Comparison Cost_Daly Of Hip Replacement Care In 12 Belgian Hospitals

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Abstract

Background In view of the expected increase in expenditure on hip replacement treatment in Belgium [10], the complication rate [3] and the possible reduction in waste estimated by the OECD [1], we are not yet in a position to objectify the effectiveness of hip replacement treatment in Belgian hospitals. This objective study aims to propose a hospital comparison through the use of a cost-DALY ratio for hip replacement surgery among 12 Belgian hospitals. Methods In our study, the DALY calculation was applied at the hospital level for complications. Mortality was calculated on the basis of the Belgian mortality and life expectancy tables [15]. A DALY has been assigned to readmissions within 30 days. The costs of this study are the hospital costs of the PACHA hospital analysis. The adjusted values (costs and DALYs) were obtained by relating the observed value to the predicted value obtained from the linear regression model. Results We have 2,411 inpatients with an average age (Standard Deviation) of 69 years (13.5 years). The complication rate during hospital stays is estimated at 6.93% while the mortality rate is 1.20%. The average cost (SD) of a stay is €8,013 (€4,304). We have registered a total of 246.5 DALYs for the 12 hospital institutions in the study. Conclusion Other indicators should complete our study, including the patient's perception of the actual results experienced by the patient. Our analysis invites the authorities to create good practice guides for common diseases such as hip replacement surgery. Based on this first experience for the orthopaedic sector, we are convinced of the usefulness of our approach in evaluating the "cost-effectiveness" of other care systems.

Background

The OECD [1] estimates that 10% of hospital spending is spent on correcting preventable medical errors. The authors of this report also believe that there is a high variability of care to correct these errors, leading to significant consumption of care that is sometimes considered unnecessary or even harmful to the patient. Faced with this situation and due to the limited availability of resources, the need to allocate quality care combined with cost control is becoming more and more prevalent in health policies.

The use of financial incentives to reduce adverse events is already found in some foreign policies: USA, Japan, Slovenia...[1]. Alongside these countries, Belgium introduced, in 2018, a "Pay for Performance" programme in hospitals to link the quality of care to financial incentives [2]. To structure the approach, Belgium has chosen to implement the Donabedian method by selecting structure, process and result indicators. For example, Belgium has allocated structural points to hospitals that are in the process of being accredited, and process points to hospitals that demonstrate antibiotic prophylaxis compliance in the hospital management of hip replacement surgery.

In terms of outcome indicators, including damage to patients, by 2015 Belgium had accumulated more than 100 years of life lost in good health (Disability Adjusted Life Years: DALY) per 100,000 inhabitants. The OECD average is more than 70 DALYs/100,000 inhabitants [3]. In Belgium, this represents more than 11,000 DALYs lost in 2015. DALY is a factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (equivalent to death). DALY is a unit of measurement commonly used in medico-economic studies to reflect the effectiveness of a treatment or intervention. To reach their conclusions, medico-economic studies focus on the costs of medical care, their outcomes on patients' health and the resources needed to achieve this outcome.

Simultaneous analysis of costs and outcomes therefore seems essential to reflect areas for improvement in health care. In 2014, De Bethune and al. [4] compared inter-hospital practices and social security costs to cover these inpatients in Belgian hospitals. They highlighted the need to work on guides to good practice combined with inter-hospital benchmarking. However, there is currently no inter-hospital comparison in Belgium that simultaneously integrates hospital costs and qualitative elements of the "patient safety" type to determine the cost-effectiveness of routine care [5]. In addition, the complexity of a complication is not currently expressed in the studies. However, the occurrence of certain complications increases the financial and medical impacts.

In 2013, Belgium seems to be a good student in the management of hip and knee surgery, with 2.06% resulting in venous thrombosis and 2.6% pulmonary embolism, while the OECD average is 3.3% and 5% respectively [3]. A study by Hauck et al. [6] shows that each year in England, approximately 36,000 DALYs (68 DALYs/100,000 inhabitants) have been recorded due to 6 types of adverse events: sepsis, pressure ulcer, hip fracture due to a fall in an hospitalised patient, deep vein thrombosis, central line infection and death in patients with a low probability of death. The causes of this damage are complex and difficult to identify in a hospital institution where there are more and more people working around the patient, requiring greater coordination of care.

In Belgium, with an average hospital cost of €9,668 in 2016 [7] and the growth in the elderly population, hip replacements will generate an increase in financial expenditure borne by the Social Security of more than €49 million (all other things being equal) by 2025 [8].

In view of the increase in expected expenditure on hip replacement treatment in Belgium [10], the complication rate [3] and the possible reduction in waste estimated by the OECD [1], we are not yet in a position to objectify the effectiveness of hip replacement treatment in

Belgian hospitals.

This is why the objective of our study aims to propose a hospital comparison through the use of cost and DALY to understand the efficiency of hip replacement management among 12 Belgian hospitals. The indicators structured according to the Donabedian model will be used a posteriori to interpret the results of the comparison.

Methods

2.1 Case selection

The study sample is based on data from 12 Belgian general hospitals, including university hospitals from the "Associated Hospital Cost Analysis Project (PACHA)" benchmarking [9]. Hospitals have been anonymised. They are identified with a randomly assigned number. In this study, we focused our analyses on inpatients classified in the Diagnosis Related Group (DRG 301) - hip replacement (grouper 28) and for which we recorded at least one night of hospitalisation in 2016. Within the DRG, we have identified inpatients with admission diagnoses: traumatological origin, and chronic origin (osteoarthritis). Among these, we identified all patients who were readmitted to the same hospital within 30 days of discharge from the first inpatient stay. The inpatient stay of our study is therefore defined as the combination of the first inpatient stay and the readmission of the same patient to the same hospital. In the end, our total population is therefore estimated at 2,411 inpatients for these 12 Belgian hospitals.

