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An inter-hospital performance assessment model for evaluating hospitals performing hip arthroplasty

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ABSTRACT

The value of hospital care to patients is expressed as a combination of reduced healthcare costs, fewer medical complications, and improved patient satisfaction. Few studies highlight the value hospitals provide to their patients through hip replacement surgery.

This study aims to define a methodology for inter-hospital comparison purposes that can assess the value of hip replacement management to patients by using indicators of costs, medical complications, and patient outcomes.

We identified medical complications and costs from medico-administrative data collected by three hospitals. We associated a Disability Adjusted Life Years (DALYs) impact with medical complications, readmissions (within 30 days), and hospital mortality. Costs were analysed from a social security perspective. Patient outcomes were collected through a questionnaire-based survey after hip surgery. To compare the three hospitals, we created a composite indicator by standardizing each dependent variable and combining a weighting of importance provided by patients.

This study analysed 342 hospital stays. The mean (standard deviation) number of DALYs per stay was estimated to be more than 0.0028 (0.016) for a mean (standard deviation) cost of €4,834 (€3,665). The composite indicator allowed hospitals to be ranked and areas for improvement to be identified. In our case mix, Hospital 3 is the lowest-ranked hospital, with excessively high costs and a relatively low level of satisfaction compared to the others.

The simultaneous evaluation of medical complications, patient outcomes, and costs is a prerequisite for quality improvement efforts by managers and practitioners. In our opinion, this experiment, which sought to estimate the value hospitals bring to patients, may be viewed as the first step towards value-based purchasing in Belgium.

1. Introduction

The number of hospital admissions for hip replacement grew by more than 91% between 2002 and 2019 in Belgium [1], which makes this treatment one of the most common interventions in hospitals. This growth, which according to trend forecasts does not seem likely to stop soon [2], raises political issues for the control of health care budgets. Indeed, given population ageing, hip replacements will generate an increase in financial expenditure for the social security system of more than €49 million (all other things being equal) by 2025.

In order to limit the increase in costs generated by demographic ageing, health policies are trying to optimize the use of resources while guaranteeing the quality of patient care [3]. This approach reflects a desire to bring value to patients through hospital-based interventions. According to international experience, this notion of hospital value is reflected, amongst other things, in a combination of reduced expenditure, fewer medical complications, and improved patient satisfaction [4].

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The measures implemented to achieve these objectives include the definition of guidelines to reduce the multiplicity of new forms of care and the average length of stays, the evaluation of results through benchmarking (e.g. financial or qualitative), the introduction of financial incentives, etc.

In this respect, we already had the opportunity to study the costs and medical complications generated in hospitals during stays in connection with hip replacements [5]. The study reveals that in 2025, the management of hip surgery in Belgian hospitals (all other things being equal) could result in a little more than 3.270 years of life lost and additional costs of over 23% for certain hospitals. This medical and economic waste is in line with the conclusions of the Organisation for Economic Co-operation and Development (OECD), which estimates that 20% of medical procedures are unnecessary [6]. However, assessments of costs and medical complications are not sufficient to uncover the value provided to patients [7]. The integration of patients' assessments becomes essential for a comprehensive analysis of hip surgery management.

In the context of hip arthroplasty, patient satisfaction goes beyond the evaluation of process indicators, in particular pain, patient mobility after the operation, etc. [8]. However, assessment of this type of common procedure are still too few and far between within hospitals, despite their interest for patients as well as for surgeons and their teams. Studies using Patient reported health status show that the average improvement in the physical function of patients after hip replacement surgery is 32% [9]. This patient-derived assessment is necessary given the discrepancies that may exist between surgeons' and patients' assessments [10,11].

With the exception of a few benchmarking studies that address each of these issues individually, we do not have any tools that allow for the simultaneous and standardised analysis of the three above-mentioned factors [12]. The aim of this study is therefore to define a methodology for inter-hospital comparison that assesses the value to patients of hip replacement management by using cost, medical complications, and patient outcome indicators. In the long term, we believe that our investigation will allow inter-hospital benchmarking to progress whatever the pathology concerned.

In the following sections, we will present the methodological aspects concerning the selection of stays, the identification of dependent variables, and the statistical and mathematical analyses that were carried out to obtain the results.

