 110003180403 (two-sided surgical inpatient) in a LOS prolongation of 0.6 days. The DBC codes were able to explain 7.4% of the LOS.

Although not significantly, only patients aged 61 to 65 years had a shorter LOS than patients aged 51 to 60 years (reference category). Episode-specific treatment variables concerned the number of lymphnode resections, conservative treatment (yes/no), administration of chemotherapy (yes/no) and two-sided mastectomy (yes/no). However, only the number of lymphnode resections and the performance of a two-sided mastectomy had a significant influence on LOS. The set of core variables performed slightly worse than the DBC codes ($R^2 = 0.062$). The set of core variables in combination with the cost categories or with numbers of resource quantities per cost category had a superior predictive ability (10.1% and 15.2% respectively).

Fifty-five % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 110003180203 (one-sided surgical inpatient). About 1 out of 10 breast cancer patients was treated in daycare (LOS = 0). Patients were more likely to receive treatment in daycare when they were admitted to a medium-sized general hospital, admitted to a non-university or university teaching hospital and/or required conservative treatment. Especially the latter variable had a great impact: patients receiving a conservative treatment were about 10 times more likely to be treated in daycare than other patients ($P < 0.001$). Patients were less likely to receive treatment in daycare when they were older than 66 years, admitted through the emergency department and/or required lymphnode resections (Appendix B-1). In contrast to the OLS model (13,439 patients), the PLL model (12,268 patients) did not identify impact of patients aged 66 to 70 years ($P = 0.216$). With the PLL model, the associations seen with the remaining variables were similar in direction but smaller in magnitude in comparison with the OLS model. An ICU admission related to a LOS prolongation of 0.6 days in the PLL model (compared to 1.7 days in the OLS model) (Appendix C-1).

Table 3.1: Breast cancer ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0,074$		Model 2 $R^2 = 0,062$		Model 3 $R^2 = 0,101$		Model 4 $R^2 = 0,152$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					1,893	0,013*	1,280	0,041	0,020	0,100	1,628	0,045
length of stay of the first inpatient admission	0	8	1,744	1,540								
DBC code 110003180202 (one-sided surgical in daycare)	0	1	0,084	0,277	-1,393	0,045*						
DBC code 110003180203 (one-sided surgical inpatient) (ref)	0	1	0,875	0,331								
DBC code 110003180403 (two-sided surgical inpatient)	0	1	0,027	0,162	0,644	0,077*						
other non-reference DBC codes	0	1	0,014	0,118	-0,438	0,106*						
age 1 to 50	0	1	0,290	0,454			0,078	0,034*	0,058	0,031	0,075	0,030*
age 51 to 60 (ref)	0	1	0,255	0,436								
age 61 to 65	0	1	0,131	0,337			-0,023	0,043				
age 66 to 70	0	1	0,113	0,316			0,095	0,045*	0,077	0,042	0,035	0,041
age >71	0	1	0,191	0,393			0,661	0,038*	0,578	0,035*	0,492	0,034*
emergency admission	0	1	0,065	0,246			0,024	0,051				
ICU admission	0	1	0,002	0,046			1,650	0,270*	1,434	0,265*	1,332	0,258*
small general hospital	0	1	0,235	0,424			0,412	0,043*	0,327	0,033*	0,296	0,032*
medium-sized general hospital	0	1	0,268	0,443			-0,015	0,042				
large general hospital (ref)	0	1	0,148	0,355								
non-university teaching hospital	0	1	0,281	0,450			0,298	0,041*	0,307	0,031*	0,283	0,030*
university teaching hospital	0	1	0,068	0,252			0,376	0,060*	0,467	0,053*	0,433	0,051*
number of lymphnode resections	0	6	0,498	0,667			0,239	0,019*	0,195	0,019*	0,151	0,018*
conservative treatment	0	1	0,011	0,105			-0,123	0,123				
administration of chemotherapy	0	1	0,001	0,027			0,440	0,460				
two-sided mastectomy	0	1	0,030	0,171			0,624	0,075*	0,581	0,073*	0,575	0,071*

Sig. $P < 0.05$

Table 3.1: continued

					Model 1 $R^2 = 0{,}074$		Model 2 $R^2 = 0{,}062$		Model 3 $R^2 = 0{,}101$		Model 4 $R^2 = 0{,}152$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,763	0,425					0,012	0,031		
laboratory services	0	1	0,709	0,454					0,425	0,029*		
microbiology/ parasitology	0	1	0,080	0,272					0,180	0,046*		
medical imaging services	0	1	0,947	0,225					-0,281	0,058*		
pathology	0	1	0,867	0,339					-0,220	0,039*		
paramedics (e.g. physical therapy)	0	1	0,146	0,353					0,483	0,036*		
blood products	0	1	0,003	0,058					0,949	0,213*		
rehabilitation	0	1	0,000	0,009					2,425	1,420		
number of admissions	0	13	1,342	0,584							-0,178	0,025*
number of outpatient visits	0	46	5,999	3,615							0,013	0,004*
number of hours at the daycare facility	0	13	0,229	0,502							-0,636	0,028*
number of diagnostic procedures	0	12	1,260	1,097							0,061	0,012*
number of laboratory services	0	119	1,828	3,064							0,052	0,004*
number of microbiology/ parasitology services	0	69	0,608	3,213							0,008	0,004*
number of medical imaging services	0	22	4,441	2,787							-0,035	0,005*
number of pathology services	0	34	4,971	3,471							0,001	0,004
number of sessions paramedics	0	60	0,422	1,660							0,070	0,007*
number of blood products	0	7	0,009	0,170							0,141	0,071*
number of sessions rehabilitation	0	2	0,000	0,017							1,239	0,690

Sig. $P < 0.05$

3.2 Acute myocardial infarction

In 2000, the standardised prevalence of AMI in patients of at least 55 years of age was about 277,300 (192,200 men and 85,100 women). The yearly incidences of AMI are estimated at 2.2 per 1,000 in men and 1.3 per 1,000 in women (14). AMI is one of the most common manifestations of coronary heart disease. Coronary heart disease was the most expensive disease in the Netherlands in 2005. Total costs amounted to € 1,290 million. Coronary heart disease was responsible for 23% of the total costs for cardiovascular diseases and 1.9% of the national health expenditures. More than a half of the costs are attributable to hospital care and almost a third to medication and medical aids. In 2005, 65% of all costs made were attributable to men. Most costs for coronary heart disease are attributable to patients aged 55 to 79 years (15). The absolute number of hospital admissions for coronary heart disease was 60,255 for men and 30,150 for women in 2004. Compared to 1995, the total number of inpatient days decreased by one third, while the number of daycare treatments has tripled (14).

National guidelines for AMI are issued by the Dutch Association for Cardiology (http://www.nvvc.nl/home). Although the benefit of PTCA over thrombolysis has not been demonstrated, a PTCA is believed to achieve a faster recovery of coronary perfusion, decrease chances of refractory infarction and stroke and reduce mortality. Comprehensive cardiac rehabilitation – tailored to the individual and the clinical context – is strongly recommended. In 2008, a total number of 30,843 AMI patients (67% males) with mean age 63 (SD 18) years were admitted for acute myocardial infarction (ICD-10 code I21) or subsequent myocardial infarction (I22) and met all the inclusion criteria (cf section 2). Table 3.2 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 3.3 (SD 3.5) days (Appendix A-2). Of the patients, 33% was appointed to the reference DBC code 110002050103 (non-ST elevated regular/no treatment inpatient). Each of the other DBC codes resulted in a LOS reduction of between 0.5 days for DBC code 110002040103 (ST elevated regular/no treatment inpatient) and 3.7 days for DBC code 110002040242 (ST elevated severe PCI in daycare). The DBC codes were able to explain 6.6% of the LOS.

Although not significantly, only patients up to 60 years had a shorter LOS than patients aged 61 to 70 years (reference category). Unfortunately, the database of the

DBC system does not record the administration of thrombolysis for AMI patients. Episode-specific treatment variables concerned Signal Intensity (SI) elevated AMI (yes/no), SI not elevated AMI (yes/no), subsequent AMI (yes/no), coronary stent (yes/no), PTCA (yes/no), catheterisation of heart (yes/no) and conservative treatment (yes/no). However, the performance of PTCA did not significantly impact LOS. The set of core variables performed slightly better than the DBC codes (R^2 = 0.079). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (20.9% and 25.2% respectively). Rehabilitation was associated with a LOS reduction of 0.5 days (0.1 days per session).

Forty-seven % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the DBC codes 110002040103 (ST elevated regular/no treatment inpatient), 110002040243 (ST elevated severe PCI inpatient) and 110002050103 (non-ST elevated regular/no treatment inpatient). About 7% of the AMI patients was treated in daycare (LOS = 0). Patients were less likely to receive treatment in daycare when they were admitted through the emergency department, admitted to a small or medium-sized general hospital, non-university or university teaching hospital or required a coronary stent and/or PTCA. Obviously, patients requiring an ICU admission were many times less likely than other patients to be treated in daycare (P = 0.001) (Appendix B-2). In contrast to the OLS model (30,843 patients), the PLL model (28,840 patients) did not identify impact of ICU admissions (P = 0.071) and stenting (P = 0.124). However, the PLL model additionally observed PTCA to influence LOS (P = 0.021). With the PLL model, the associations seen with the remaining variables were similar in direction but smaller in magnitude in comparison with the OLS model. A subsequent AMI related to a LOS reduction of 0.4 days in the PLL model (compared to 1.5 in the OLS model). A conservative treatment related to a LOS reduction of 0.3 days in the PLL model (compared to 2.0 in the OLS model) (Appendix C-2).

Table 3.2: AMI ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0,066$		Model 2 $R^2 = 0,079$		Model 3 $R^2 = 0,209$		Model 4 $R^2 = 0,252$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					4,212	0,033*	1,347	0,115	0,020	0,100		
length of stay of the first inpatient admission	0	19	3,297	3,502								
DBC code 110002040242 (ST elevated severe PCI in daycare)	0	1	0,031	0,174	-3,712	0,114*						
DBC code 110008010103 (follow up after acute coronary syndrome regular/no treatment inpatient)	0	1	0,041	0,198	-1,764	0,101*						
DBC code 110002040213 (ST elevated mild PCI inpatient)	0	1	0,029	0,167	-1,704	0,118*						
DBC code 110002050243 (non-ST elevated severe PCI inpatient)	0	1	0,035	0,183	-1,701	0,108*						
DBC code 110002040243 (ST elevated severe PCI inpatient)	0	1	0,221	0,415	-1,582	0,053*						
DBC code 110002040103 (ST elevated regular/no treatment inpatient)	0	1	0,249	0,432	-0,503	0,051*						
DBC code 110002050103 (non-ST elevated regular/no treatment inpatient) (ref)	0	1	0,331	0,471								
other non-reference DBC codes	0	1	0,063	0,244	-1,964	0,083*						
age 1 to 60	0	1	0,386	0,487			-0,028	0,051				
age 61 to 70 (ref)	0	1	0,234	0,424								
age 71 to 80	0	1	0,222	0,416			0,189	0,057*	0,124	0,044*	0,042	0,043
age 81 to 85	0	1	0,092	0,289			0,246	0,076*	0,218	0,064*	0,098	0,062
age >86	0	1	0,066	0,248			0,032	0,087				
male	0	1	0,674	0,469			-0,144	0,042*	-0,123	0,039*	-0,121	0,038*
emergency admission	0	1	0,491	0,500			0,490	0,040*	0,177	0,038*	0,023	0,039
ICU admission	0	1	0,011	0,106			0,484	0,181*	-0,383	0,169*	-0,934	0,166*
small general hospital	0	1	0,169	0,375			0,341	0,075*	0,358	0,069*	0,492	0,068*
medium-sized general hospital	0	1	0,205	0,404			-0,493	0,072*	-0,540	0,067*	-0,576	0,065*
large general hospital (ref)	0	1	0,130	0,336								
non-university teaching hospital	0	1	0,338	0,473			0,790	0,064*	0,649	0,059*	0,533	0,058*
university teaching hospital	0	1	0,158	0,365			0,537	0,079*	0,558	0,073*	0,484	0,069*
Signal Intensity elevated AMI (ref)	0	1	0,547	0,498								
Signal Intensity not elevated AMI	0	1	0,398	0,490			0,416	0,044*	-0,446	0,041*	0,342	0,040*

Sig. $P < 0.05$

Table 3.2: continued

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,066		R^2 = 0,079		R^2 = 0,209		R^2 = 0,252	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
subsequent AMI	0	1	0,055	0,228			-1,464	0,091*	-1,394	0,084*	-1,381	0,087*
coronary stent	0	1	0,269	0,443			0,470	0,074*	intolerant		0,383	0,070*
PTCA	0	1	0,297	0,472			-0,140	0,080				
catheterisation of heart (ref)	0	1	0,365	0,481								
conservative treatment	0	1	0,635	0,481			1,978	0,094*	1,125	0,075*	1,523	0,074*
diagnostic procedures	0	1	0,852	0,355					1,049	0,055*		
laboratory services	0	1	0,817	0,387					0,661	0,055*		
microbiology/ parasitology	0	1	0,129	0,335					1,959	0,055*		
medical imaging services	0	1	0,610	0,488					0,931	0,040*		
pathology	0	1	0,003	0,059					1,371	0,304*		
paramedics (e.g. physical therapy)	0	1	0,121	0,326					1,876	0,055*		
blood products	0	1	0,007	0,084					0,531	0,211*		
medical devices	0	1	0,269	0,443					0,329	0,071*		
rehabilitation	0	1	0,024	0,153					-0,514	0,117*		
number of admissions	0	8	1,098	0,392							-2,009	0,047*
number of outpatient visits	0	17	0,891	0,925							0,366	0,021*
number of hours at the daycare facility	0	3	0,082	0,282							-0,879	0,069*
number of diagnostic procedures	0	2216	4,363	13,425							0,016	0,001*
number of laboratory services	0	230	5,017	8,178							0,054	0,003*
number of microbiology/ parasitology services	0	207	0,954	4,626							0,029	0,001*
number of medical imaging services	0	28	1,094	1,450							0,630	0,014*
number of pathology services	0	6	0,005	0,104							0,211	0,166
number of sessions paramedics	0	74	0,493	2,085							0,204	0,008*
number of blood products	0	15	0,019	0,278							-0,044	0,062
number of medical devices	0	402	0,428	2,436							0,012	0,007
number of sessions rehabilitation	0	32	0,072	0,675							-0,131	0,026*

Sig. $P < 0.05$

3.3 CABG

CABG can be performed after AMI or in patients with existing coronary heart disease who are referred to the hospital by the cardiologist. In the Netherlands, about 16,000 CABGs are performed each year. In 2007, 58 CABGs were performed per 100,000 inhabitants. Seventy-five% of CABGs were performed in men. The mean age of the patients was 66 years in men and 70 years in women. Sixty-eight% of CABGs involved at least one vein and at least one artery. All patients are treated in the inpatient setting [14].

In 2008, a total number of 13,439 patients (76%) with mean age 67 (SD 10) years received a bypass anastomosis for heart revascularization (ICD-9-CM procedure code 36.1) and met all the inclusion criteria (cf section 2). Table 3.3 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 4.9 (SD 4.3) days (Appendix A-3). Of the patients, 51% was appointed to the reference DBC code 110023200110 (CABG, venous grafts and ≤ 1 arterial graft ~ first surgery without implant). Each of the other DBC codes resulted in a LOS prolongation of between 0.5 days for DBC code 110024000110 (CABG (≥ 2 arterial grafts) ~ first surgery without implant) and 2.4 days for DBC code 110025500120 (CABG + mitral valve plasty +/- tricuspidal valve plasty ~ first surgery with implant). The DBC codes were able to explain only 2.0% of the LOS.