2.2 Indicators of “Patient Safety” and Charlson index

To develop the Patient Safety indicators, we used the construction methodology of the Agency for Healthcare Research and Quality (AHRQ), version 5.0 [10]. The AHRQ's quality indicators are measures of quality of health care, based on medico-administrative data accessible in hospital databases at the end of an inpatient stay. Only the secondary diagnostic codes mentioned as "not present at admission" were used to identify complications of stays.

In this study, we used the following indicators: "PSI 03 - pressure ulcer rate", "PSI 06 - iatrogenic pneumothorax rate", "PSI 09 - postoperative bleeding rate or hematoma rate", "PSI 10 - postoperative physiological and metabolic disorders rate", "PSI 11 - postoperative respiratory failure rate", "PSI 12 - deep vein thrombosis rate or postoperative pulmonary embolism", "PSI 13 - postoperative sepsis rate" and "PSI 16 - number of transfusion reactions". The construction of the "infection" indicator focused on the identification of a list of codes from the "International Statistical Classification of Diseases and Related Health Problems" (ICD 10) mentioning the infectious nature. The Charlson index [11] was applied to the entire population and to the diagnostic codes present at admission in order to express the level of comorbidity of inpatients managed by hospital institutions.

2.3 Patient Safety – DALY

The DALY is calculated by summing the number of years of life lost due to premature death (YLL: Years of Life Lost) and the number of years of life lost due to disability (YLD: Years Lost due to Disability) [12]. In our study, the DALY calculation was applied at the hospital level.

DALY = YLL + YLD

Specifically, the number of years lost due to a disability (YLD) is calculated by multiplying incident cases by the duration and weight of the disability for a given disease. To conduct our study, we used the disability weights from the Institute for Health Metrics and Evaluation reports on Global Burden of Disease (GBD 2016) [13] for decubitus ulcers (stage III and IV) and postoperative respiratory failure, while the disability weights from the article by Jha et al. [14] were used for the remaining complications. When we couldn't find DALY, we went back to a pathology that was clinically similar to our complication. The durations of short-term complications are derived from the literature review of the article by Jha et al. The calculation of the DALY was then applied to all stays of our population.

Number of years of life lost due to disability (patient safety) per hospital stay (YLD) = weight of complication x duration of complication

We considered readmission as a source of pain/discomfort for the patient, which explains why we also granted a DALY for stays where the readmission was within 30 days and related to the initial reason for hospitalisation. The duration of invalidity for readmissions corresponds to the sum of the duration of stay of the first stay and the duration of stay before the beginning of the second admission. Mortality was calculated on the basis of the Belgian mortality and life expectancy tables [15]. The disability weight of death corresponding to 1 in our study was multiplied by the life expectancy according to the individual's age.

Number of years of life lost due to death per hospital stay (YLL) = 1-the number of years of life/age

If a patient has both a complication and a death during the stay, we only count the patient's death.

2.4 Hospital cost data

The costs in this study only consider hospital costs for the acute management of hospital stays from a hospital perspective and not from a social security perspective. We excluded all costs of revalidation units and included the costs of readmissions related to the initial reason for the first hospitalisation. In addition, we have also broken down the total cost (hospital cost) into two quite distinct costs:

- The hospitalisation costs include resources consumed in the department in which the patient has been hospitalised: the cost of consumables, staff costs, equipment costs, administrative costs and hotel costs.
- The costs of medical and pharmaceutical procedures consist of the costs of medical procedures, pharmaceutical products, implants and prostheses.

The total cost of the inpatient = (the cost of the first admission - the cost of the revalidation service) + the total cost of the readmission

Statistical Analyses

The statistical analyses were performed using the SPSS software, version 25. We used the descriptive "mean / standard deviation" statistics to make a univariate description of all the variables in our study. Despite the asymmetry of the quantitative variables, we did not use "medians - confidence intervals" because of the lack of possible interpretation for small values such as DALY. The Kruskal-Wallis and Mann-Whitney tests were used to verify significant differences in dependent variables (cost - DALY) on ordinal and dichotomous independent variables.

The main results from the comparison between hospitals are structured according to the Donabedian model. The indicators in this table have been constructed on the one hand according to the literature review and on the other hand according to the availability of data in our database [16-17-18].

To correct the distribution of our dependent variables such as DALY and cost, we performed a logarithmic transformation. We then recoded our independent variables into dummy variables. A linear - stepwise regression was then performed on these new dependent variables to identify the predicted hospital values. We chose this statistical model to adjust the data according to the hospital's case mix. The predictors used for the model are the Charlson index, age, admission diagnosis, gender, type of admission, type of discharge destination, transition to intensive care unit, transition to geriatric unit, geriatric assessment during hospitalisation, readmission within 30 days after the end of the first stay, the time between the date of admission and the date of operation, the time between the date of operation and the first physiotherapy service, complications and the duration of the inpatient stay. The selection of these independent variables was made on the basis of indicators from the literature [16-17-18] and according to the significance of the data from the univariate analysis. Homoscedasticity was controlled by means of a graph. The use of the Charlson index in the regression is preferred to the relative weight (case mix index) since the Charlson index includes comorbidities present at admission and not complications encountered during the hospital stay. Finally, the ratios were calculated between the observed value and the predicted value of the inpatient stay (from the log regression). If the cost ratio is greater than 1, it means that the hospital has a higher than expected cost in relation to its hospital profile. This rule also applies to the DALY ratio.

Results

Table 1 describes the main results from the univariate analysis and hospital comparison. The indicators in Table 1 are structured according to the Donabedian model. Tables 2 and 3 summarise the main regression results.

4.1 Description of the inpatients

We have 2,411 inpatients with an average age (Standard Deviation) of 69 years (13.5 years) (Table 1). More than 59% of the population is female (Table 1). The complication rate during hospital stays is estimated at 6.93% while the mortality rate is 1.20% (Table 1). More than 76% of inpatients are admitted for a reason of chronic origin (osteoarthritis...) (Table 1). 89% of the deceased patients were admitted for traumatological reasons. The mortality rate for inpatients with a "Patient Safety" complication is 20%. Patients who died in hospital have a mean Charlson index (SD) of 2.19 (1.68) compared to 0.63 (1.047) for patients who did not die ($p<0.001$). The average rate of haemorrhage haematomas is 3.61%, infection 2.32%, physiological complications 0.87%, pressure ulcer 0.54%, respiratory arrest 0.37%, deep vein thrombosis 0.25% and sepsis 0.21% (Table 1). The group admitted for reasons of trauma, which represents just under 24% of inpatients, accounts for more than half the complications (54%). 2.74% of inpatients go through an intensive care unit and 3.65% of the population go to a geriatric unit. 62% of inpatients have no comorbidity according to the Charlson index. 5.60% of inpatients are readmitted to the same institution within 30 days (Table 1). 67% of these inpatients return for a reason related to their previous hospitalisations. 7 patients died following these readmissions.

4.1.1 Evaluation of the duration and costs of the stay

The average cost (SD) of an inpatient stay is €8,013 (€4,304) (Table 1). It also seems to increase with age (p<0.001) from €7,446 (€2,453) in the 18-50 age category to €9,148 (€5,039) in the 81-102 age category. Inpatients admitted for a "chronic" reason such as osteoarthritis have an average total cost (SD) of €7,414 (€3,087), while inpatients admitted for the "trauma" group such as femur fracture represent an average cost (SD) of €9,939 (€6,529) (p<0.001). Inpatients that have been readmitted after the first stay have an average total cost (SD) of €8,445 (€3,707). The average cost (SD) of readmission is estimated at €6,953 (€7,873). The average cost (SD) of managing these DRGs including the first and second inpatient stays therefore increases to €16,036 (€9,882).

The average cost (SD) of an inpatient stay that does not transit through the intensive care unit is €7,725 (€2,627) while the average cost (SD) of an inpatient stay that transits through the intensive care unit is €18,250 (€18,124). The average cost (SD) of an inpatient stay that does not go through a geriatric unit is €7,743 while the average cost (SD) of an inpatient stay that goes through a geriatric unit is €15,141 (€10,725).

Finally, the average cost (SD) of the inpatient stay when the patient is operated on the day of admission is €6,844 (€2,173) while the average cost (SD) of the stay when operated on more than 5 days after admission is €13,418 (€6,873). 57% of stays see operations take place one day after admission.

The average length of stay (LOS) (SD) is 7.1 days (5.5 days) (Table 1). The LOS (SD) is 5.67 days (3.78 days) if the admission diagnosis is chronic and 11.48 days (7.53 days) if the admission diagnosis is traumatological (p<0.001).

The LOS (SD) of 12.41 days (9.58 days) is also higher when the patient died while in hospital (p<0.001). LOS (SD) also tends to increase with time from the date of admission to the date of surgery, from 5.61 days (3.60 days) when the patient is operated on the same day to 19.52 days (10.87 days) when the patient is operated on more than 5 days later (p<0.001).

11.92 days is the LOS (SD) that elapses between the date of discharge from the first inpatient stay and the date of admission to the second inpatient stay (readmission) (8.89 days). The LOS (SD) for readmission inpatients is 12.69 (13.89) days.

4.1.2 Evaluation of the length of stay and costs associated with complications

54% of inpatients admitted through emergency services have a complication. Among the 62% of patients who have no Charlson index comorbidity, 3.78% of inpatients have at least one complication during their stay (p<0.001). Among the 5.4% of stays that have a Charlson index greater than 2, 36% of them have at least one complication (p<0.001). The average duration (SD) increases from 6.53 (4.43 days) days when the inpatient does not encounter a complication to 14 days (11.14 days) if the inpatient encounters at least one complication during hospitalisation (p<0.001). The average cost (SD) increases from €7,611 (€2,566) when the inpatient does not have at least one complication to €13,419 (€12,181) if the inpatient has at least one complication during hospitalisation (p<0.001).

4.1.3 Impact of DALY

We have registered a total of 246.5 DALYs to cover these inpatients in the 12 hospitals in our study (Table 1). Deaths alone represent more than 240 DALYs (YLL). Complications and readmissions represent 6.5 DALYs for the entire group (YLD) (Figure 1). The average number (SD) of DALYs per inpatient is estimated at more than 0.102 DALYs (0.97 DALYs). The average number of DALYs increases from 0.03 (0.51 DALYs) with a Charlson index of 0 to 1.43 (4.91 DALYs) when the Charlson is at 5 (p<0.001). The average cost (SD) of an inpatient without DALYs is €7,706 (€2,868). This average cost (SD) rises to €14,639 when the inpatient records at least DALYs (€11,898) (p<0.001).

4.2 Benchmarking

4.2.1 Donabedian indicators

Hospitals 1, 11 and 12 have the highest number of inpatients admitted for reasons of traumatological origin (between 36.70% and 38.59%) (Table 1). The average length of stay (SD) varies from 5.1 days (3.73 days) for hospital 7 to 11.6 days (8.78 days) for hospital 1 (Table 1).