Although not significantly, only patients up to 60 years had a shorter LOS than patients aged 61 to 65 years (reference category). Episode-specific treatment variables concerned subsequent CABG (yes/no), PTCA (yes/no), more thank 1 vessel treated (yes/no), valve surgery on heart (yes/no), multiple CABG (yes/no), mitral valve replacement (yes/no), aortic valve replacement (yes/no), mitral valve plasty (yes/no), tricuspidal valve plasty (yes/no), hypertrophic obstructive cardiomyopathy (yes/no), ventricular tachycardia (yes/no), ventricular septal rupture (yes/no), maze procedure (yes/no), aortic surgery (yes/no), number of aortic prostheses and implant (yes/no). However, the performance of PTCA, the presence of hypertrophic obstructive cardiomyopathy, the presence of ventricular tachycardia and the performance of the maze procedure did not significantly impact LOS. The set of core variables performed much better in explaining variation in LOS than the DBC codes ($R^2 = 0.200$). The set of core variables in combination with numbers of resource quantities even had a predictive ability of 53.0%.

Thirty-five % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 110023200110 (CABG, venous grafts and ≤ 1 arterial graft ~ first surgery without implant). Still, none of the CABG patients was treated in daycare. Hence, PLL model included exactly the same patients as the OLS model (13,439 patients). In contrast to the OLS model, the PLL model did not identify impact of valve surgery on heart ($P = 0.317$) and tricuspidal valve plasty ($P = 0.112$). The associations seen with the remaining variables in both models were similar in direction. However, the magnitude of a substantial number of variables differed substantially between models. For example, a ventricular septal rupture related to a LOS prolongation of 0.9 days in the PLL model (compared to 6.0 in the OLS model). Similarly, an admission to a non-university teaching hospital related to a LOS reduction of 0.6 days (compared to 3.8 days in the OLS model) and an admission to a university teaching hospital to a LOS reduction of 0.7 days (compared to 4.2 days in the OLS model). Other variables which showed differences of between 1.0 and 2.0 days between both models concerned the emergency admission, multiple CABG, mitral valve replacement, aortic valve replacement, mitral valve plasty, aortic surgery and implant (Appendix C-3).

Table 3.3: CABG ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 R^2 = 0,020		Model 2 R^2 = 0,200		Model 3 R^2 = 0,285		Model 4 R^2 = 0,530	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					4,478	0,058*	6,490	0,195*	4,413	0,256*	7,643	0,157*
length of stay of the first inpatient admission	0	25	4,937	4,303								
DBC code 110023200110 (CABG, venous grafts and ≤ 1 arterial graft ~ first surgery without implant) (ref)	0	1	0,513	0,500								
DBC code 110024000110 (CABG (≥ 2 arterial grafts) ~ first surgery without implant)	0	1	0,249	0,433	0,533	0,102*						
DBC code 110023200210 (CABG, venous grafts and ≤ 1 arterial graft ~ re-surgery with implant)	0	1	0,019	0,138	0,884	0,307*						
DBC code 110024250120 (CABG (1 arterial graft) + AVR ~ first surgery with implant)	0	1	0,077	0,267	1,030	0,162*						
DBC code 110025700120 (CABG (2 arterial grafts) + AVR ~ first surgery with implant)	0	1	0,021	0,144	1,095	0,294*						
DBC code 110025500120 (CABG + MPL +/- TPL ~ first surgery with implant)	0	1	0,029	0,168	2,463	0,253*						
other non-reference DBC codes	0	1	0,090	0,286	1,578	0,151*						
age 1 to 60	0	1	0,239	0,426			-0,016	0,126				
age 61 to 65 (ref)	0	1	0,170	0,376								
age 66 to 70	0	1	0,181	0,385			0,151	0,134				
age 71 to 75	0	1	0,187	0,390			0,359	0,133*	0,202	0,102*	0,198	0,082*
age >76	0	1	0,222	0,416			0,763	0,131*	0,594	0,100*	0,348	0,080*
male	0	1	0,755	0,430			-0,219	0,094*	-0,246	0,091*	-0,153	0,072*
emergency admission	0	1	0,032	0,175			-2,053	0,219*	-1,293	0,215*	-1,418	0,169*
ICU admission	0	1	0,078	0,269			0,987	0,157*	0,493	0,161*	-0,859	0,139*
large general hospital (ref)	0	1	0,124	0,329								
non-university teaching hospital	0	1	0,489	0,500			-3,823	0,137*	-3,943	0,152*	-1,357	0,128*
university teaching hospital	0	1	0,388	0,487			-4,219	0,131*	-4,188	0,139*	-1,781	0,111*
subsequent CABG	0	1	0,035	0,184			0,939	0,219*	0,867	0,212*	0,332	0,169*
PTCA	0	1	0,000	0,014			1,201	2,692				
more thank 1 vessel treated	0	1	0,291	0,454			0,238	0,098*	0,080	0,094	0,044	0,074
valve surgery on heart	0	1	0,185	0,388			-1,082	0,498*	-0,689	0,450	-0,836	0,358*

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,020		R^2 = 0,200		R^2 = 0,285		R^2 = 0,530	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
multiple cabg	0	1	0,787	0,410			1,787	0,116*	1,947	0,120*	1,250	0,093*
mitral valve replacement	0	1	0,010	0,099			1,886	0,489*	1,466	0,459*	1,211	0,365*
aortic valve replacement	0	1	0,129	0,336			1,773	0,330*	1,248	0,287*	0,626	0,228*
mitral valve plasty	0	1	0,066	0,247			2,071	0,353*	1,672	0,333*	1,613	0,264*
tricuspidal valve plasty	0	1	0,046	0,210			0,826	0,356*	0,852	0,329*	0,147	0,262
hypertrophic obstructive cardiomyopathy	0	1	0,004	0,067			-0,002	0,580				
ventricular tachycardia	0	1	0,001	0,024			0,254	1,557				
ventricular septal rupture	0	1	0,001	0,031			6,018	1,217*	5,277	1,173*	1,867	0,939*
maze procedure	0	1	0,025	0,157			0,413	0,302				
aortic surgery	0	1	0,008	0,089			2,105	0,535*	1,211	0,519*	0,021	0,412
number of aortic prostheses	0	4	0,265	0,629			-1,127	0,070*	-0,137	0,165	0,074	0,058
implant	0	1	0,186	0,390			1,268	0,361*	1,182	0,347*	1,090	0,276*
diagnostic procedures	0	1	0,576	0,494					-0,264	0,095*		
laboratory services	0	1	0,930	0,255					0,306	0,173		
microbiology/ parasitology	0	1	0,423	0,494					0,903	0,091*		
medical imaging services	0	1	0,895	0,307					1,179	0,170*		
pathology	0	1	0,059	0,236					2,008	0,201*		
paramedics (e.g. physical therapy)	0	1	0,281	0,450					1,596	0,094*		
blood products	0	1	0,052	0,222					0,385	0,176*		
medical devices	0	1	0,170	0,376					-1,514	0,277*		
rehabilitation	0	1	0,008	0,087					-0,160	0,427		
number of admissions	0	6	1,363	0,580							-3,525	0,059*
number of outpatient visits	0	19	0,828	0,962							0,126	0,034*
number of hours at the daycare facility	0	2	0,026	0,163							-2,659	0,198*
number of diagnostic procedures	0	117	2,824	5,564							0,020	0,007*
number of laboratory services	0	687	9,058	21,829							-0,022	0,002*
number of microbiology/ parasitology services	0	967	3,196	13,916							0,002	0,002
number of medical imaging services	0	78	3,836	3,566							0,469	0,013*
number of pathology services	0	9	0,067	0,296							0,606	0,118*
number of sessions paramedics	0	122	1,858	4,454							0,162	0,008*
number of blood products	0	27	0,189	1,179							0,080	0,028*
number of medical devices	0	13	0,005	0,149							0,367	0,195
number of sessions rehabilitation	0	17	0,036	0,547							-0,002	0,053

3.4 Stroke

In the Netherlands, the yearly incidence of stroke was 2.0 per 1,000 men and 2.3 per 1,000 women in 2004. The yearly incidence of stroke in people of at least 55 years was estimated at 7.7 per 1,000 men and 6.8 per 1,000 women. In 2004, the standardised prevalence of stroke was about 216,500 (2,670 per 100,000 inhabitants) [(14)]. On a population level, stroke was one of the most expensive diseases in the Netherlands in 2005. Absolute costs were estimated at € 633 million for men (58%) and € 884 million for women (42%). Stroke was responsible for 2.2% of the national health expenditures. Sixty-three% of the costs are attributable to the elderly and 29% to hospital and medical specialist care. Costs were highest in the patient aged 70 to 89 years [(15)]. In 2004, the absolute number of hospital admissions for stroke was almost 35,000 [(14)].

Best practice recommendations are developed by the Institute of Quality in Healthcare (http://www.cbo.nl/).Patients are only admitted for thrombolysis within 24 hours after onset of clinical symptoms. In 2008, a total number of 31,188 stroke patients (50% males) with mean age 68 (SD 19) years were admitted for intracerebral haemorrhage (ICD-10 code I61), cerebral infarction (I63) or stroke, not specified as haemorrhage or infarction (I64) and met all the inclusion criteria (cf section 2). Table 3.4 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. Of the patients, 4.3% was admitted for thrombolysis. The mean LOS of the first inpatient admission was 5.7 (SD 6.7) days (Appendix A-4). Of the patients, 66% was appointed to the reference DBC code 110011110113 (non-hemorrhagic stroke regular treatment inpatient). DBC code 110011110112 (non-hemorrhagic stroke regular treatment in daycare) resulted in a LOS reduction of exactly 5.7 days. The (positive/ negative) impact was limited to <1 day for the remaining (inpatient) DBC codes. The DBC codes were able to explain 6.8% of the LOS.

Patients in aged 61 to 70 years had the lowest LOS. Episode-specific treatment variables concerned intracereberal haemorrhage (yes/no), unspecified stroke (yes/no), thrombolysis (yes/no), number of endarterectomies and conservative treatment (yes/no). However, the number of endarterectomies did not significantly impact LOS. The set of core variables performed worse than the DBC codes (R^2 = 0.033). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (11.7% and 23.1% respectively).

One third of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the DBC codes 110011110113 (non-hemorrhagic stroke regular treatment inpatient) and 110011020113 (intracerebral hemorrhage regular treatment inpatient). About 1 out of 10 stroke patients was treated in daycare. Patients were less likely than other patients to receive treatment in daycare when they were older than 71 years, admitted through the emergency department, admitted to a small or medium-sized general hospital or to a non-university teaching hospital and/or suffered from intracereberal haemorrhage (Appendix B-4). The PLL model (28,269 patients) and OLS model (31,188 patients) identified the same variables to impact LOS. The direction of emergency admission was positive in the OLS model (0.4 days) and negative in the PLL model (0.1 days; $P < 0.001$). However, with the PLL model, the associations seen with the remaining variables were similar in direction but smaller in magnitude in comparison with the OLS model. An ICU admission related to a LOS reduction of 0.3 days in the PLL model (compared to 2.9 in the OLS model). Other variables which showed differences of between 1.0 and 2.0 days between both models concerned admission to a non-university teaching hospital and conservative treatment (Appendix C-4).

Table 3.4: Stroke ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,068		R^2 = 0,033		R^2 = 0,117		R^2 = 0,231	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					6,199	0,045*	6,208	0,251*	0,955	0,600	7,250	0,236*
length of stay of the first inpatient admission	0	33	5,680	6,738								
DBC code 110011110112 (non-hemorrhagic stroke regular treatment in daycare)	0	1	0,090	0,287	-5,699	0,130*						
DBC code 110011010113 (subarachnoid hemorrhage regular treatment inpatient)	0	1	0,035	0,183	-0,651	0,201*						
DBC code 110011030113 (intracranial hemorrhage regular treatment inpatient)	0	1	0,045	0,206	-0,428	0,179*						
DBC code 110011110113 (non-hemorrhagic stroke regular treatment inpatient) (ref)	0	1	0,663	0,473								
DBC code 110011110213 (non-hemorrhagic stroke thrombolysis inpatient)	0	1	0,043	0,204	0,669	0,181*						
DBC code 110011020113 (intracerebral hemorrhage regular treatment inpatient)	0	1	0,116	0,320	0,874	0,117*						
other non-reference DBC codes	0	1	0,008	0,090	-5,210	0,407*						
age 1 to 60	0	1	0,255	0,436			0,181	0,115				
age 61 to 70 (ref)	0	1	0,188	0,391								
age 71 to 80	0	1	0,281	0,450			0,625	0,113*	0,532	0,088*	0,475	0,083*
age 81 to 85	0	1	0,147	0,354			0,985	0,133*	0,815	0,110*	0,764	0,104*
age >86	0	1	0,129	0,335			1,137	0,139*	0,846	0,117*	0,846	0,111*
male	0	1	0,503	0,500			-0,420	0,077*	-0,287	0,074*	-0,337	0,069*
emergency admission	0	1	0,571	0,495			0,400	0,078*	0,037	0,076	-0,393	0,073*
ICU admission	0	1	0,005	0,072			2,938	0,517*	1,657	0,494*	-0,903	0,474
small general hospital	0	1	0,218	0,413			0,950	0,130*	1,060	0,124*	0,558	0,118*
medium-sized general hospital	0	1	0,263	0,440			-0,636	0,126*	-0,696	0,120*	-0,712	0,113*
large general hospital (ref)	0	1	0,139	0,346								
non-university teaching hospital	0	1	0,287	0,452			1,931	0,125*	1,538	0,120*	0,748	0,113*
university teaching hospital	0	1	0,093	0,290			1,141	0,163*	1,865	0,161*	0,908	0,150*
intracereberal haemorrhage (ref)	0	1	0,200	0,400								
unspecified stroke	0	1	0,800	0,400			-0,748	0,096*	-0,989	0,095*	-0,419	0,088*
thrombolysis (ref)	0	1	0,043	0,204								
conservative treatment	0	1	0,957	0,204			-1,255	0,187*	0,364	0,568	-0,264	0,168
number of endarterectomies	0	2	0,000	0,018			1,901	2,077				

Sig. $P < 0.05$

Table 3.4: continued

					Model 1		Model 2		Model 3		Model 4	
					$R^2 = 0,068$		$R^2 = 0,033$		$R^2 = 0,117$		$R^2 = 0,231$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,714	0,452					0,731	0,086*		
laboratory services	0	1	0,898	0,303					0,986	0,130*		
microbiology/ parasitology	0	1	0,226	0,418					3,591	0,089*		
medical imaging services	0	1	0,927	0,261					1,471	0,147*		
pathology	0	1	0,009	0,096					-0,203	0,379		
paramedics (e.g. physical therapy)	0	1	0,380	0,485					1,478	0,078*		
blood products	0	1	0,003	0,050					1,992	0,708*		
medical devices	0	1	0,042	0,200					1,260	0,579*		
rehabilitation	0	1	0,001	0,037					3,077	0,981*		
number of admissions	0	7	1,167	0,515							-3,039	0,068*
number of outpatient visits	0	32	1,483	1,241							-0,046	0,029
number of hours at the daycare facility	0	3	0,100	0,313							-3,670	0,118*
number of diagnostic procedures	0	108	1,246	1,527							0,123	0,024*
number of laboratory services	0	318	5,959	11,643							0,053	0,003*
number of microbiology/ parasitology services	0	474	2,068	8,046							0,062	0,005*
number of medical imaging services	0	51	2,208	1,761							0,733	0,022*
number of pathology services	0	7	0,012	0,152							0,113	0,223
number of sessions paramedics	0	210	4,264	9,837							0,141	0,004*
number of blood products	0	25	0,008	0,261							-0,104	0,128
number of medical devices	0	2200	0,114	12,459							0,005	0,003*
number of sessions rehabilitation	0	16	0,004	0,177							0,423	0,188*

Sig. $P < 0.05$

3.5 Inguinal hernia repair

In the Netherlands, inguinal hernia repair is the most frequently performed general surgical intervention. The life-time risk of inguinal hernia is 25% for men and 4% for women. The incidence amounted to 400 per 100,000 men and to 50 per 100,000 women in 2004. In 2007, 29,065 inguinal hernia repairs were performed, of which 10,214 in the inpatient setting and 18,851 as daycare treatment [(14)].