In particular, geriatric and intensive care varies from hospital to hospital, with more than 17% of hospital stays in geriatrics, while hospital 2 receives more than 14% of its inpatients in an intensive care unit. Our hospital comparison also shows a variability in the use of geriatric internal binding from 0% for hospitals 10 and 12 to 25% for hospital 2 (Table 1). The average intervention time is less than 48 hours for chronic admission reasons in all hospitals. When the reason for admission is traumatological, 7 hospitals have an average duration of more than 2 days before the operation. The inpatients admitted for a trauma diagnosis have the longest intervention time (SD), particularly the hospital 4 with 5.4 days (6.6 days). Only 9% of hospital 5 inpatients receive physiotherapy sessions, while hospital 3 provides 100% of its patients with physiotherapy (Table 1). In terms of outcomes, haematoma haemorrhage complications, infections and metabolic disorders account for the largest number of cases. The complication rate for all complications combined varies from 2.6% (7) to more than 14% (2, 8, 11) depending on the hospital (Table 1). Finally, readmission rates can be high in some hospitals since hospitals 2 and 4 are respectively more than 11% and 18%. The mortality rate also varies by hospital, from 0% for hospitals 3 and 8 to 4.5% for hospital 2 (Table 1).

Table 1: Comparison of Donabedian Indicators for the management of hip replacement surgery among the 12 Belgian hospitals in the study.

Donabedian indicators for the management of arthroplasty among 12 Belgian hospitals (N=2,411)

	Hospitals	1	2	3	4	5	6	7	8	9	10	11	12	Group
Structure	Number of stays*	109	92	47	108	376	113	639	183	251	179	184	130	2,411
	Sex													
	Female	59.63%	58.7%	57.4%	61.1%	61.4%	55.8%	56.5%	58.5%	59,0%	55.9%	63,0%	74.6%	59.5%
	Male	40.4%	41.3%	42.3%	38.9%	38.6%	44.2%	43.5%	41.5%	41,0%	44.1%	37,0%	25.4%	40.5%
	Diagnostic type													
	Chronic	63.3%	67.4%	72.3%	66.7%	71,0%	78.8%	87.2%	81.4%	80.1%	81.6%	61.4%	61.5%	76.3%
	Traumatology	36.7%	32.6%	27.7%	33.3%	29,0%	21.2%	12.8%	18.6%	19.9%	18.4%	38.6%	38.5%	23.7%
	Age* average (Standard Deviation)	69.9 (14)	71.9 (14.6)	63.9 (15.4)	70.6 (11.9)	68.7 (16.1)	68.3 (14)	69.7 (11.5)	67.8 (12.7)	69.1 (11.1)	69.8 (12.8)	73.5 (18.2)	73.7 (11.2)	69.8 (13.5)
	Charlson average* (SD)	1.02 (1.48)	1.02 (1.42)	0.85 (2.12)	0.93 (1.62)	0.67 (1.24)	0.64 (1.02)	0.56 (1.03)	0.84 (1.41)	0.58 (0.99)	0.62 (1.03)	0.61 (1.19)	0.75 (1.32)	0.68 (1.23)
Process	**Number of days between admission day and operating day (day)* average (SD)**	1.6 (1.9)	1.7 (3.3)	1.4 (2.6)	2.2 (4.5)	1.1 (1.2)	1.2 (1)	1.1 (0.9)	1 (2)	0.5 (1.12)	0.3 (0.9)	0.8 (1.5)	1.5 (1.6)	1.05 (1.7)
	Chronic* average (SD)	1.1 (0.34)	1.1 (0.65)	0.7 (2.4)	0.5 (0.6)	1 (0.9)	1 (1)	0.9 (0.6)	0.5 (0.5)	0.2 (0.6)	0.2 (0.7)	0.3 (1)	1 (0.7)	0.7 (0.7)
	Traumatology* average (SD)	2.6 (2.8)	2.9 (5.6)	3 (2.4)	5.4 (6.6)	1.2 (2.3)	1.8 (1.9)	1.9 (1.7)	3.1 (4)	1.9 (1.5)	1 (1.5)	1.7 (1.8)	2.3 (2.1)	2.15 (3.1)
	Length of stay (excluding revalidation) average (SD)	11.6 (8.8)	8.3 (5.1)	9.5 (6.9)	9.8 (8.5)	6.5 (4.3)	7.6 (5.4)	5.1 (3.7)	6.7 (5.43)	6.9 (5.9)	6.2 (4.2)	8.9 (5.8)	9 (4.6)	7.1 (5.5)
	Length of stay in surgical care unit* average (SD)	11.3 (8)	7.8 (4.9)	7.7 (5.2)	6.4 (6.9)	6.3 (3.1)	6.7 (3)	4.8 (3.3)	6.5 (4.8)	6 (8)	6 (4)	7.5 (4.6)	8.8 (4.5)	6.4 (4.5)
	Geriatric													
	Geriatric internal liaison percent	13.76%	25,00%	17.02%	27.78%	10.37%	17.7%	0.47%	6.56%	2.79%	0,00%	24.46%	0,00%	8.28%
	Geriatric care unit percent	1.83%	4.35%	10.64%	17.59%	0.8%	4.42%	2.19%	0.55%	5.18%	1.68%	8.7%	2.31%	3.65%
	Length of stay in geriatric care unit* average (SD)	21 (28.3)	11 (7.4)	17.6 (7.2)	19.3 (8)	26.3 (30.3)	20.4 (7.8)	13.9 (7.9)	29 (-)	19.5 (11)	12.3 (6)	16.1 (7.1)	6.7 (6)	17.2 (10.1)
	Intensive care unit percent	4.58%	14.13%	4.26%	1.85%	1.33%	1.76%	1.41%	0.55%	1.99%	2.23%	3.26%	9.23%	2.74%
	Physiotherapy session													
	After the operation percent	88.99%	96.74%	100,00%	65.74%	9.31%	98.23%	68.08%	99.45%	99.6%	96.09%	96.74%	15.38%	69.97%
	Number of days between 1st intervand 1st physiotherapy* average (SD)	2.2 (1.6)	1 (0.6)	1.1 (0.4)	1.5 (4.2)	2.1 (1.6)	1.3 (1.3)	1.5 (1.4)	1 (0.4)	1.1 (0.4)	1.3 (1.1)	0.9 (1.1)	4.4 (3.4)	1.33 (1.55)
Outcomes 1	**Complication**	11.93%	14.13%	4.26%	7.41%	2.93%	10.62%	2.66%	14.21%	3.98%	8.38%	14.67%	10,00%	6.93%
	Postoperative_Respiratory_Failure	0.92%	1.09%	0,00%	0,00%	0.53%	1.77%	0.16%	0,00%	0,00%	0.56%	0,00%	0.77%	0.37%
	Perioperative Hemorrhage or Hematoma	8.26%	8.7%	2.13%	2.78%	1.06%	6.19%	0.78%	12.02%	1.99%	4.47%	5.43%	3.85%	3.61%
	Infection	1.83%	5.43%	2.13%	2.78%	0.53%	1.77%	1.25%	1.64%	1.99%	3.91%	7.61%	3.08%	2.32%
	Pressure Ulcer (III or IV)	0.92%	0,00%	0,00%	0,00%	0,00%	0,00%	0.63%	0.55%	0.4%	0,00%	3.26%	0,00%	0.54%
	Perioperative_Pulmonary_Embolism_or_Deep_Venous_Thrombosis	0.92%	0,00%	0,00%	0.93%	0,00%	0,00%	0.31%	0,00%	0,00%	0,00%	0.54%	0.77%	0.25%
	Sepsis	1.83%	0,00%	0,00%	0,00%	0,00%	0.88%	0,00%	0,00%	0,00%	0.56%	0.54%	0,00%	0.21%
	Postoperative_Phyiologic_and_Metabolic_Derangement	2.75%	2.17%	2.13%	0.93%	0.53%	3.54%	0.31%	0.55%	0.4%	0.56%	0,00%	2.31%	0.87%
	Transfusion Reaction	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0.4%	0,00%	0,00%	0,00%	0.04%
	Iatrogenic Pneumothorax	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,00%
Outcomes 2	Case Mix Index average*	1.69 (0.29)	1.72 (0.43)	1.66 (0.22)	1.78 (0.31)	1.71 (0.36)	1.71 (0.40)	1.67 (0.22)	1.65 (0.18)	1.64 (0.26)	1.68 (0.28)	1.77 (0.43)	1.7 (0.45)	1.69 (0.31)
	Mortality*	1.83%	4.35%	0,00%	1.85%	1.06%	2.65%	0.31%	0,00%	1.2%	1.12%	1.63%	3.08%	1.2%
	Readmission < 30 days (11 months)													
	% total readmissions	6.42%	11.96%	2.13%	12.04%	5.85%	3.54%	3.29%	8.2%	4.78%	5.59%	7.61%	3.85%	5.6%
	% readmissions related to arthroplasty reasons	2.75%	8.7%	0,00%	8.33%	3.99%	3.54%	2.19%	6.01%	3.19%	4.47%	2.72%	0.77%	3.57%
	Mortality of readmission*	14.29%	18.18%	0.00%	4.76%	0.00%	0.00%	0.00%	8.33%	10.00%	7.14%	0.00%	0.00%	5.19%
DALY - COST	DALY (YLL+YLD) Total	17.64	40.06	0.03	14,00	27.52	30.8	14.3	0.73	25.37	38.6	18.36	19.11	246.5
	DALY (YLL+YLD)* Average (SD)	0.162 (0.941)	0.435 (1,855)	0.001 (0.003)	0.13 (0.933)	0.073 (0.643)	0.273 (1,766)	0.022 (0.373)	0.004 (0.022)	0.101 (0.765)	0.216 (2,192)	0.1 (0.625)	0.147 (0.842)	0.102 (0.975)
	Total average cost excluding revalidation*	€11,187 (€7,778)	€10,266 (€4,008)	€7,828 (€3,518)	€9,099 (€4,466)	€8,322 (€3,492)	€9,027 (€4,357)	€7,078 (€1,795)	€8,343 (€2,189)	€6,413 (€3,540)	€7,644 (€8,379)	€7,943 (€4,260)	€9,052 (€5,126)	€8,018 (€4,304)
	Total average cost including cost or readmission (excluding revalidation)*	€11,606 (€7,987)	€12,241 (€9,667)	€7,915 (€3,760)	€9,992 (€6,990)	€8,799 (€4,337)	€9,276 (€4,603)	€7,210 (€2,086)	€8,898 (€3,416)	€6,693 (€4,209)	€8,049 (€8,760)	€8,391 (€4,130)	€9,326 (€5,323)	€8,419 (€5,131)
	* Kruskal-Wallis = p > 0,05													