The guideline Inguinal hernia of the Dutch Surgery Association recommends the use of open surgery (i.e. the Lichtenstein Technique) as the preferred treatment option. Endoscopic techniques may be considered when applied by experienced teams and in case of specific indications (http://www.heelkunde.nl). In 2008, a total number of 24,201 inguinal hernia patients (90% males) with mean age 49 (SD 24) years received a laparoscopic unilateral repair of inguinal hernia (ICD-9-CM procedure code 17.1), laparoscopic bilateral repair of inguinal hernia (17.2), other unilateral repair of inguinal hernia (53.0) or other bilateral repair of inguinal hernia (53.1) and met all the inclusion criteria (cf section 2). Table 3.5 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 0.4 (SD 0.6) days (Appendix A-5). Of the patients, 58% was appointed to the reference DBC code 110001210202 (open surgery in daycare). DBC code 110001210302 (laparoscopic in daycare) obviously had no impact on LOS. However, the remaining (inpatient) DBC codes resulted in a LOS prolongation of between 0.6 and 0.7 days. The DBC codes were able to explain up to 48.8% of the LOS.

Patients aged 1 to 30 years had a shorter LOS than patients older than 30 years. Episode-specific treatment variables concerned the laparoscopic procedure (yes/no) and recurrent inguinal hernia (yes/no). However, the performance of the laparoscopic procedure did not significantly impact LOS. The set of core variables performed worse than the DBC codes ($R^2 = 0.104$). The set of core variables in combination with the cost categories had a predictive ability of 15.8% and in combination with numbers of resource quantities a predictive ability of 41.3%.

Two out of 3 inguinal hernia patients was treated in daycare. Patients were more likely than other patients to receive treatment in daycare when they were up to 30 years, male and/or admitted to a medium-sized general hospital. Patients were less likely to receive treatment in daycare when they were older than 61 years, admitted through the emergency department, admitted to a small general hospital, a non-university- or university teaching hospital, received the laparoscopic procedure and/or suffered from a recurrent inguinal hernia (Appendix B-5). In contrast to the OLS model (24,201 patients), the PLL model (7,874 patients) did not identify impact patients aged 1 to 30 years (P = 0.965), ICU admission (P = 0.055), admission to a small general hospital (P = 0.251) nor admission to a moderate general hospital (P = 0.121). However, the PLL model additionally observed laparoscopic procedure to influence LOS (P < 0.001). With both models, the associations seen with the remaining variables were similar in direction and magnitude (Appendix C-5).

Table 3.5: Inguinal hernia repair ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0{,}488$		Model 2 $R^2 = 0{,}104$		Model 3 $R^2 = 0{,}158$		Model 4 $R^2 = 0{,}413$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					0,500	0,003*	0,629	0,013*	0,587	0,012*	0,822	0,019*
length of stay of the first inpatient admission	0	5	0,358	0,639								
DBC code 110001210302 (laparoscopic in daycare)	0	1	0,118	0,322	0,000	0,007						
DBC code 110001210202 (open surgery in daycare) (ref)	0	1	0,583	0,493								
DBC code 110001210303 (laparoscopic inpatient)	0	1	0,052	0,221	0,596	0,010*						
DBC code 110001210203 (open surgery inpatient)	0	1	0,248	0,432	0,719	0,005*						
age 1 to 30	0	1	0,219	0,414			-0,036	0,009*	-0,026	0,008*	0,003	0,006
age 31 to 50 (ref)	0	1	0,208	0,406								
age 51 to 60	0	1	0,179	0,384			0,008	0,009				
age 61 to 70	0	1	0,202	0,401			0,074	0,009*	0,047	0,008*	0,019	0,006*
age >71	0	1	0,192	0,394			0,274	0,009*	0,222	0,008*	0,098	0,007*
male	0	1	0,898	0,302			-0,048	0,010*	-0,037	0,009*	-0,026	0,008*
emergency admission	0	1	0,061	0,239			0,286	0,012*	0,193	0,012*	0,144	0,010*
ICU admission	0	1	0,000	0,021			0,734	0,132*	0,591	0,131*	0,344	0,113*
small general hospital	0	1	0,260	0,439			0,030	0,010*	0,008	0,009	0,014	0,008
medium-sized general hospital	0	1	0,293	0,455			-0,025	0,009*	-0,027	0,009*	0,007	0,008
large general hospital (ref)	0	1	0,132	0,339								
non-university teaching hospital	0	1	0,266	0,442			0,082	0,010*	0,071	0,009*	0,064	0,008*
university teaching hospital	0	1	0,049	0,215			0,267	0,015*	0,263	0,015*	0,198	0,012*
laparoscopic inguinal hernia procedure	0	1	0,169	0,375			0,011	0,008				
recurrent inguinal hernia	0	4	0,097	0,357			0,084	0,008*	0,070	0,008*	0,026	0,006*

Sig. $P < 0.05$

Table 3.5: continued

					Model 1		Model 2		Model 3		Model 4	
					$R^2 = 0,488$		$R^2 = 0,104$		$R^2 = 0,158$		$R^2 = 0,413$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,158	0,365					0,019	0,008*		
laboratory services	0	1	0,281	0,449					0,148	0,007*		
microbiology/ parasitology	0	1	0,017	0,130					0,191	0,022*		
medical imaging services	0	1	0,124	0,329					0,101	0,009*		
pathology	0	1	0,024	0,152					0,109	0,018*		
paramedics (e.g. physical therapy)	0	1	0,002	0,045					1,024	0,060*		
blood products	0	1	0,000	0,020					1,106	0,134*		
medical devices	0	1	0,000	0,009					-0,483	0,306		
number of admissions	1	4	1,024	0,161							0,162	0,016*
number of outpatient visits	0	29	2,315	1,239							0,005	0,002*
number of hours at the daycare facility	0	30	0,728	0,528							-0,481	0,005*
number of diagnostic procedures	0	8	0,177	0,441							0,016	0,005*
number of laboratory services	0	103	0,454	1,567							0,025	0,002*
number of microbiology/ parasitology services	0	72	0,134	1,683							-0,011	0,002*
number of medical imaging services	0	21	0,160	0,513							0,035	0,005*
number of pathology services	0	5	0,028	0,195							0,041	0,012*
number of sessions paramedics	0	37	0,008	0,307							0,041	0,008*
number of blood products	0	13	0,002	0,119							0,026	0,021
number of medical devices	0	2	0,000	0,013							-0,785	0,189*

Sig. $P < 0.05$

3.6 Appendectomy

The incidence of acute appendicitis at the GP practice is estimated at 1 per 1,000 patients per year. In patients older than 25 years, more men than women are caught by the disease. Although the performance of the laparoscopic procedure is increasing, the appendix is usually removed through open surgery [14].

In 2008, a total number of 9,664 appendicitis patients (54% males) with mean age 31 (SD 18) years received operations on appendix (ICD-9-CM procedure code 47) and met all the inclusion criteria (cf section 2). Table 3.6 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 2.1 (SD 1.8) days (Appendix A-6). Of the patients, 61% was appointed to the reference DBC code 110001130203 (open surgery inpatient). DBC code 110001130303 (laparoscopic inpatient) prolonged the LOS significantly, but only by 0.1 days. The DBC codes were not able to explain the LOS ($R^2 = 0.001$).

Patients up to 10 years and older than 36 years had the highest LOS. The episode-specific treatment variable concerned the laparoscopic procedure (yes/no), but did not significantly impact LOS. The set of core variables performed slightly better than the DBC codes ($R^2 = 0.069$). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (14.6% and 15.7% respectively).

Sixty % of the inpatient admissions had a LOS of 1, but virtually none of the appendectomy patients was treated in daycare (21/ 9,664 patients), all of which concerned laparoscopic surgeries. Patients were about 10 times less likely than other patients to receive treatment in daycare when they were admitted through the emergency department ($P = 0.002$) (Appendix B-6). The PLL model (1,654 patients) and OLS model (1,664 patients) identified the exact same variables to impact LOS. The impact of the variables had the same direction in both models and slightly smaller magnitude in the PLL model (Appendix C-6).

Table 3.6: Appendectomy ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 R^2 = 0,001		Model 2 R^2 = 0,069		Model 3 R^2 = 0,146		Model 4 R^2 = 0,157	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					2,032	0,023*	1,706	0,075*	1,382	0,078*	1,899	0,081*
length of stay of the first inpatient admission	1	10	2,064	1,761								
DBC code 110001130203 (open surgery inpatient) (ref)	0	1	0,609	0,488								
DBC code 110001130303 (laparoscopic inpatient)	0	1	0,390	0,488	0,085	0,037*						
other non-reference DBC codes	0	1	0,001	0,032	-1,032	0,557*						
age 1 to 10	0	1	0,107	0,310			0,186	0,071*	0,172	0,056*	0,209	0,056*
age 11 to 15 (ref)	0	1	0,143	0,350								
age 16 to 20	0	1	0,138	0,345			-0,079	0,066				
age 21 to 35	0	1	0,251	0,434			-0,061	0,058				
age >36	0	1	0,360	0,480			0,328	0,055*	0,207	0,037*	0,182	0,037*
male	0	1	0,536	0,499			-0,056	0,037				
emergency admission	0	1	0,761	0,427			0,062	0,043				
ICU admission	0	1	0,007	0,081			1,529	0,214*	0,763	0,209*	0,117	0,217
small general hospital	0	1	0,231	0,421			0,217	0,056*	0,257	0,055*	0,245	0,054*
medium-sized general hospital	0	1	0,286	0,452			-0,269	0,053*	-0,262	0,052*	-0,304	0,051*
large general hospital (ref)	0	1	0,176	0,381								
non-university teaching hospital	0	1	0,229	0,420			0,603	0,056*	0,536	0,054*	0,521	0,054*
university teaching hospital	0	1	0,079	0,270			1,036	0,077*	1,042	0,076*	1,206	0,075*
laparoscopic appendectomy procedure	0	1	0,391	0,488			0,015	0,038				

Sig. $P < 0.05$

Table 3.6: continued

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,001		R^2 = 0,069		R^2 = 0,146		R^2 = 0,157	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,118	0,323					0,658	0,054*		
laboratory services	0	1	0,909	0,288					-0,008	0,063		
microbiology/ parasitology	0	1	0,229	0,420					0,947	0,041*		
medical imaging services	0	1	0,593	0,491					0,059	0,035		
pathology	0	1	0,778	0,416					0,044	0,043		
paramedics (e.g. physical therapy)	0	1	0,011	0,106					0,931	0,158*		
blood products	0	1	0,001	0,023					1,200	0,724		
number of admissions	1	6	1,086	0,327							-0,762	0,061*
number of outpatient visits	0	13	2,266	1,195							0,091	0,016*
number of hours at the daycare facility	0	2	0,013	0,113							0,483	0,159*
number of diagnostic procedures	0	12	0,148	0,475							0,448	0,038*
number of laboratory services	0	69	2,581	3,302							0,091	0,007*
number of microbiology/ parasitology services	0	158	1,959	6,721							0,032	0,003*
number of medical imaging services	0	12	0,987	1,187							0,085	0,017*
number of pathology services	0	7	0,802	0,464							0,054	0,038
number of sessions paramedics	0	28	0,059	0,796							-0,038	0,021
number of blood products	0	2	0,001	0,045							0,472	0,361

Sig. $P < 0.05$

3.7 Cholecystectomy

Cholelithiasis is most frequently seen in patients aged 70 to 80 years. For these patients, the prevalence is estimated at 16% in men and 40% in women. Cholecystectomy is the most common means of treating symptomatic gallstones. In 2007, 24,521 cholecystectomies were performed, of which 3,280 open surgeries and 21,241 laparoscopic procedures [(14)].

In 2008, a total number of 16,339 cholelithiasis patients (29% males) with mean age 51 (SD 17) years received a cholecystectomy (ICD-9-CM procedure code 51.2) and met all the inclusion criteria (cf section 2). Table 3.7 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 1.7 (SD 1.6) days (Appendix A-7). Of the patients, 78% was appointed to the reference DBC code 110003230303 (laparoscopic inpatient). DBC code 110003230302 (laparoscopic in daycare) resulted in a LOS reduction of 1.1 days, while DBC code 110003230203 (open surgery inpatient) in a LOS prolongation of 1.8 days. The DBC codes were able to explain 11.9% of the LOS.

Patients older than 61 years had the highest LOS. The episode-specific treatment variable concerned the laparoscopic procedure (yes/no), which significantly reduced LOS about 1.5 days. The set of core variables performed slightly better than the DBC codes ($R^2 = 0.163$). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (21.0% and 22.5% respectively).

Sixty-eight % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 110003230303 (laparoscopic inpatient). About 1 out of 20 cholecystectomy patients was treated in daycare, all of which concerned laparoscopic procedures. Patients were more likely than other patients to receive treatment in daycare when they were admitted to a university teaching hospital and/or received the laparoscopic procedure. Especially the latter variable had a great impact: patients receiving the laparoscopic procedure were about 20 times more likely to be treated in daycare ($P < 0.001$). Patients were less likely to receive treatment in daycare when they were older than 61 years, admitted through the emergency department and/or admitted to a medium-sized general hospital (Appendix B-7). The PLL model (15,532 patients) and OLS model (16,339 patients) identified the exact same variables to impact LOS. The impact of the variables had the same direction in both models and smaller magnitude in the PLL model. An ICU admission related to a LOS prolongation of 0.6 days in the PLL model (compared to 1.7 in the OLS model) (Appendix C-7).