4.2.2 Benchmarking DALY

Table 1 above shows the DALYs and hospital costs recorded within the 12 hospitals to manage hip replacement in 2016. The average DALY (SD) varies by hospital, with hospital 3 at 0.001 (0.003) and hospital 2 at 0.435 (1.855) (Table 1). Hospitals 2, 10, 6, 5 and 9 have the highest number of DALYs. At 5, they total more than 136 DALYs which cover 41% of the inpatients. Hospitals 2, 6 and 10 have the highest average number of DALYs (YLD + YLL) per inpatient (Table 1).

Hospital 2, which has a large number of DALYs, also has significant total costs. Hospitals with the lowest average cost do not systematically have fewer DALYs as shown by Hospital 6 and 11 (Table 1). However, when we analyse our data, we see that the average cost of benefits varies between 58% for hospitals 1, 2, 4 and 12 and more than 73% of the total cost for hospitals 7 and 8.

4.2.3 Data adjustment according to the hospital profile

A linear regression - stepwise, was performed to determine the impact of our predictors (see statistical analyses) on the hospital cost of hip replacements. In our model a significant positive link was found: R^2 is evaluated at 0.680.

Table 2: Result of cost linear regression stepwise

Model Summary[q]								
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate				
16	.826[p]	0.682	0.680	0.19581				
Coefficients[a]								
Model		Unstandardised Coefficients		Standardised Coeff	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
16	(Constant)	8.579	0.010		831.611	0.000	8.559	8.599
	Length of stay	0.039	0.001	0.623	37.077	0.000	0.037	0.041
	Readmission	0.571	0.018	0.379	32.532	0.000	0.536	0.605
Unit care	Intensive	0.268	0.026	0.127	10.206	0.000	0.217	0.320
	Geriatric	-0.106	0.026	-0.057	-4.062	0.000	-0.157	-0.055
	Geriatric internal liaison	0.047	0.016	0.038	2.986	0.003	0.016	0.079
	Complication	0.112	0.018	0.083	6.126	0.000	0.076	0.149
Days between admission day and operating day	1	0.113	0.009	0.161	12.395	0.000	0.095	0.131
	4	0.071	0.023	0.043	3.117	0.002	0.026	0.115
	3	0.070	0.026	0.033	2.661	0.008	0.018	0.122
	2	0.050	0.021	0.030	2.341	0.019	0.008	0.092
Physiotherapy session	1	-0.023	0.008	-0.033	-2.765	0.006	-0.040	-0.007
	4	0.049	0.020	0.029	2.463	0.014	0.010	0.087
Destination	Deceased	0.127	0.043	0.040	2.958	0.003	0.043	0.211
	Transfer to care home	-0.039	0.016	-0.032	-2.458	0.014	-0.070	-0.008
	Transfer to hospital	0.035	0.017	0.027	2.141	0.032	0.003	0.068
Age	> 81 years old	-0.029	0.011	-0.035	-2.513	0.012	-0.051	-0.006
a. Dependent Variable: LN_cost								

In our model, the independent variables that influence the logarithm of cost are length of stay, readmission within 30 days, complications, transition to intensive care, internal geriatric liaison, transfer to another hospital, number of days between the date of admission and the surgical intervention of more than 1 day, intervention by a physiotherapist after 4 days and the patient's death. However, the transition to a geriatric unit, the intervention of the physiotherapist on the first day after the operation, the transfer to a rest and care home and the age category over 81 years also show a significant but negative relationship to the total cost (Table 2).

When DALY is our dependent variable, our linear regression has an R^2 at 0.894. For DALY, significant variables are complications, readmission related to arthroplasty, death, length of stay, transition to intensive care, and patient referral by a general practitioner. However, the Charlson index at 3 and admission through the emergency department without a medical ambulance also show a significant but negative relationship to the logarithm of DALY (Table 3).

Table 3: Result of DALY linear regression stepwise

Model Summary[j]								
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate				
9	.946[i]	0.895	0.894	0.62781				
Coefficients[a]								
Model		Unstandardised Coefficients		Standardised Coeff	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
9	(Constant)	-9.271	0.021		-439.921	0.000	-9.312	-9.230
	Complication	4.359	0.059	0.574	74.510	0.000	4.245	4.474
	Readmission	3.836	0.056	0.457	68.478	0.000	3.726	3.946
Destination	Deceased	6.430	0.133	0.363	48.507	0.000	6.170	6.690
	Length of stay	0.014	0.003	0.041	5.214	0.000	0.009	0.020
Unit care	Intensive	0.269	0.084	0.023	3.210	0.001	0.105	0.434
Charlson index	3	-0.155	0.074	-0.014	-2.093	0.036	-0.300	-0.010
Addressed by	general practitioner	0.191	0.075	0.018	2.558	0.011	0.045	0.337
Emergency room	without medical ambulance	-0.078	0.037	-0.016	-2.078	0.038	-0.151	-0.004

Graph 1 below shows the hospital ratios obtained from our regression models on cost and DALY. The ratios per hospital are calculated by dividing the observed mean value by the predicted mean value from the regression model. As a reminder, when the ratio is above 1, it means that the observed value is higher than the value predicted by our model.

In an attempt to more easily identify hospitals with higher than expected ratios, we translate this data into a 4-zone graph. The upper right-hand area shows hospitals that have a higher cost and DALY than predicted. While the lower left area shows hospitals that have a lower cost and DALY than their predicted case mix.

Graph 1: Graphic of cost observed/cost expected and DALY observed - DALY expected from linear regression among 12 Belgian hospitals.

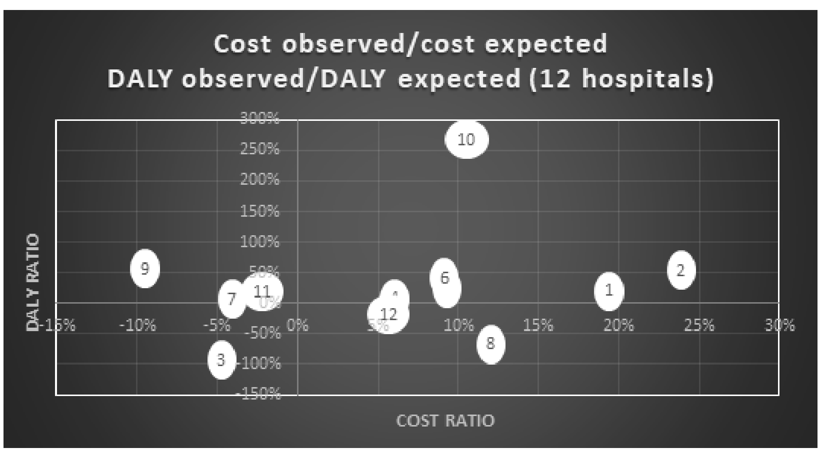

Table 4: Results of cost observed/cost expected and DALY observed - DALY expected from linear regression

Hospitals	1	2	3	4	5	6	7	8	9	10	11	12
Observed/predicted COST	1.194	1.239	0.953	1.060	1.093	1.091	0.959	1.120	0.905	1.105	0.978	1.057
Observed/predicted DALY	1.202	1.533	0.071	1.076	1.250	1.417	1.071	0.332	1.561	3.688	1.191	0.816

Hospitals 1, 2, 4, 5, 6 and 10 seem to have higher observed costs and DALYs than the predicted values in our model. The financial difference between the observed cost and the predicted cost for hospital 1 is €1,881. With 109 stays, the excessive hospital cost therefore amounts to more than €200,000. Only hospital 3 has lower observed values than our model for both costs and DALYs. Hospitals 7, 9 and 11 have observed costs lower than our model. Hospitals 8 and 12 have observed DALYs lower than our model.

Discussion

The objective of our study was to conduct a cost-DALY comparison for the management of hip replacement surgery in a sample of 12 Belgian general hospitals. To position hospitals, we identified the hospital costs of acute inpatient stays as well as the DALY impact of their management at the hospital. The DALYs have allowed us to weigh the complications encountered during stays, with it being understood that they do not all have the same impact on the patient. In calculating the DALY, we also took into account the impact of readmissions and the mortality rate. At the end of this analysis, we are able to propose an inter-hospital comparison that simultaneously integrates financial and qualitative aspects according to the hospital's case mix. The hospital costs of our study are quite close to the literature reviewed [19-20] with an average cost ranging from €7,816 in Austria to €8,805 in Sweden. The differences can be explained partly by the methodology of the studies and partly by the models of care organisation in the different countries. Regarding the evaluation of DALYs, it is very difficult to find similar studies that evaluate the process and outcomes of hospital care around hip replacement.

5.1 Impact of DALY

In our study, the number of DALYs is estimated at more than 246 years of life lost for 2,411 inpatients admitted for hip replacement surgery, or 0.10 years of life lost per stay. Our study shows that some hospitals have a cost of up to 23% more than expected to cover their inpatients. The financial impact on a Belgian scale could therefore be very significant. Our study would show that in 2025, the complications of prosthesis care in Belgian hospitals (all other things being equal) could result in just over 3,270 years of life lost [7-8] at the level of Belgian hospitals.

5.2 Donabedian - clinical itineraries

To identify the indicators in our article, we have drawn on the literature and, in particular, on the guides to good practice already available in many countries: England, the United States, Scotland... [21-22-23]. Studies show that the comparison of structural, process and outcome indicators identified by providers is used to improve hospital and patient performance [16-17-24]. This is why our approach integrating the Donabedian model makes sense in terms of interaction with clinicians and hospital managers.

5.2.1 Process indicators

The review of good practice guidelines points to the need for ortho-geriatric management, an intervention time of within 48 hours, and the rapid mobilisation of patients [18-25-26]. These indicators built from medical and administrative data are present in our study. The simultaneous management of orthopaedics and geriatrics is highlighted to reduce the cost of stay [26-27]. Only the geriatric aspect could be explored in our study. As such, our study shows divergent practices regarding the care of the ageing population. This variability is partly explained by the financing of geriatric stays in Belgium [28].

The average length of our inpatient stays of 7.1 days is lower than in the technical report of the “Institut National d'Assurance Maladie Invalidité” (INAMI) [7] due to the selection of our population and the exclusion of data related to revalidation. This exclusion was made to make our comparison between hospitals that do not all have a revalidation service more reliable. Our results seem to be in line with Maeda et al. [29] who obtain high costs for stays with a longer average length of stay and a high complication rate. The average overall length of stay of our study is within the ranges of Geissler et al. [30], which reports that variability can be encountered depending on the treatments or the different modalities of postoperative care organisation. In addition, the lack of social support that accompanies the aging process also seems to justify a longer stay to meet the population's rehabilitation needs [31]. This organisation of care is reflected in our study by the number of returns home and the number of transfers from stays to rest homes, which can vary from 60% (hospital 1) to 89% (hospital 10) and from 3.54% (hospital 6) to 20.77% (hospital 11).

In identifying process indicators, we did not have the opportunity, due to the lack of data, to analyse pain management, the impact of access routes and surgical techniques, as well as post-revision as considered in other studies [4].

5.2.2 Results indicators

The haemorrhage/haematoma indicator has a significant impact in our hospitals, potentially explained by the systematic presence of a postoperative haematoma in the surgeon's operating protocol. Indeed, Belgian financing rules may incite certain hospitals to over or under code medical information in order to optimise financing [28]. But eliminating all complications would not seem to reduce the observed cost variations [29].

Our average readmission rate of 5.6% is comparable to the Dundon study [32] which was 5%. The results of the study by Cary et al. [33] are similar to our results regarding the number of readmissions for reasons of periprosthetic fractures, dislocations, infections, etc.

The collection of structured indicators according to Donabedian's approach in our study aims, among other things, to translate cost-effectiveness from more operational information. The integration of this tool into the practice of hospital actors involved in the care chain could perhaps increase communication [1], which seems to be an issue in the fight against adverse events. As Thakker [34] demonstrates, regular presentation of results encourages teams and ensures the implementation of corrective actions.

With regard to foreign approaches and the article by De Bethune et al. [4], it must be noted that, in Belgium, there is currently no guide to good practice at the national level. Yet, Dellinger et al. [35] reported a 23% reduction in the number of surgical site infections in combination with compliance with Evidence Based Medicine based care processes. Farrow et al. also shows a significant improvement in outcome indicators following the introduction of standards for hip management [25]. In the absence of benchmarks, Belgian hospital managers and health care providers are therefore not in a position to assess the quality, achievement of an outcome and performance of their institution. This performance also requires the patient's integration through the evaluation of his/her satisfaction. Indeed, Gjertsen et al. [36] suggest that a high proportion of patients report postoperative problems that are not mentioned in the preoperative phase: pain, walking. This reinforces the need to integrate patients' perceptions of their care through Patient Reported Outcome Measures (PROM).