Table 3.7: Cholecystectomy ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0,119$		Model 2 $R^2 = 0,163$		Model 3 $R^2 = 0,210$		Model 4 $R^2 = 0,225$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					1,592	0,013*	2,641	0,056*	2,073	0,060*	2,789	0,061*
length of stay of the first inpatient admission	0	11	1,662	1,647								
DBC code 110003230302 (laparoscopic in daycare)	0	1	0,049	0,216	-1,092	0,055*						
DBC code 110003230303 (laparoscopic inpatient) (ref)	0	1	0,867	0,340								
DBC code 110003230203 (open surgery inpatient)	0	1	0,084	0,277	1,779	0,043*						
other non-reference DBC codes	0	1	0,000	0,016	-0,592	0,763						
age 1 to 40	0	1	0,283	0,450			-0,026	0,034				
age 41 to 50 (ref)	0	1	0,214	0,410								
age 51 to 60	0	1	0,205	0,404			0,050	0,037				
age 61 to 70	0	1	0,166	0,372			0,338	0,039*	0,246	0,032*	0,254	0,032*
age >71	0	1	0,133	0,339			0,762	0,042*	0,568	0,036*	0,608	0,035*
male	0	1	0,289	0,453			0,061	0,027*	0,030	0,026	0,048	0,026
emergency admission	0	1	0,224	0,417			0,510	0,029*	0,127	0,031*	0,342	0,030*
ICU admission	0	1	0,004	0,064			1,661	0,184*	1,278	0,180*	1,200	0,182*
small general hospital	0	1	0,235	0,424			0,059	0,035				
medium-sized general hospital	0	1	0,249	0,432			-0,131	0,034*	-0,151	0,029*	-0,201	0,028*
large general hospital (ref)	0	1	0,177	0,382								
non-university teaching hospital	0	1	0,235	0,424			0,342	0,035*	0,292	0,029*	0,296	0,029*
university teaching hospital	0	1	0,051	0,220			0,745	0,058*	0,733	0,055*	0,812	0,054*
laparoscopic cholecystectomy procedure	0	1	0,916	0,277			-1,504	0,044*	-1,205	0,044*	-1,361	0,043*

Sig. $P < 0.05$

Table 3.7: continued

					Model 1		Model 2		Model 3		Model 4	
					$R^2 = 0{,}119$		$R^2 = 0{,}163$		$R^2 = 0{,}210$		$R^2 = 0{,}225$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,194	0,395					0,140	0,031*		
laboratory services	0	1	0,851	0,356					0,168	0,034*		
microbiology/ parasitology	0	1	0,117	0,322					0,712	0,039*		
medical imaging services	0	1	0,340	0,474					0,457	0,028*		
pathology	0	1	0,791	0,407					0,050	0,029		
paramedics (e.g. physical therapy)	0	1	0,029	0,166					0,571	0,071*		
blood products	0	1	0,003	0,057					0,229	0,201		
medical devices	0	1	0,000	0,014					-1,162	0,848		
rehabilitation	0	1	0,000	0,011					2,723	1,036*		
number of admissions	0	7	1,134	0,426							-0,259	0,032*
number of outpatient visits	0	25	2,633	1,459							-0,012	0,009
number of hours at the daycare facility	0	5	0,068	0,263							-1,097	0,044*
number of diagnostic procedures	0	73	0,242	0,809							0,014	0,016
number of laboratory services	0	298	3,087	5,978							0,010	0,003*
number of microbiology/ parasitology services	0	472	1,123	7,591							-0,005	0,002*
number of medical imaging services	0	55	0,681	1,446							0,215	0,011*
number of pathology services	0	7	0,823	0,479							0,079	0,024*
number of sessions paramedics	0	60	0,139	1,438							-0,008	0,008
number of blood products	0	25	0,011	0,300							-0,006	0,039
number of medical devices	0	24	0,002	0,188							-0,051	0,061
number of sessions rehabilitation	0	2	0,000	0,017							2,508	0,650*

Sig. $P < 0.05$

3.8 Hip replacement

The most common reason for a hip replacement is to treat joint failure caused by hip osteoarthritis. Other indications include hip fractures, benign and malignant bone tumours and avascular necrosis. Approximately 260,000 people older than 55 years suffer from hip osteoarthritis. The yearly incidences of hip osteoarthritis are estimated at 0.9 per 1,000 in men and 1.6 per 1,000 in women. Hip fractures most frequently occur in patients aged 75 to 94 years. For patients older than 85 years the number of hip fractures was 1.5 times higher than for patients aged 80 to 85 years. In 2007, 32,061 hip replacements were performed (196 per 100,000 inhabitants), of which 2,107 involved a secondary diagnosis (14). In 2005, the national costs of hip fracture amounted to € 391.6 million. This equals 0.6% of the national health expenditures. Twenty-six% of the costs were attributable to men and 74% to women. Most costs are attributable to the elderly (15). The mean LOS has decreased from 25 days in 1994 to 16 days in 2004. This decrease is due to the shifts in setting and nursing: more patients are treated at home (14).

In 2008, a total number of 23,650 patients (32% males) with mean age 68 (SD 17) years received a resurfacing hip, total, acetabulum and femoral head (ICD-9-CM procedure code 00.85), resurfacing hip, partial, femoral head (00.86), resurfacing hip, partial, acetabulum (00.87), total hip replacement (81.51), partial hip replacement (81.52) or revision of hip replacement, not otherwise specified (81.53) and met all the inclusion criteria (cf section 2). Table 3.8 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 4.6 (SD 3.5) days (Appendix A-8). Of the patients, 84% was appointed to the reference DBC code 110017010223 (arthosis surgical inpatient with prosthesis). DBC code 110030190223 (femur fracture surgical inpatient with prosthesis) resulted in a LOS prolongation of 2.1 days. The DBC codes were able to explain 4.0% of the LOS.

Patients aged 61 to 70 years had the lowest LOS. Episode-specific treatment variables concerned the primary diagnosis fracture (yes/no), the primary diagnosis tumour (yes/no), the primary diagnosis arthrosis (yes/no) and the primary diagnosis necrosis (yes/no). The primary diagnosis tumour significantly reduced LOS 1.6 days, while the diagnosis fracture prolonged LOS 1.7 days. The set of core variables performed slightly better than the DBC codes (R^2 = 0.105). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (12.4% and 16.2% respectively).

Thirty-one % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 110017010223 (arthosis surgical inpatient with prosthesis). Virtually none of the hip replacement patients was treated in daycare (18/ 23,650 patients). Patients diagnosed with a tumour were about 50 times more likely than other patients to be treated in daycare ($P < 0.001$) (Appendix B-8). In contrast to the OLS model (23,650 patients), the PLL model (23,632 patients) identified impact of the primary diagnosis necrosis ($P = 0.033$) rather than tumour ($P = 0.178$). With the PLL model, the associations seen with the remaining variables were similar in direction but smaller in magnitude in comparison with the OLS model. The impact on LOS was between 1.0 and 2.0 days smaller in the PLL model for ICU admissions, admissions to a university teaching hospital and the primary diagnosis fracture (Appendix C-8).

Table 3.8: Hip replacement ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,040		R^2 = 0,105		R^2 = 0,124		R^2 = 0,162	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					4,338	0,024*	4,038	0,075*	4,666	0,286*	6,141	0,220*
length of stay of the first inpatient admission	0	20	4,611	3,505								
DBC code 110017010223 (arthosis surgical inpatient with prosthesis) (ref)	0	1	0,838	0,368								
DBC code 110030190223 (femur fracture surgical inpatient with prosthesis)	0	1	0,131	0,338	2,065	0,066*						
other non-reference DBC codes	0	1	0,030	0,171	0,096	0,131						
age 1 to 60	0	1	0,215	0,411			0,137	0,065*	0,197	0,065*	0,126	0,063*
age 61 to 70 (ref)	0	1	0,264	0,441								
age 71 to 75	0	1	0,171	0,377			0,344	0,069*	0,333	0,069*	0,331	0,067*
age 76 to 80	0	1	0,167	0,373			0,610	0,070*	0,594	0,070*	0,590	0,068*
age >81	0	1	0,184	0,387			0,934	0,072*	0,915	0,072*	0,888	0,070*
male	0	1	0,315	0,465			-0,267	0,048*	-0,274	0,048*	-0,234	0,047*
emergency admission	0	1	0,099	0,298			-0,447	0,092*	-0,484	0,092*	-0,158	0,091
ICU admission	0	1	0,006	0,075			2,157	0,289*	2,169	0,287*	1,556	0,285*
small general hospital	0	1	0,274	0,446			0,017	0,075				
medium-sized general hospital	0	1	0,271	0,444			-1,138	0,075*	-1,225	0,056*	-1,072	0,055*
large general hospital (ref)	0	1	0,129	0,335								
non-university teaching hospital	0	1	0,290	0,454			0,760	0,075*	0,734	0,055*	0,640	0,053*
university teaching hospital	0	1	0,037	0,189			2,077	0,133*	1,528	0,130*	2,171	0,125*
primary diagnosis fracture	0	1	0,144	0,351			1,702	0,083*	1,168	0,215*	1,042	0,211*
primary diagnosis tumour	0	1	0,004	0,060			-1,567	0,366*	-2,000	0,416*	-2,352	0,402*
primary diagnosis arthrosis (ref)	0	1	0,841	0,366								
primary diagnosis necrosis	0	1	0,012	0,108			0,389	0,203				

Sig. $P < 0.05$

Table 3.8: continued

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,040		R^2 = 0,105		R^2 = 0,124		R^2 = 0,162	
Name	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,305	0,461					0,101	0,049*		
laboratory services	0	1	0,966	0,181					-0,498	0,138*		
microbiology/ parasitology	0	1	0,181	0,385					0,428	0,059*		
medical imaging services	0	1	0,982	0,132					1,174	0,178*		
pathology	0	1	0,118	0,323					-0,322	0,070*		
paramedics (e.g. physical therapy)	0	1	0,490	0,500					0,287	0,047*		
blood products	0	1	0,029	0,167					0,586	0,129*		
medical devices	0	1	0,831	0,375					-1,223	0,066*		
rehabilitation	0	1	0,000	0,007					3,720	3,295		
number of admissions	0	21	1,117	0,422							-1,962	0,063*
number of outpatient visits	0	22	2,860	1,642							-0,108	0,015*
number of hours at the daycare facility	0	16	0,018	0,172							0,129	0,141
number of diagnostic procedures	0	35	0,359	0,674							0,159	0,033*
number of laboratory services	0	315	5,521	6,998							0,031	0,004*
number of microbiology/ parasitology services	0	176	1,101	4,888							0,047	0,005*
number of medical imaging services	0	34	3,451	2,235							0,068	0,011*
number of pathology services	0	7	0,132	0,389							-0,074	0,056
number of sessions paramedics	0	164	3,788	6,291							0,030	0,003*
number of blood products	0	13	0,068	0,485							0,197	0,044*
number of medical devices	0	10	1,014	0,660							0,223	0,034*
number of sessions rehabilitation	0	3	0,000	0,020							1,187	1,074

Sig. $P < 0.05$

3.9 Knee replacement

A knee replacement is only performed when symptoms can no longer be treated without surgery, such as with painkillers. In 2007, 17,226 knee replacements were performed (105 per 100,000 inhabitants). The operation usually takes about an hour after which the patient is admitted to the hospital for an average of 5-10 days. However, the LOS was expected to decrease to at most 6 days owing to intensified treatment programs which combine rehabilitation and preoperative follow up [14].

In 2008, a total number of 16,480 patients (32% males) with mean age 66 (SD 16) received a revision of knee replacement, total (all components; ICD-9-CM procedure code 00.80), revision of knee replacement, tibial component (00.81), revision of knee replacement, femoral component (00.82), revision of knee replacement, patellar component (00.83), revision of total knee replacement, tibial insert (liner; 00.84), total knee replacement (81.54) or revision of knee replacement, not otherwise specified (81.55) and met all the inclusion criteria (cf section 2). Table 3.9 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission appeared to have decreased to 4.3 (SD 2.8) days (Appendix A-9). Of the patients, 99% was appointed to the reference DBC code 110018010223 (arthrosis surgical inpatient with prosthesis). The DBC codes were not able to explain the LOS (R^2 = 0.004).

LOS appeared to increase with age. Episode-specific treatment variables concerned total replacement of knee (yes/no), transfusion of blood and blood components (yes/no), the primary diagnosis arthrosis (yes/no) and the primary diagnosis fracture (yes/no). The primary diagnosis fracture significantly reduced LOS 4.1 days and the total replacement of the knee 1.3 days, while the transfusion of blood and blood components prolonged LOS 0.7 days. The set of core variables performed better than the DBC codes (R^2 = 0.097). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (10.1% and 14.5% respectively).

Thirty % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 110018010223 (arthrosis surgical inpatient with prosthesis). Virtually none of the knee replacement patients was treated in daycare (47/ 16,480 patients). Patients up to 65 years were about 3 times more likely than other patients to be treated in daycare (*P* = 0.003), while patients admitted to medium-sized general hospital were about 18 times more likely to be treated in daycare (*P* = 0.004) (Appendix B-9). The PLL model (16,480 patients) and OLS model (16,433 patients) identified the exact same variables to impact LOS. The impact of the variables had the same direction in both models and smaller magnitude in the PLL model. The impact on LOS was between 1.0 and 2.0 days smaller in the PLL model for total replacement of knee and the primary diagnosis fracture (Appendix C-9).

Table 3.9: Knee replacement ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0,004$		Model 2 $R^2 = 0,097$		Model 3 $R^2 = 0,101$		Model 4 $R^2 = 0,145$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					4,327	0,022*	5,377	0,094*	4,463	0,180*	6,243	0,099*
length of stay of the first inpatient admission	0	15	4,307	2,832								
DBC code 110018010223 (arthrosis surgical inpatient with prosthesis) (ref)	0	1	0,992	0,091								
other non-reference DBC codes	0	1	0,008	0,091	-2,043	0,240						
age 1 to 65	0	1	0,390	0,488			-0,107	0,063				
age 66 to 70 (ref)	0	1	0,167	0,373								
age 71 to 75	0	1	0,169	0,375			0,136	0,074				
age 76 to 80	0	1	0,159	0,366			0,401	0,076*	0,414	0,060*	0,383	0,058*
age >81	0	1	0,114	0,318			0,650	0,083*	0,660	0,069*	0,636	0,067*
male	0	1	0,315	0,465			-0,348	0,047*	-0,358	0,046*	-0,342	0,045*
emergency admission	0	1	0,019	0,137			0,021	0,155				
ICU admission	0	1	0,002	0,046			1,064	0,454*	1,001	0,453*	1,285	0,442*
small general hospital	0	1	0,285	0,451			0,054	0,073				
medium-sized general hospital	0	1	0,286	0,452			-0,973	0,073*	-0,948	0,053*	-1,042	0,052*
large general hospital (ref)	0	1	0,127	0,333								
non-university teaching hospital	0	1	0,268	0,443			0,707	0,073*	0,659	0,054*	0,567	0,052*
university teaching hospital	0	1	0,034	0,182			1,161	0,133*	1,233	0,129*	0,968	0,125*
total replacement of knee	0	1	0,844	0,363			-1,317	0,064*	-1,483	0,068*	-1,404	0,063*
transfusion of blood and blood components	0	1	0,012	0,109			0,712	0,193*	0,687	0,193*	0,512	0,190*
primary diagnosis arthrosis (ref)	0	1	0,998	0,047								
primary diagnosis fracture	0	1	0,002	0,047			-4,095	0,458*	-3,582	0,467*	-4,588	0,448*

Sig. $P < 0.05$

Table 3.9: continued

					Model 1		Model 2		Model 3		Model 4	
					$R^2 = 0{,}004$		$R^2 = 0{,}097$		$R^2 = 0{,}101$		$R^2 = 0{,}145$	
Name	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,270	0,444					0,015	0,049		
laboratory services	0	1	0,965	0,183					0,226	0,135		
microbiology/ parasitology	0	1	0,141	0,348					-0,011	0,063		
medical imaging services	0	1	0,978	0,146					0,682	0,153*		
pathology	0	1	0,052	0,222					0,342	0,096*		
paramedics (e.g. physical therapy)	0	1	0,477	0,499					0,298	0,046*		
rehabilitation	0	1	0,000	0,008					-3,201	2,674		
number of admissions	0	7	1,091	0,357							-1,219	0,066*
number of outpatient visits	0	23	3,244	1,806							-0,014	0,012
number of hours at the daycare facility	0	3	0,017	0,142							-1,552	0,159*
number of diagnostic procedures	0	10	0,316	0,592							0,185	0,036*
number of laboratory services	0	397	4,708	5,763							0,033	0,004*
number of microbiology/ parasitology services	0	137	0,668	3,402							-0,003	0,007
number of medical imaging services	0	21	3,085	1,767							0,109	0,013*
number of pathology services	0	4	0,053	0,232							0,260	0,089*
number of sessions paramedics	0	96	3,992	6,587							0,029	0,003*
number of sessions rehabilitation	0	2	0,000	0,016							-0,279	1,305

Sig. $P < 0.05$

3.10 Childbirth

In the Netherlands, women regularly give birth at home. However, for this episode of care only women admitted to the hospital are considered. In 2008, 182,000 women gave birth. The median age of primiparous was 29.4 years. The proportion of Caesarean sections increased from 8.1% in 1993 to 13.6% in 2002 [(14)]. In 2005, the costs for natal care during pregnancy, childbirth and childbed were estimated at € 1.4 billion which equals 2.0% of the national health expenditures. The costs for health problems in the perinatal period were estimated at € 355 million which equals 0.5% of the national health expenditures [(15)].

In 2008, a total number of 75,363 females with mean age 31 (SD 5) were admitted for a single live birth (ICD-10 code Z37.0), single stillbirth (Z37.1), twins, both liveborn (Z37.2), twins, one liveborn and one stillborn (Z37.3), twins, both stillborn (Z37.4), other multiple births, all liveborn (Z37.5), other multiple births, some liveborn (Z37.6), other multiple births, all stillborn (Z37.7) or outcome of delivery, unspecified (Z37.9) and met all the inclusion criteria (cf section 2). Table 3.10 presents the DBC codes, core variables and descriptive statistics relating to these patients as well as OLS regression results. The mean LOS of the first inpatient admission was 1.3 (SD 1.0) days (Appendix A-10). Of the patients, 70% was appointed to the reference DBC code 11000V510133 (spontaneous partus without complications inpatient). DBC code 11000V510131 (spontaneous partus without complications outpatient) resulted in a LOS reduction of 0.8 days, while DBC code 11000V510143 (instrumental partus/obstretical/multiple birth without complications inpatient) in a prolongation of 0.1 days. The DBC codes were able to explain 7.0% of the LOS.

Patients up to 20 years had the highest LOS, but patients older than 21 years had a reduced LOS of only 0.1 days. Episode-specific treatment variables concerned the Caesarean-section (yes/no), multiple delivery (yes/no), obstetrical trauma (yes/no) and episiotomy (yes/no). In addition, the occurrence of an obstetrical trauma did not significantly impact the LOS. The set of core variables performed slightly better than the DBC codes ($R^2 = 0.099$). The set of core variables in combination with the cost categories or numbers of resource quantities per cost category had a superior predictive ability (14.1% and 13.2% respectively).

Sixty-nine % of the inpatient admissions related to a LOS of only 1, which was mainly attributable to patients receiving the reference DBC code 11000V510133 (spontaneous partus without complications inpatient). None of the childbirths took place in daycare. Hence, PLL model included exactly the same patients as the OLS model (75,363 patients). In contrast to the OLS model, the PLL model did not identify impact of emergency admission (P = 0.100) and episiotomy (P = 0.191). However, ICU admissions were additionally observed to influence LOS (P = 0.001). The impact of the variables had the same direction in both models and a slightly smaller magnitude in the PLL model (Appendix C-10).

Table 3.10: Childbirth ~ DBC codes, core variables, descriptive statistics and OLS regression results

					Model 1 $R^2 = 0,070$		Model 2 $R^2 = 0,099$		Model 3 $R^2 = 0,141$		Model 4 $R^2 = 0,132$	
Description	**Min**	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
(constant)					1,409	0,004*	0,987	0,042*	0,877	0,041*	0,954	0,041*
length of stay of the first inpatient admission	0	6	1,292	1,030								
DBC code 11000V510131 (spontaneous partus without complications outpatient)	0	1	0,090	0,286	-0,822	0,012*						
DBC code 11000V510133 (spontaneous partus without complications inpatient) (ref)	0	1	0,699	0,459								
DBC code 11000V510143 (instrumental partus/obstretical/multiple birth without complications inpatient)	0	1	0,191	0,393	0,113	0,009*						
other non-reference DBC codes	0	1	0,019	0,137	-0,639	0,025*						
age 1 to 20 (ref)	0	1	0,025	0,156								
age 21 to 25	0	1	0,135	0,341			-0,095	0,024*	-0,086	0,023*	-0,092	0,023*
age 26 to 30	0	1	0,319	0,466			-0,102	0,023*	-0,090	0,022*	-0,095	0,022*
age 30 to 35	0	1	0,334	0,472			-0,096	0,023*	-0,080	0,022*	-0,085	0,022*
age >36	0	1	0,188	0,391			-0,106	0,023*	-0,087	0,023*	-0,096	0,023*
emergency admission	0	1	0,354	0,478			-0,025	0,007*	-0,039	0,007*	-0,023	0,007*
ICU admission	0	1	0,000	0,010			intolerant					
small general hospital	0	1	0,245	0,430			-0,007	0,012				
medium-sized general hospital	0	1	0,262	0,440			-0,125	0,012*	-0,136	0,009*	-0,155	0,009*
large general hospital (ref)	0	1	0,133	0,340								
non-university teaching hospital	0	1	0,252	0,434			0,135	0,012*	0,124	0,009*	0,101	0,009*
university teaching hospital	0	1	0,108	0,310			0,380	0,015*	0,350	0,012*	0,402	0,012*
delivery by Caesarean-section	0	1	0,000	0,007			1,119	0,464*	1,118	0,453*	1,042	0,456*
multiple delivery	0	1	0,014	0,120			0,577	0,029*	0,519	0,028*	0,465	0,028*
obstetrical trauma	0	1	0,013	0,112			0,049	0,030				
episiotomy	0	1	0,005	0,071			-0,121	0,048*	-0,069	0,047	-0,094	0,047*

Sig. $P < 0.05$

Table 3.10: continued

					Model 1		Model 2		Model 3		Model 4	
					R^2 = 0,070		R^2 = 0,099		R^2 = 0,141		R^2 = 0,132	
	Min	**Max**	**Mean**	**SD**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
diagnostic procedures	0	1	0,352	0,478					0,028	0,007*		
laboratory services	0	1	0,553	0,497					0,185	0,007*		
microbiology/ parasitology	0	1	0,119	0,323					0,460	0,011*		
medical imaging services	0	1	0,007	0,084					0,243	0,040*		
blood products	0	1	0,003	0,052					0,431	0,063*		
medical devices	0	1	0,000	0,004					0,465	0,906*		
rehabilitation	0	1	0,000	0,004					-0,122	0,906		
number of diagnostic procedures	0	60	0,655	1,673							0,001	0,002
number of laboratory services	0	81	0,993	1,632							0,090	0,002*
number of microbiology/ parasitology services	0	142	0,650	3,117							0,012	0,001*
number of medical imaging services	0	13	0,016	0,270							-0,036	0,012*
number of pathology services	0	15	0,045	0,233							0,156	0,015*
number of sessions paramedics	0	34	0,012	0,235							0,155	0,014*
number of blood products	0	8	0,007	0,137							0,085	0,024*
number of medical devices	0	4	0,000	0,015							0,131	0,228
number of sessions rehabilitation	0	1	0,000	0,004							-0,140	0,911

Sig. $P < 0.05$

4. Discussion

The present study aimed to examine the accuracy of the patient classification for 10 episodes of care in the Netherlands. Regression models were used to identify suitable variables which could serve as adjustment factors for the patient classification and explain cost/LOS variation. For inguinal hernia repair, the DBC codes (model 1) were able to explain 49% of the variation in LOS. However, for each of the other episodes of care the predictive ability of the DBC codes was much lower (12% for cholecystectomy and <10% for the remaining episodes of care). This suggests that the patient classification is currently not characterized by distinct cost variation *between* DBCs nor by limited cost variation *within* DBCs.

With the exception of breast cancer, stroke and inguinal hernia repair, our set of core variables (model 2) performed somewhat better than the DBC codes. Still, the predictive power of the core variables was rather modest (15% for cholecystectomy, 11% for hip replacement and <10% for the remaining episodes of care). Age and gender have earlier been found to explain very little variation in LOS [(16,17)]. Our regression analyses suggested that ICU admissions could be a valuable adjustment factor. ICU admissions significantly prolonged LOS in all of the episodes of care (between 0.4 days for stroke and 2.2 days for hip replacement; $P < 0.05$). However, such a clear conclusion cannot be drawn for emergency admissions. Emergency admissions did not significantly impact LOS for breast cancer, appendectomy and knee replacement, but significantly reduced LOS in 4 and prolonged LOS in 3 of the episodes of care. For CABG, the reduction even amounted to 2.1 days (compared to < 0.5 days reduction/ prolongation for the remaining episodes of care).

The hospital type (small general hospital, medium-sized general hospital, large general hospital, non-university teaching hospital or university teaching hospital) could serve as another valuable adjustment factor. With the exception of CABG, patients admitted to teaching hospitals had a higher LOS than general hospitals for each of the episodes of care. In our model 2, the LOS of non-university teaching hospitals was between 0.1 (inguinal hernia repair) and 1.9 days (stroke) longer than that of large general hospitals (reference group). The LOS of university teaching hospitals was between 0.3 (inguinal hernia repair) and 2.1 days (hip replacement) longer than that of large general hospitals. There are two reasons why teaching hospitals might have a different LOS/cost than general hospitals. If teaching hospitals systematically attract more severe patients within each DBC, their mean LOS/cost may be higher. In that case, the teaching status is simply picking up additional patient heterogeneity, rather than it having anything to do with the teaching function itself. Secondly, the provision of patient care and medical education is a complementary process and it is not straightforward to disentangle these two components for funding purposes. If medical education is underfunded/ overfunded relative to patient care, the LOS/cost of patient care in teaching hospitals will appear higher/ lower than in general hospitals [7].

The aim of DBCs is to classify patients into mutually exclusive groups of patients, with the patients in each group having the same expected resource requirements. Resource quantities have earlier been demonstrated to be able to explain cost variation between groups of patients (see for instance [9-11]). The resource quantities of all patients admitted to any hospital in the Netherlands are collected in the database of the DBC system. This allowed for the identification of suitable cost categories which could serve as adjustment factors for the patient classification. When core variables were supplemented with the cost categories or numbers of resource quantities per cost category, the accuracy of the patient classification varied by episode of care. With respect to the cost categories (model 3), we observed paramedical services to be the only cost category which was significant for each of the episodes of care. Additionally, paramedical services and blood products were the only two cost categories which had a consistently positive association with LOS. For the remaining cost categories, the direction of influence varied by episode of care. For example, the use of medical devices related to a reduced LOS of 1.5 days for CABG (aortic/ mitral valve), but to a prolonged LOS of 0.3 days for AMI (coronary stent) and of 1.3 days for stroke (thrombolytica). Rehabilitation services related to a reduced LOS of 3.2 days for knee replacement, but to a prolonged LOS of 3.7 days for hip replacement. However, rehabilitation services were provided to a minority of both hip- and knee replacement patients.

The set of core variables in combination with numbers of resource quantities per cost category (model 4) had generally the greatest predictive ability (between 13% for childbirth and 53% for CABG). Inpatient admissions, laboratory services and medical imaging services were the only three cost categories which were significant for all episodes of care. Furthermore, diagnostic procedures were the only cost category which had a consistently positive association with LOS. For the remaining cost categories, the direction of influence varied by episode of care. In some rare instances, a cost category positively (negatively) affected LOS while the corresponding numbers of resource quantities for this cost category showed a negative (positive) impact. For instance, the LOS for hip replacement reduced 1.2 days when a hip prostheses were required (model 3), but was prolonged by 0.2 days per hip prosthesis required (model 4).

To be able to make comparisons possible between our results and the results of the other countries participating in the EuroDRG project, we additionally conducted PLL regression on the subsets of patients receiving treatments in the inpatient setting. Compared to the OLS models, the impact of the variables generally had a smaller magnitude in the PLL models. This may obviously firstly be explained by the exclusion of patients treated in daycare. Secondly, PLL regression has been suggested to be the standard model for count data analysis [(7)]. In general, it is known that cost/LOS of episodes of care are skewed because few patients with high cost/LOS may have a considerable impact on the mean cost/LOS (Appendix A). The PLL model may be the better model to describe this distribution.

Table 4.1 presents the pseudo R^2 values with respect to the models including DBC/DRGs only (model 1) for the participating EuroDRG countries which have used LOS as a proxy to actual costs (Austria, France, Ireland, Spain and Sweden). For inguinal hernia repair, the table confirms that model 1 is able to explain LOS variation in the Netherlands. The addition of DBC codes to the naive model (with only an intercept) is an substantial improvement (likelihood ratio test: $P << 0.001$), which suggests that the current two partition variables (surgical versus laparoscopic; inpatient versus daycare) are significant adjustment factors for this episode of care. However, firstly, these same to variables were not able to explain much of the LOS variation for appendectomy and cholecystectomy. Secondly, in each of the other countries the predictive ability of the DRG codes for inguinal hernia repair was much lower, and comparable to that of the other episodes of care. This was even true for France, which country also uses surgical versus laparoscopic and inpatient versus daycare as partition variables (in addition to the partition variables age, the existence of comorbidities and complications and LOS).

France, Ireland and Spain generally have the highest pseudo R^2 values, which may partially be explained by their higher number of DRG codes. The pseudo R^2 values are fairly similar in the Netherlands, Austria and Sweden. Additionally, the numbers of DRG/DBC codes which together comprise ≥ 97% of all patients are very comparable in the Netherlands, Austria, Ireland and Sweden. Hence, in spite of the differences in the patient classification between countries, DBCs may predict the LOS of specific episodes of care as well as DRGs do. Moreover, there seem to be more differences between episodes of care than between countries.

Table 4.1: Pseudo R^2 values (number of DRG codes which together comprise ≥ 97% of all patients) with respect to model 1 for the participating EuroDRG countries which have used LOS as a proxy to actual costs

	Netherlands	Austria	France	Ireland	Spain	Sweden
Breast cancer	**0.192 (3)**	0.112 (4)	0.187 (9)	0,062 (4)	0,396 (8)	0.126 (8)
AMI	**0.074 (7)**	0.084 (7)	0.276 (17)	0,037 (7)	0,377 (7)	0.052 (8)
CABG	**0.014 (7)**	0.062 (6)	0.072 (16)	0.067 (9)	0,064 (9)	0.021 (7)
Stroke	**0.112 (6)**	0.124 (6)	0.116 (11)	0.069 (6)	0,026 (9)	0.021 (3)
Inguinal hernia repair	**0.803 (2)**	0.052 (4)	0.150 (8)	0.118 (4)	0,240 (5)	0.050 (5)
Appendectomy	**0.001 (2)**	0.038 (4)	0.096 (6)	0.055 (4)	0,278 (7)	0.086 (3)
Cholecystectomy	**0.148 (3)**	0.087 (3)	0.196 (9)	0.211 (4)	0,424 (6)	0.240 (8)
Hip replacement	**0.021 (3)**	0.080 (9)	0.106 (11)	0,068 (4)	0,179 (5)	0.074 (3)
Knee replacement	**0.009 (2)**	0.056 (6)	0.067 (6)	0,037 (3)	0,216 (5)	0.066 (3)
Childbirth	**0.178 (4)**	0.073 (4)	0.057 (7)	0.092 (6)	0,707 (6)	0.054 (5)

Cross-country comparisons provide a tool to learn from the experience of DRG systems and may support the improvement and sustainability of the DBC system. For model 1, the partition variables used in DRG systems do not evidently lead to a more accurate patient classification (table 4.1). However, the lack of Charlson co-morbidities and global quality prevented the comparison of our model 2 (, 3 and 4) with the other participating countries in the EuroDRG project. Even though it is not feasible to collect these parameters in the short run, some developments are forthcoming which may provide opportunities to increase the participation of the Netherlands in cross-country comparisons regarding the efficiency and provision of unnecessary services of hospital care. A computerized grouping algorithm to classify patients into about 4,000 DBCs (the so-called 'DOTs'; 'DBCs Towards Transparency') based on ICD-10 is currently being tested. The new grouping algorithm discards medical specialty for the definition of DOTs, integrates some of the comorbidities into existing DBC/DOTs and includes some 'core variables' as additional partition variables for the definition of DOTs [4].

The accuracy of patient classification greatly determines the extent to which hospital efficiency can be achieved [1,2]. The results of the present study suggest that the patient classification in the Netherlands is currently not sufficiently distinct to define mutually exclusive groups of patients (with the exception of inguinal hernia repair). Still, our results may serve as a basis to examine hospital efficiency within the Netherlands. ICU admissions and hospital type have been valuable adjustment factors. However, some global parameters which are not directly related to the primary care chain (such as age and gender) were unable to explain LOS variation. Moreover, parameters which were expected to have predictive power (such as some episode specific procedures and cost categories) have generally been proven to be poor adjustment factors.

From these conclusions, some general recommendations could be drawn:

1. The possibility to link actual costs to the resource quantities recorded in the database of the DBC system should be explored. The large proportions of inpatient admissions with a LOS of only 1 day (appendix A) suggest that LOS may not be a good proxy to actual costs. As first admission days have previously been demonstrated to be much more expensive than subsequent inpatient days, variation in LOS does not always adequately reflect variation in actual costs. The availability of actual costs in the national database would allow for a more truthful examination of the accuracy of the patient classification.