5.3 Financing

Our study shows that some hospitals have an additional cost of more than 23% compared to the expected costs for their population. And yet, even in the absence of a reference framework for the management of hip replacement, Belgium has, since 01 January 2019, undertaken a new financing mechanism for 57 pathology groups (including elective hip replacement). With the introduction of flat rates per pathology, the control of hospital costs therefore becomes more important. Given the diversity of medical practices across regions, schools and financial leitmotivs [37], our article therefore demonstrates the value of combining both costs and qualitative indicators to evaluate medical practices. This argument was mentioned by the Belgian Health Care Knowledge Centre (KCE) in its report on pathology clustering [38]. In addition, Antonova et al. [39] specify that Bundled Payment can lead to benchmarking for sharing best practices but that it is necessary to identify criteria for quality assessment and risk adjustment methods. Indeed, decision-makers must reward the relevance of care rather than the quantity [1].

5.4 Limitations

Despite the innovative nature of our study, it has its limitations.

The DALY impact is probably greater than we estimated in our study.

- The scope of the study was essentially hospital-based, which is why the calculation of the DALY was limited to complications during hospital stays.
- Since we only had 2016 data from the hospitals participating in the PACHA benchmarking, we were unable to identify the readmissions
  - within 30 days for stays where the person was admitted to a hospital after 02 December 2016.
  - of inpatients that could have taken place in a structure other than that of the first inpatient stay.
- We have not identified any "patient safety" medical complications that have occurred during readmissions or at home.
- In the absence of disability weights for some complications, we have resumed pathologies that were clinically similar to our medical complications.

Belgian financing rules may incite certain hospitals to overwrite or underwrite medical information in order to optimise financing [28].

Access to quality data after discharge from hospital was not possible in this study.

Neither the ICD10-PCS codification nor the Belgian nomenclature allowed us to distinguish the surgical approaches used in hospitals.

Despite these limitations, our study provides us with several interesting lessons. In a future study, the integration of complementary structural variables and the integration of PROMS (Patient Reported Outcome Measures) would allow us to understand hospital performance around a care chain.

Conclusion

Comparing hospitals between each other makes it possible to identify hypothetical failures in their management. In the accreditation procedures of hospital institutions where the role of the "patient-partner" becomes a critical component, it is essential to provide patients with structured information that will enable them to choose the institution to which they will entrust their health. Evaluating the rates of patient-safety indicators associated with costs is a prerequisite for quality and cost improvement efforts on the part of managers and practitioners. However, the provision of benchmarking to assess the performance of hospital care costs must be refined and integrated into the improvement of the quality of care provided by hospitals.

Since 1990, France has ranked its hospitals ("Palmarès des Hôpitaux") according to a series of indicators such as length of stay, financial management, etc., but these reports seem to have always been contested, particularly because of the absence of a weighting of these indicators in the overall ranking of hospital institutions [40].

The descriptive approach, through the use of indicators according to the Donabedian model, then makes it possible to translate our ratios for the attention of managers - service providers so that they understand and support the corrective measures of the sector concerned. However, other indicators should complete our study, including the patient's perception of the actual results experienced by the patient.

In view of the reimbursement policy recently launched in Belgium [2], and the variability of costs observed within institutions, our analysis invites the authorities to create guides to good practice for common pathologies such as the treatment of hip arthroplasty. Based on this first experience for the orthopaedic sector, we are convinced of the usefulness of our approach in evaluating the "cost-effectiveness" of other care systems.

Abbreviations

OECD: Organisation for Economic Co-operation and Development

DALY: Disability Adjusted Life Years

PACHA: Projet d’Analyse de Coût par Pathologie

DRG Diagnosis related group

AHRQ: the Agency for Healthcare Research and Quality

PSI: Patient Safety Indicator

YLL: Years of Life Lost

YLD: Years Lost due to Disability

GBD: Global Burden of Disease

LOS: Length pf stay

SD: Standard deviation

INAMI : Institut National d'Assurance Maladie Invalidité

KCE: the Belgian Health Care Knowledge Centre

ICD10-PCS: International Classification of Diseases – 10th revision – Procedure Coding System

PROM: Patient Reported Outcome Measures

Declarations

Ethics approval and consent to participate: Not application

Consent for publication: Not application

Availability of data and material: The datasets generated and/or analysed during the current study are not publicly available due this study because this study is partly based on cost data from a hospital benchmarking pf cost by pathology but are available from the corresponding author on reasonable request and after anonymization.

There is no potential conflict of interest.

Funding: Not application.

Authors contribution:

Background: FD

Methods: FD, MG; BD, BB, PVW, BM, PL, MP

Data: PL, MP

Interpretation of results: FD, MG, BD, BB, MP

Revised discussion: FD, MG, PL, MP

Revised conclusion: FD, MG, MP

All authors have read and approved the manuscript.

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Figures

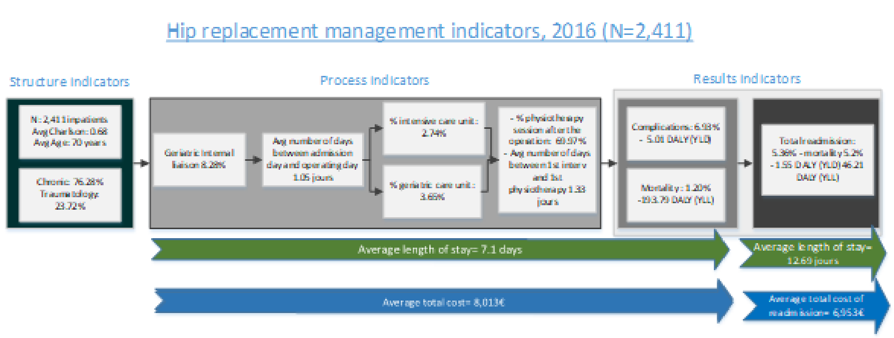

Figure 1

Process view - indicators of hip replacement management, for the 12 Belgian hospitals in the study, N=2,411