2. In order to define mutually exclusive groups of patients, future studies need to investigate which specific parameters are clearly associated with the cost/LOS of certain types of episodes of care. If necessary, these parameters need to be added to the dataset collected in the database of the DBC system.

3. The validity of the data collected in the national database should be investigated. Data validity is a prerequisite to valid results, which could support efforts by health policy makers to improve hospital efficiency. Moreover, it could support secondary objectives such as the conduct of economic evaluations and assessment of the quality of inpatient care.

References

(1) Street A, Scheller-Kreinsen D, Geissler A & Busse R. Determinants of hospital costs and performance variation: methods, models and variables for the EuroDRG project. *Working Papers in Health Policy and Management* 2010 May;3.

(2) Kobel C, Thuilliez J, Bellanger MM & Pfeiffer KP. DRG systems and similar Patient Classification Systems in Europe. In: *Diagnosis-Related Groups in Europe: moving towards transparency, efficiency and quality in hospitals* (Busse R, Geissler A, Quentin W & Wiley MM, editors), Open University Press and WHO Regional Office for Europe: Buckingham, 2011.

(3) Tan SS, Serdén L, Geissler A*, et al*. DRGs and cost accounting: which is driving which? In: *Diagnosis-Related Groups in Europe: moving towards transparency, efficiency and quality in hospitals* (Busse R, Geissler A, Quentin W & Wiley MM, editors), Open University Press and WHO Regional Office for Europe: Buckingham, 2011.

(4) Tan SS, van Ineveld BM, Redekop WK & Hakkaart-van Roijen L. The Netherlands: the Diagnose Behandeling Combinaties (DBCs). In: *Diagnosis-Related Groups in Europe: moving towards transparency, efficiency and quality in hospitals* (Busse R, Geissler A, Quentin W & Wiley MM, editors), Open University Press and WHO Regional Office for Europe: Buckingham, 2011.

(5) Tan SS, van Ineveld BM, Redekop WK & Hakkaart-van Roijen L. Structural reforms and hospital payment in the Netherlands. *EuroObserver* 2010 Autumn;12: 7-9.

(6) Oostenbrink JB & Rutten FF. Cost assessment and price setting of inpatient care in The Netherlands. the DBC case-mix system. *Health Care Manag Sci* 2006;9: 287-294.

(7) Street A, Kobel C, Renaud T & Thuilliez J. Variations in costs and length of stay among patients and across hospitals: analytical methods, model specifications and interpretations. *Journal of Health Economics* (forthcoming).

(8) The Healthcare Inspectorate (IGZ). Basic Set of Hospital Performance Indicators 2004. The Healthcare Inspectorate: The Hague; 2005.

(9) Rothen HU, Stricker K, Einfalt J*, et al*. Variability in outcome and resource use in intensive care units. *Intensive Care Med* 2007;33: 1329-36.

(10) Evans E, Imanaka Y, Sekimoto M*, et al*. Risk adjusted resource utilization for AMI patients treated in Japanese hospitals. *Health Econ* 2007;16: 347-359.

(11) Dormont B & Milcent C. The sources of hospital cost variability. *Health Econ* 2004;13: 927-939.

(12) Busse R, Schreyogg J & Smith PC. Variability in healthcare treatment costs amongst nine EU countries - results from the HealthBASKET project. *Health Econ* 2008;17: S1-8.

(13) Tan SS, Oostenbrink JB & Rutten FFH. Costs and prices of healthcare services in the Netherlands: a micro costing approach based on case-vignettes: A contribution to Work Package 9 of the EU funded research project ‘HealthBASKET’: Assessment of services delivered and costs. Report number: 06.89 edition, institute for Medical Technology Assessment: Rotterdam; Oct 2006.

(14) Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Nationaal Kompas Volksgezondheid. In: *Volksgezondheid Toekomst Verkenning 2010*, Fifth edition, Bohn Stafleu van Loghum: Houten, 2010.

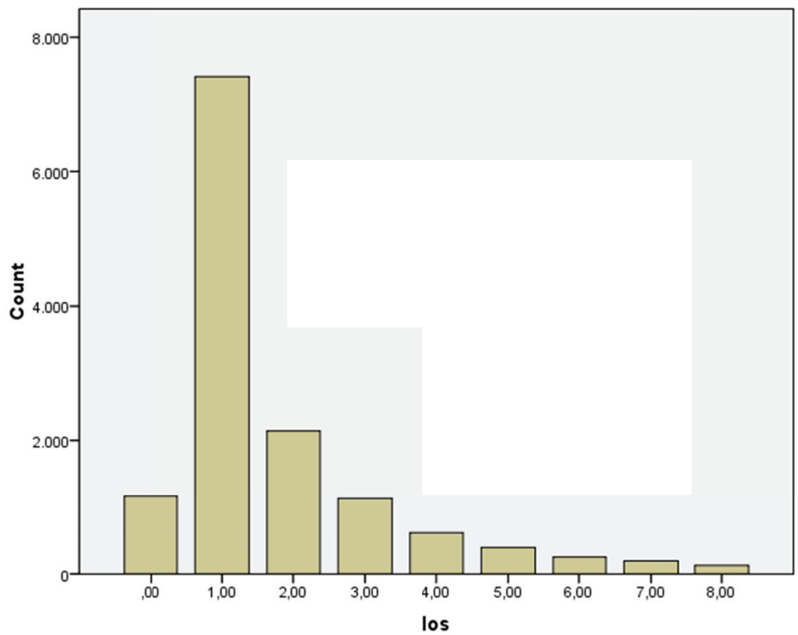
(15) Poos MJJC, Smit JM, Groen J, Kommer GJ & Slobbe LCJ. Kosten van ziekten in Nederland 2005. Fifth edition, RIVM: Bilthoven; 2008.

(16) Hvenegaard A, Street A, Sorensen TH & Gyrd-Hansen D. Comparing hospital costs: what is gained by accounting for more than a case-mix index? *Soc Sci Med* 2009;69: 640-647.

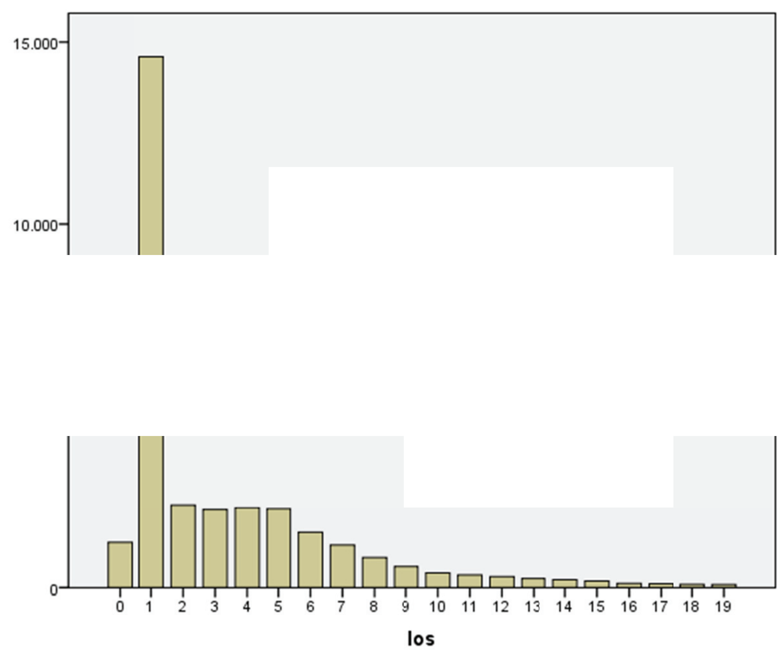
(17) Newhouse JP, Manning WG, Keeler EB & Sloss EM. Adjusting capitation rates using objective health measures and prior utilization. *Health Care Financ Rev* 1989;10: 41-54.

Appendices

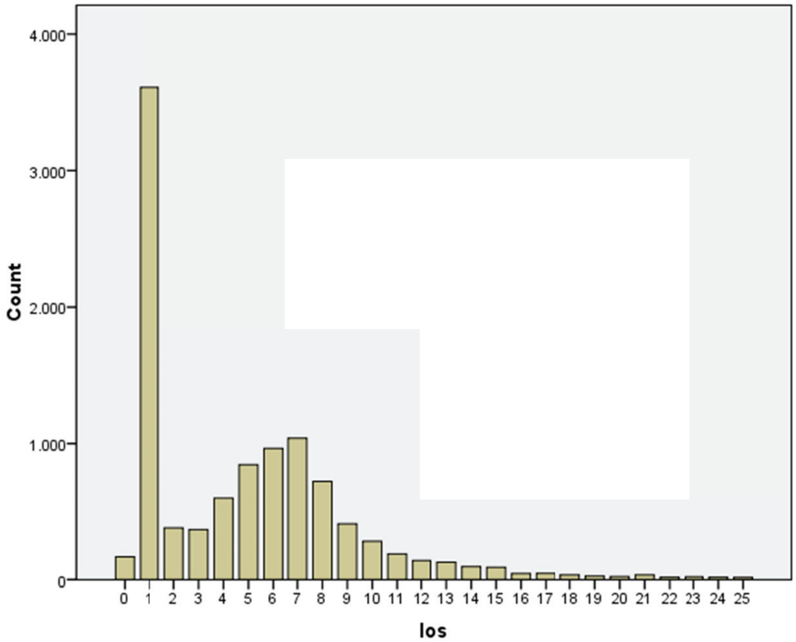
Appendix A1: histogram of the LOS distribution for breast cancer



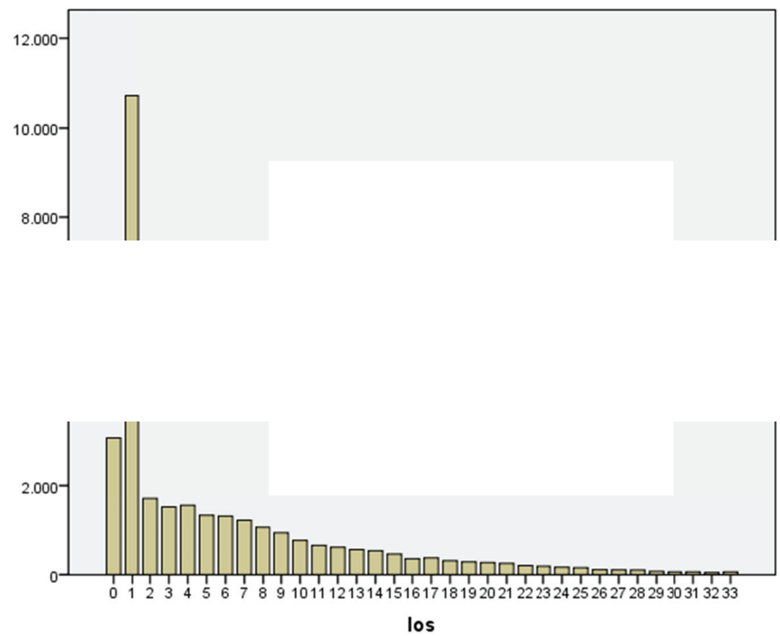
Appendix A2: histogram of the LOS distribution for AMI



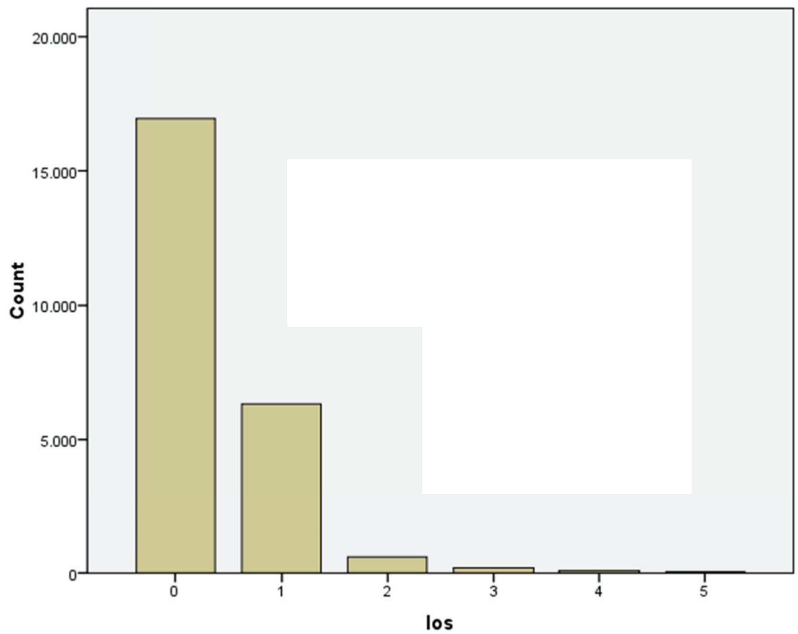
Appendix A3: histogram of the LOS distribution for CABG



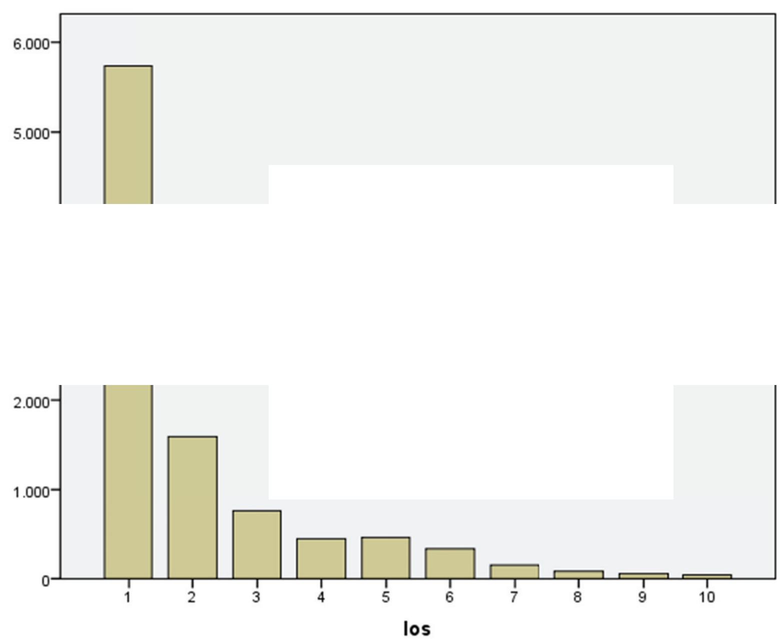
Appendix A4: histogram of the LOS distribution for stroke



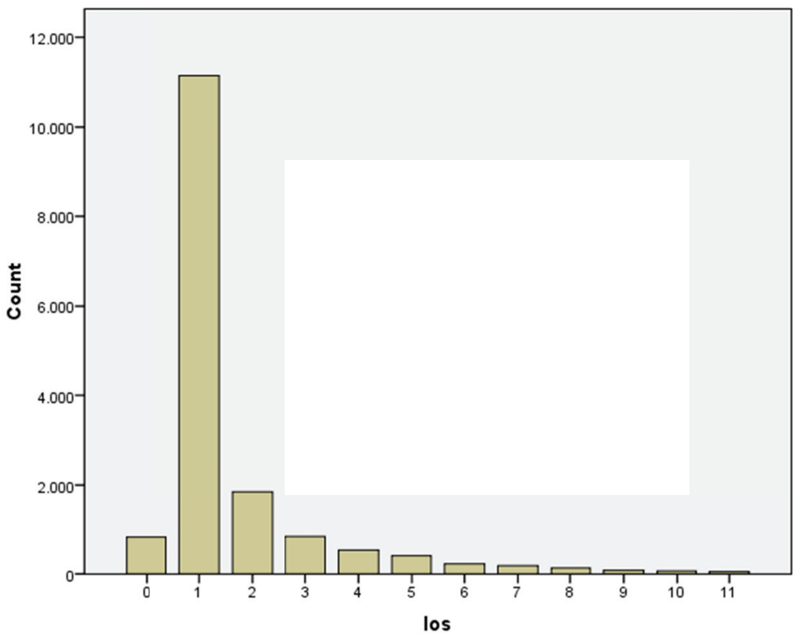
Appendix A5: histogram of the LOS distribution for inguinal hernia repair



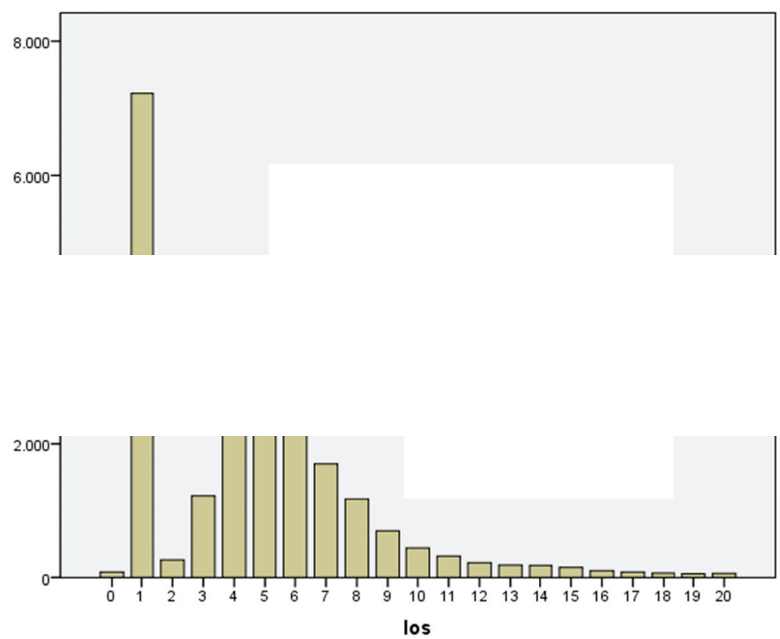
Appendix A6: histogram of the LOS distribution for appendectomy



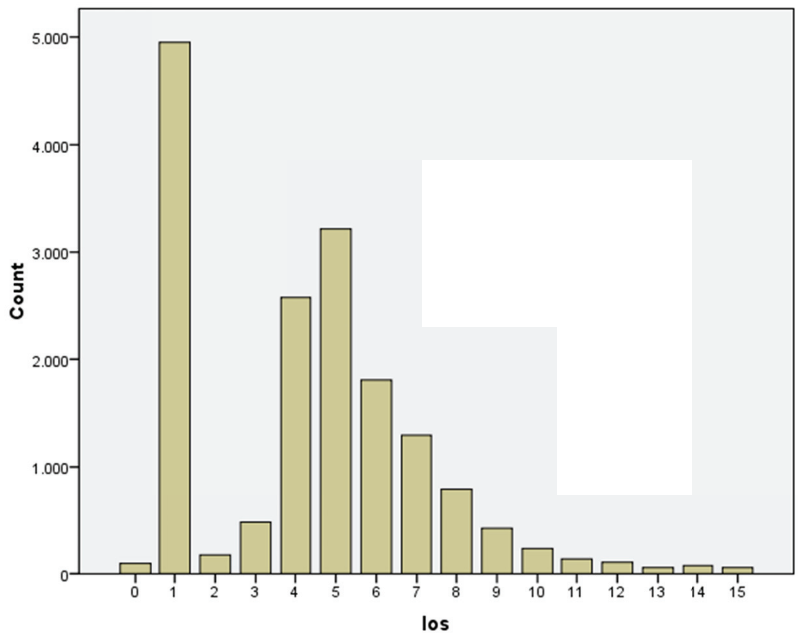
Appendix A7: histogram of the LOS distribution for cholecystectomy



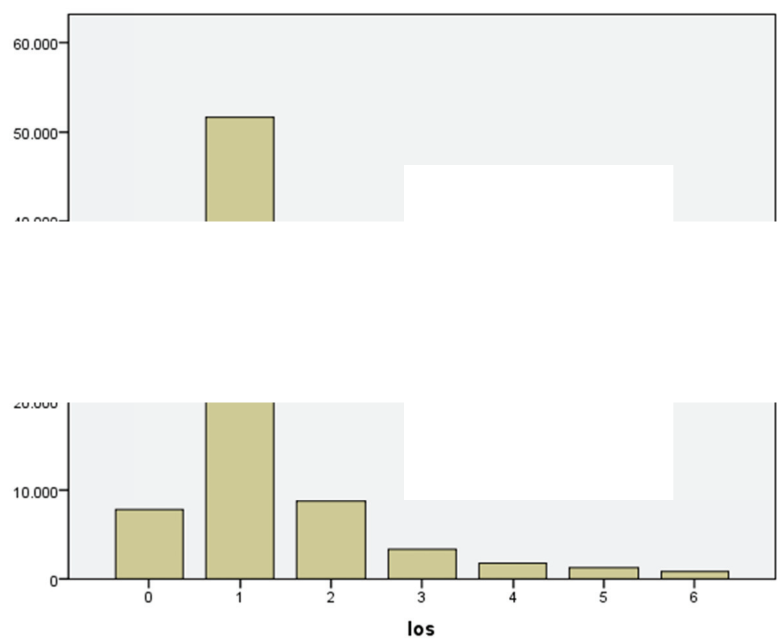
Appendix A8: histogram of the LOS distribution for hip replacement



Appendix A9: histogram of the LOS distribution for knee replacement



Appendix A10: histogram of the LOS distribution for childbirth



Appendix B1 logistic regression ~ the odds of treatment in daycare for breast cancer

Number of observations read		13439
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	23,600
	df	8
	Sig.	0,003
Cox & Snell R Square		0,056
Nagelkerke R Square		0,122

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-2,164	0,116	348,669	0,000	0,115
age 1 to 50	0,021	0,078	0,075	0,785	1,022
age 61 to 65	-0,181	0,105	3,009	0,083	0,834
age 66 to 70	-0,506	0,120	17,681	0,000	0,603
age >71	-0,806	0,110	54,128	0,000	0,447
emergency admission	-0,726	0,171	17,951	0,000	0,484
ICU admission	-18,382	7188,955	0,000	0,998	0,000
small general hospital	-0,158	0,131	1,454	0,228	0,854
medium-sized general hospital	0,753	0,116	42,191	0,000	2,123
non-university teaching hospital	0,466	0,119	15,402	0,000	1,594
university teaching hospital	0,455	0,152	8,961	0,003	1,576
number of lymphnode resections	-1,046	0,072	213,797	0,000	0,351
conservative treatment	2,328	0,181	165,466	0,000	10,260
administration of chemotherapy	-19,126	12431,64	0,000	0,999	0,000
two-sided mastectomy	-0,008	0,176	0,002	0,962	0,992

Appendix B2 logistic regression ~ the odds of treatment in daycare for AMI

Number of observations read		30843
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	48,411
	df	8
	Sig.	0,000
Cox & Snell R Square		0,172
Nagelkerke R Square		0,443

	B	S.E.	Wald	Sig.	Exp(B)
Constant	20,482	295,168	0,005	0,945	785,844e6
age 1 to 60	-0,028	0,066	0,176	0,675	0,973
age 71 to 80	-0,113	0,079	2,055	0,152	0,894
age 81 to 85	-0,020	0,121	0,029	0,866	0,980
age >86	-0,258	0,174	2,189	0,139	0,773
male	0,118	0,061	3,786	0,052	1,125
emergency admission	-1,002	0,067	221,875	0,000	0,367
ICU admission	-3,262	1,016	10,314	0,001	0,038
small general hospital	-1,408	0,161	76,039	0,000	0,245
medium-sized general hospital	-0,925	0,148	39,124	0,000	0,397
non-university teaching hospital	-0,735	0,088	69,294	0,000	0,480
university teaching hospital	-0,839	0,098	72,761	0,000	0,432
Signal Intensity not elevated AMI	-19,659	295,169	0,004	0,947	0,000
subsequent AMI	-20,008	295,169	0,005	0,946	0,000
coronary stent	-2,072	0,066	983,719	0,000	0,126
PTCA	-0,538	0,078	47,496	0,000	0,584
conservative treatment	-20,575	295,169	0,005	0,944	0,000

Appendix B4 logistic regression ~ the odds of treatment in daycare for stroke

Number of observations read		31188
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	138,381
	df	8
	Sig.	0,000
Cox & Snell R Square		0,119
Nagelkerke R Square		0,253

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-,617	,073	71,104	,000	,539
age 1 to 60	0,044	0,059	0,563	0,453	1,045
age 71 to 80	-0,234	0,059	15,602	0,000	0,792
age 81 to 85	-0,524	0,075	48,261	0,000	0,592
age >86	-1,025	0,094	118,573	0,000	0,359
male	0,060	0,043	1,954	0,162	1,061
emergency admission	-2,182	0,053	1690,060	0,000	0,113
ICU admission	-17,944	2730,364	0,000	0,995	0,000
small general hospital	-0,340	0,072	22,352	0,000	0,712
medium-sized general hospital	-0,151	0,067	5,116	0,024	0,860
non-university teaching hospital	-0,814	0,070	136,430	0,000	0,443
university teaching hospital	-0,084	0,083	1,038	0,308	0,919
unspecified stroke	2,103	0,099	449,069	0,000	8,190
conservative treatment	-19,179	12336,29	0,000	0,999	0,000
number of endarterectomies	18,867	1037,657	0,000	0,985	156,20e6

Appendix B5 logistic regression ~ the odds of treatment in daycare for inguinal hernia repair

Number of observations read		24201
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	69,467
	df	8
	Sig.	0,000
Cox & Snell R Square		0,105
Nagelkerke R Square		0,148

	B	S.E.	Wald	Sig.	Exp(B)
Constant	1,425	0,072	396,186	0,000	4,156
age 1 to 30	0,307	0,052	35,173	0,000	1,360
age 51 to 60	-0,062	0,051	1,449	0,229	0,940
age 61 to 70	-0,529	0,047	124,161	0,000	0,589
age >71	-1,444	0,047	940,616	0,000	0,236
male	0,118	0,052	5,085	0,024	1,126
emergency admission	-1,217	0,059	432,688	0,000	0,296
ICU admission	-21,793	11221,36	0,000	0,998	0,000
small general hospital	-0,187	0,051	13,496	0,000	0,829
medium-sized general hospital	0,200	0,051	15,127	0,000	1,221
non-university teaching hospital	-0,327	0,051	40,846	0,000	0,721
university teaching hospital	-0,733	0,079	87,030	0,000	0,480
laparoscopic inguinal hernia procedure	-0,240	0,041	33,741	0,000	0,787
recurrent inguinal hernia	-0,459	0,039	136,874	0,000	0,632

Appendix B6 logistic regression ~ the odds of treatment in daycare for appendectomy

Number of observations read		9664
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	4,085
	df	8
	Sig.	0,849
Cox & Snell R Square		0,002
Nagelkerke R Square		0,115

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-5,925	1,314	20,340	0,000	0,003
age 1 to 10	0,343	1,424	0,058	0,810	1,409
age 16 to 20	-0,003	1,420	0,000	0,999	0,997
age 21 to 35	0,398	1,161	0,118	0,732	1,489
age >36	0,368	1,124	0,107	0,743	1,445
male	0,229	0,657	0,122	0,727	1,258
emergency admission	-2,146	0,705	9,278	0,002	0,117
ICU admission	-13,764	4682,461	0,000	0,998	0,000
small general hospital	-1,513	1,159	1,703	0,192	0,220
medium-sized general hospital	-1,175	0,926	1,610	0,205	0,309
non-university teaching hospital	-1,162	0,927	1,571	0,210	0,313
university teaching hospital	-0,528	0,953	0,307	0,580	0,590
laparoscopic appendectomy procedure	1,359	0,736	3,411	0,065	3,893

Appendix B7 logistic regression ~ the odds of treatment in daycare for cholecystectomy

Number of observations read		16339
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	5,544
	df	8
	Sig.	0,698
Cox & Snell R Square		0,027
Nagelkerke R Square		0,084

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-5,483	0,588	86,830	0,000	0,004
age 1 to 40	0,035	0,094	0,135	0,713	1,035
age 51 to 60	-0,159	0,105	2,279	0,131	0,853
age 61 to 70	-0,700	0,134	27,356	0,000	0,497
age >71	-1,372	0,195	49,328	0,000	0,254
male	0,075	0,085	0,772	0,379	1,078
emergency admission	-0,787	0,116	46,105	0,000	0,455
ICU admission	-17,526	4573,044	0,000	0,997	0,000
small general hospital	-0,199	0,106	3,520	0,061	0,820
medium-sized general hospital	-0,783	0,123	40,385	0,000	0,457
non-university teaching hospital	-0,024	0,102	0,056	0,813	0,976
university teaching hospital	1,107	0,126	76,825	0,000	3,024
laparoscopic cholecystectomy procedure	3,042	0,581	27,430	0,000	20,940

Appendix B8 logistic regression ~ the odds of treatment in daycare for hip replacement

Number of observations read		23650
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	1,23E-05
	df	8
	Sig.	1,000
Cox & Snell R Square		0,009
Nagelkerke R Square		0,709

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-45,007	731,653	0,004	0,951	0,000
age 1 to 60	13,439	419,986	0,001	0,974	686073,9
age 71 to 75	13,400	419,988	0,001	0,975	660195,1
age 76 to 80	1,250	662,831	0,000	0,998	3,490
age >81	0,963	639,720	0,000	0,999	2,620
male	-0,027	0,562	0,002	0,962	0,973
emergency admission	-13,297	647,332	0,000	0,984	0,000
ICU admission	-9,992	2394,896	0,000	0,997	0,000
small general hospital	11,942	540,929	0,000	0,982	153603,5
medium-sized general hospital	11,905	540,929	0,000	0,982	148067,1
non-university teaching hospital	11,122	540,928	0,000	0,984	67650,16
university teaching hospital	11,916	540,928	0,000	0,982	149667,6
primary diagnosis fracture	1,692	598,904	0,000	0,998	5,430
primary diagnosis tumour	18,750	257,534	0,005	0,942	139,02e6
primary diagnosis necrosis	14,876	257,535	0,003	0,954	2888686

Appendix B9 logistic regression ~ the odds of treatment in daycare for knee replacement

Number of observations read		16480
Dependent variable		treatment in daycare
Hosmer and Lemeshow Test	Chi-square	1,11E-05
	df	8
	Sig.	1,000
Cox & Snell R Square		0,017
Nagelkerke R Square		0,432

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-6,659	1,102	36,523	0,000	0,001
age 1 to 65	1,429	0,485	8,678	0,003	4,174
age 71 to 75	-0,239	0,679	0,124	0,725	0,788
age 76 to 80	-14,363	633,312	0,001	0,982	0,000
age >81	-14,400	744,811	0,000	0,985	0,000
male	0,433	0,305	2,015	0,156	1,542
emergency admission	-14,987	1738,874	0,000	0,993	0,000
ICU admission	0,612	5957,417	0,000	1,000	1,845
small general hospital	1,370	1,123	1,488	0,223	3,936
medium-sized general hospital	2,952	1,020	8,381	0,004	19,145
non-university teaching hospital	1,206	1,123	1,154	0,283	3,340
university teaching hospital	1,620	1,101	2,163	0,141	5,053
total replacement of knee	-17,184	312,661	0,003	0,956	0,000
transfusion of blood and blood components	-13,671	1937,196	0,000	0,994	0,000
primary diagnosis fracture	-16,508	5698,882	0,000	0,998	0,000

Appendix C1 PLL regression ~ subset of breast cancer patients receiving treatment in the inpatient setting

Number of observations read	12268
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1a			Model 1b			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	0,638	0,007	0,000	0,639	0,007	0,000	0,364	0,022	0,000	0,381	0,015	0,000
DBC code 110003180403 (two-sided surgical inpatient)	0,293	0,041	0,000	0,292	0,041	0,000						
other non-reference DBC codes	0,197	0,113	0,081									
age 1 to 50							0,051	0,019	0,007	0,051	0,016	0,002
age 61 to 65							-0,028	0,024	0,242			
age 66 to 70							0,031	0,025	0,216			
age >71							0,308	0,021	0,000	0,308	0,019	0,000
emergency admission							-0,016	0,028	0,574			
ICU admission							0,569	0,117	0,000	0,565	0,117	0,000
small general hospital							0,225	0,024	0,000	0,209	0,019	0,000
medium-sized general hospital							0,025	0,024	0,285			
non-university teaching hospital							0,197	0,023	0,000	0,181	0,018	0,000
university teaching hospital							0,236	0,030	0,000	0,222	0,026	0,000
number of lymphnode resections							0,087	0,010	0,000	0,085	0,010	0,000
conservative treatment							0,177	0,106	0,096			
administration of chemotherapy							0,150	0,166	0,365			
two-sided mastectomy							0,291	0,042	0,000	0,291	0,042	0,000

Appendix C2 PLL regression ~ subset of AMI patients receiving treatment in the inpatient setting

Number of observations read	28840
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	1,437	0,009	0,000	0,854	0,043	0,000	0,822	0,038	0,000
DBC code 110008010103 (follow up after acute coronary syndrome regular/no treatment inpatient)	-0,546	0,034	0,000						
DBC code 110002040213 (ST elevated mild PCI inpatient)	-0,541	0,044	0,000						
DBC code 110002050243 (non-ST elevated severe PCI inpatient)	-0,517	0,033	0,000						
DBC code 110002040243 (ST elevated severe PCI inpatient)	-0,470	0,016	0,000						
DBC code 110002040103 (ST elevated regular/no treatment inpatient)	-0,127	0,014	0,000						
other non-reference DBC codes	-0,131	0,034	0,000						
age 1 to 60				-0,011	0,015	0,469			
age 71 to 80				0,053	0,018	0,003	0,059	0,015	0,000
age 81 to 85				0,068	0,024	0,005	0,072	0,022	0,001
age >86				0,006	0,027	0,827			
male				-0,039	0,013	0,002	-0,041	0,013	0,001
emergency admission				0,123	0,012	0,000	0,123	0,012	0,000
ICU admission				0,101	0,056	0,071			
small general hospital				0,099	0,022	0,000	0,104	0,022	0,000
medium-sized general hospital				-0,132	0,023	0,000	-0,132	0,023	0,000
non-university teaching hospital				0,223	0,020	0,000	0,225	0,020	0,000
university teaching hospital				0,125	0,026	0,000	0,124	0,026	0,000
Signal Intensity not elevated AMI				0,109	0,013	0,000	0,109	0,013	0,000
subsequent AMI				-0,372	0,034	0,000	-0,374	0,034	0,000
coronary stent				-0,044	0,028	0,124			
PTCA				-0,073	0,032	0,021	-0,082	0,031	0,008
conservative treatment				0,340	0,036	0,000	0,368	0,032	0,000

Appendix C3 PLL regression ~ subset of CABG patients receiving treatment in the inpatient setting

Number of observations read	13439
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	1,497	0,012	0,000	1,656	0,037	0,000	1,664	0,033	0,000
DBC code 110024000110 (CABG (≥ 2 arterial grafts) ~ first surgery without implant)	0,113	0,019	0,000						
DBC code 110023200210 (CABG, venous grafts and ≤ 1 arterial graft ~ re-surgery with implant)	0,179	0,068	0,008						
DBC code 110024250120 (CABG (1 arterial graft) + AVR ~ first surgery with implant)	0,208	0,032	0,000						
DBC code 110025700120 (CABG (2 arterial grafts) + AVR ~ first surgery with implant)	0,221	0,065	0,001						
DBC code 110025500120 (CABG + MPL +/- TPL ~ first surgery with implant)	0,439	0,049	0,000						
other non-reference DBC codes	0,303	0,033	0,000						
age 1 to 60				-0,003	0,026	0,893			
age 66 to 70				0,039	0,028	0,163			
age 71 to 75				0,080	0,028	0,004	0,069	0,023	0,003
age >76				0,161	0,028	0,000	0,146	0,022	0,000
male				-0,044	0,021	0,031	-0,045	0,020	0,027
emergency admission				-0,423	0,056	0,000	-0,422	0,056	0,000
ICU admission				0,179	0,030	0,000	0,180	0,030	0,000
non-university teaching hospital				-0,612	0,022	0,000	-0,608	0,021	0,000
university teaching hospital				-0,715	0,020	0,000	-0,716	0,020	0,000
subsequent CABG				0,188	0,053	0,000	0,186	0,053	0,000
PTCA				0,261	0,450	0,561			
more thank 1 vessel treated				0,050	0,020	0,011	0,035	0,019	0,068
valve surgery on heart				-0,122	0,122	0,317			
multiple cabg				0,436	0,028	0,000	0,445	0,028	0,000
mitral valve replacement				0,303	0,120	0,012	0,247	0,111	0,026
aortic valve replacement				0,309	0,084	0,000	0,276	0,057	0,000
mitral valve plasty				0,360	0,089	0,000	0,421	0,053	0,000
tricuspidal valve plasty				0,129	0,081	0,112			
hypertrophic obstructive cardiomyopathy				-0,021	0,103	0,838			
ventricular tachycardia				0,085	0,261	0,746			
ventricular septal rupture				0,940	0,290	0,001	0,974	0,278	0,000
maze procedure				0,058	0,082	0,481			
aortic surgery				0,440	0,129	0,001	0,484	0,120	0,000
number of aortic prostheses				-0,298	0,022	0,000	-0,300	0,022	0,000
implant				0,265	0,089	0,003	0,193	0,060	0,001

Appendix C4 PLL regression ~ subset of stroke patients receiving treatment in the inpatient setting

Number of observations read	28269
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	-0,042	0,031	0,177	1,848	0,043	0,000	1,842	0,037	0,000
DBC code 110011010113 (subarachnoid hemorrhage regular treatment inpatient)	1,752	0,049	0,000						
DBC code 110011030113 (intracranial hemorrhage regular treatment inpatient)	1,793	0,044	0,000						
DBC code 110011110113 (non-hemorrhagic stroke regular treatment inpatient) (ref)	1,865	0,032	0,000						
DBC code 110011110213 (non-hemorrhagic stroke thrombolysis inpatient)	1,968	0,042	0,000						
DBC code 110011020113 (intracerebral hemorrhage regular treatment inpatient)	1,997	0,036	0,000						
age 1 to 60				0,036	0,020	0,080			
age 71 to 80				0,097	0,020	0,000	0,076	0,016	0,000
age 81 to 85				0,139	0,023	0,000	0,117	0,020	0,000
age >86				0,138	0,024	0,000	0,117	0,021	0,000
male				-0,070	0,013	0,000	-0,071	0,013	0,000
emergency admission				-0,078	0,014	0,000	-0,078	0,014	0,000
ICU admission				0,337	0,078	0,000	0,352	0,077	0,000
small general hospital				0,143	0,024	0,000	0,142	0,024	0,000
medium-sized general hospital				-0,157	0,025	0,000	-0,156	0,025	0,000
non-university teaching hospital				0,267	0,022	0,000	0,269	0,022	0,000
university teaching hospital				0,200	0,028	0,000	0,206	0,028	0,000
unspecified stroke				-0,027	0,017	0,109			
conservative treatment				-0,107	0,030	0,000	-0,100	0,029	0,001
number of endarterectomies				0,127	0,276	0,645			

Appendix C5 PLL regression ~ subset of inguinal hernia repair patients receiving treatment in the inpatient setting

Number of observations read	7874
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	0,198	0,007	0,000	0,138	0,027	0,000	0,140	0,022	0,000
DBC code 110001210303 (laparoscopic inpatient)	-0,106	0,013	0,000						
age 1 to 30				0,001	0,020	0,965			
age 51 to 60				0,003	0,019	0,892			
age 61 to 70				0,040	0,018	0,024	0,038	0,014	0,008
age >71				0,133	0,017	0,000	0,132	0,014	0,000
male				-0,100	0,022	0,000	-0,101	0,022	0,000
emergency admission				0,167	0,022	0,000	0,165	0,022	0,000
ICU admission				0,255	0,133	0,055			
small general hospital				0,021	0,019	0,251			
medium-sized general hospital				-0,028	0,018	0,121			
non-university teaching hospital				0,117	0,020	0,000	0,117	0,014	0,000
university teaching hospital				0,363	0,032	0,000	0,363	0,028	0,000
laparoscopic inguinal hernia procedure				-0,061	0,013	0,000	-0,062	0,013	0,000
recurrent inguinal hernia				0,040	0,015	0,008	0,040	0,015	0,007

Appendix C6 PLL regression ~ subset of appendectomy patients receiving treatment in the inpatient setting

Number of observations read	9654
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	0,709	0,011	0,000	0,545	0,038	0,000	0,532	0,024	0,000
DBC code 110001130303 (laparoscopic inpatient)	0,041	0,018	0,020						
age 1 to 10				0,092	0,035	0,008	0,113	0,029	0,000
age 16 to 20				-0,042	0,031	0,179			
age 21 to 35				-0,030	0,028	0,279			
age >36				0,158	0,027	0,000	0,182	0,019	0,000
male				-0,027	0,018	0,133			
emergency admission				0,028	0,021	0,183			
ICU admission				0,551	0,094	0,000	0,549	0,094	0,000
small general hospital				0,110	0,029	0,000	0,110	0,029	0,000
medium-sized general hospital				-0,159	0,028	0,000	-0,159	0,028	0,000
non-university teaching hospital				0,282	0,028	0,000	0,280	0,028	0,000
university teaching hospital				0,449	0,037	0,000	0,446	0,036	0,000
laparoscopic appendectomy procedure				0,008	0,019	0,689			

Appendix C7 PLL regression ~ subset of cholecystectomy patients receiving treatment in the inpatient setting

Number of observations read	15532
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	0,465	0,008	0,000	0,817	0,031	0,000	0,840	0,026	0,000
DBC code 110003230203 (open surgery inpatient)	0,750	0,022	0,000						
other non-reference DBC codes	-0,465	0,008	0,000						
age 1 to 40				-0,013	0,018	0,464			
age 51 to 60				0,031	0,020	0,128			
age 61 to 70				0,180	0,022	0,000	0,176	0,019	0,000
age >71				0,360	0,025	0,000	0,355	0,022	0,000
male				0,038	0,016	0,017	0,042	0,016	0,008
emergency admission				0,251	0,017	0,000	0,250	0,017	0,000
ICU admission				0,552	0,091	0,000	0,561	0,091	0,000
small general hospital				0,031	0,021	0,135			
medium-sized general hospital				-0,110	0,021	0,000	-0,127	0,018	0,000
non-university teaching hospital				0,200	0,020	0,000	0,183	0,017	0,000
university teaching hospital				0,456	0,031	0,000	0,440	0,030	0,000
laparoscopic cholecystectomy procedure				-0,563	0,024	0,000	-0,567	0,024	0,000

Appendix C8 PLL regression ~ subset of hip replacement patients receiving treatment in the inpatient setting

Number of observations read	23632
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1a			Model 1b			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	1,467	0,005	0,000	1,469	0,005	0,000	1,393	0,017	0,000	1,395	0,011	0,000
DBC code 110030190223 (femur fracture surgical inpatient with prosthesis)	0,389	0,015	0,000	0,388	0,015	0,000						
other non-reference DBC codes	0,039	0,035	0,267									
age 1 to 60							0,038	0,013	0,004	0,036	0,013	0,006
age 71 to 75							0,085	0,014	0,000	0,085	0,014	0,000
age 76 to 80							0,143	0,015	0,000	0,143	0,015	0,000
age >81							0,203	0,017	0,000	0,203	0,017	0,000
male							-0,061	0,011	0,000	-0,061	0,011	0,000
emergency admission							-0,075	0,022	0,001	-0,075	0,022	0,001
ICU admission							0,369	0,061	0,000	0,369	0,061	0,000
small general hospital							0,004	0,017	0,831			
medium-sized general hospital							-0,293	0,019	0,000	-0,295	0,014	0,000
non-university teaching hospital							0,156	0,017	0,000	0,153	0,011	0,000
university teaching hospital							0,375	0,025	0,000	0,366	0,021	0,000
primary diagnosis fracture							0,315	0,020	0,000	0,316	0,020	0,000
primary diagnosis tumour							-0,168	0,125	0,178			
primary diagnosis necrosis							0,095	0,045	0,033	0,097	0,045	0,029

Appendix C9 PLL regression ~ subset of knee replacement receiving treatment in the inpatient setting

Number of observations read	16433
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	1,465	0,005	0,000	1,698	0,020	0,000	1,706	0,013	0,000
other non-reference DBC codes	-0,388	0,126	0,002						
age 1 to 65				-0,023	0,014	0,118			
age 71 to 75				0,032	0,017	0,062			
age 76 to 80				0,092	0,018	0,000	0,096	0,014	0,000
age >81				0,146	0,020	0,000	0,149	0,017	0,000
male				-0,083	0,011	0,000	-0,085	0,011	0,000
emergency admission				-0,001	0,040	0,988			
ICU admission				0,229	0,110	0,037	0,231	0,110	0,035
small general hospital				0,015	0,018	0,419			
medium-sized general hospital				-0,251	0,019	0,000	-0,262	0,014	0,000
non-university teaching hospital				0,158	0,017	0,000	0,146	0,012	0,000
university teaching hospital				0,218	0,028	0,000	0,204	0,025	0,000
total replacement of knee				-0,302	0,012	0,000	-0,303	0,012	0,000
transfusion of blood and blood components				0,144	0,049	0,003	0,146	0,049	0,003
primary diagnosis fracture				-1,401	0,364	0,000	-1,403	0,365	0,000

Appendix C10 PLL regression ~ subset of childbirth patients receiving treatment in the inpatient setting

Number of observations read	75363
Dependent variable	LOS
Distribution:	Poisson
Link function:	Log

	Model 1			Model 2a			Model 2b		
	B	SE	Sig.	B	SE	Sig.	B	SE	Sig.
(Intercept)	0,334	0,003	0,000	-0,100	0,024	0,000	-0,110	0,023	0,000
DBC code 11000V510131 (spontaneous partus without complications outpatient)	-2,106	0,028	0,000						
DBC code 11000V510143 (instrumental partus/obstretical/multiple birth without complications inpatient)	0,080	0,007	0,000						
other non-reference DBC codes	-0,964	0,026	0,000						
age 21 to 25				-0,071	0,020	0,000	-0,071	0,020	0,000
age 26 to 30				-0,077	0,019	0,000	-0,077	0,019	0,000
age 30 to 35				-0,072	0,019	0,000	-0,072	0,019	0,000
age >36				-0,079	0,020	0,000	-0,079	0,020	0,000
emergency admission				-0,009	0,006	0,100			
ICU admission				0,750	0,227	0,001	0,752	0,227	0,001
small general hospital				-0,008	0,009	0,345			
medium-sized general hospital				-0,118	0,009	0,000	-0,112	0,007	0,000
non-university teaching hospital				0,091	0,009	0,000	0,097	0,007	0,000
university teaching hospital				0,287	0,013	0,000	0,294	0,011	0,000
delivery by Caesarean-section				0,719	0,070	0,000	0,722	0,070	0,000
multiple delivery				0,334	0,022	0,000	0,335	0,022	0,000
obstetrical trauma				0,040	0,025	0,108			
episiotomy				-0,078	0,059	0,191			

Erasmus University Rotterdam
Institute of Health Policy & Management

Visiting address

Burgemeester Oudlaan 50
3062 PA Rotterdam

Postal address

P.O. Box 1738
3000 DR Rotterdam
The Netherlands

Tel. **+31 10 408 8555**
Internet **www.bmg.eur.nl**
E-mail **research@bmg.eur.nl**

11813. B&T Ontwerp en advies. Oplage: 80 ex.

ERASMUS UNIVERSITEIT ROTTERDAM
INSTITUTE OF
HEALTH POLICY & MANAGEMENT