2. Material and method

2.1. Selection of stays

The study sample is based on data from three Belgian general hospitals, including one university hospital. The hospitals have a capacity of 220–350 inpatient beds for acute care and include indices for surgical, medical, and geriatric beds. They are located in close proximity to each other. The hospitals were anonymised and are only identified by a randomly assigned number. The data were collected from the hospitals' medico-administrative records Fig. 1. In this study, we focused our analyses on patients over 18 years of age who had been hospitalised and

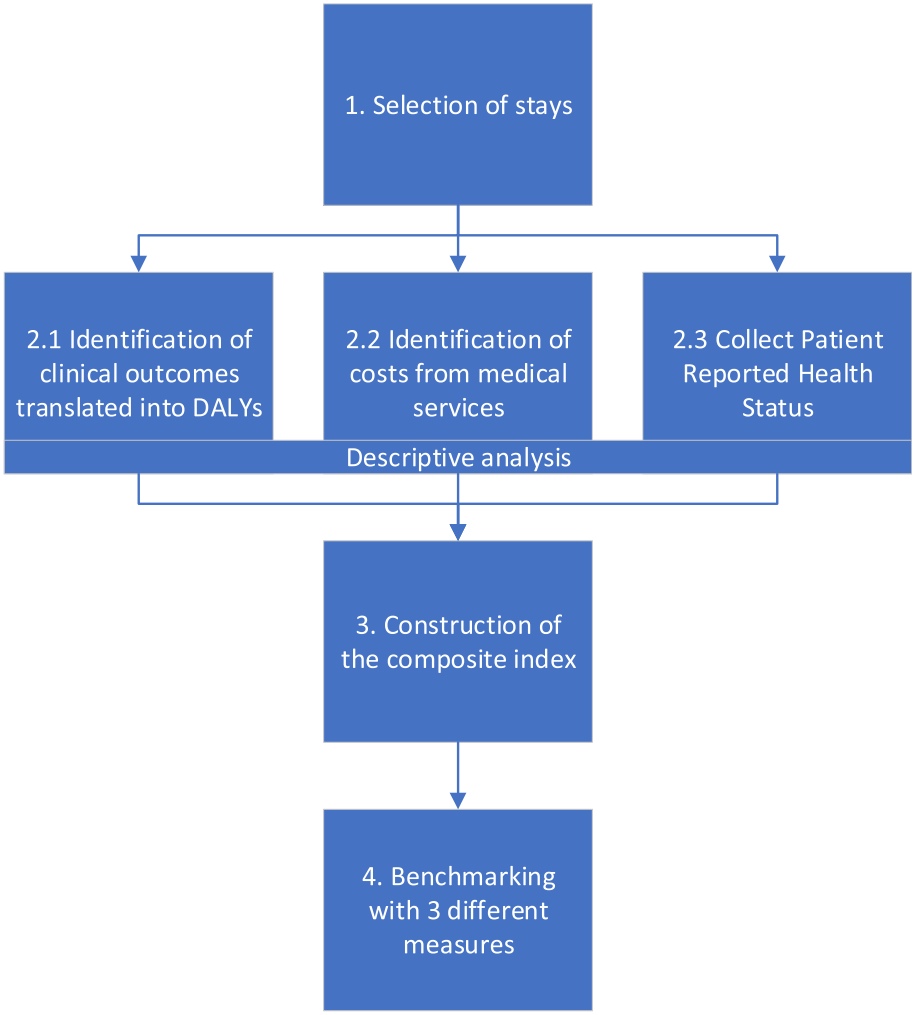


Fig. 1. Methodological workflow for comparing hospital performance indicators.

classified in the 'Diagnosis Related Group (DRG 301) — hip prosthesis' and had spent at least one night at the hospital in 2018. Within the DRG ('Diagnosis Related Group'), we selected inpatients with an admission diagnosis either of chronic origin (such as osteoarthritis) or trauma admissions-related (such as hip fracture). Of these, we identified all patients who were readmitted to the same hospital within 30 days of discharge after the first hospital stay. In our study, 'hospital stay' is therefore defined as the combination of first hospital stay and readmission of the same patient to the same hospital. Our total population is thus estimated to be 342 stays at the three hospitals surveyed.

2.2. The dependent variables

This section specifies the variables that will be used to compare hospitals with each other. We will successively address the clinical outcomes, the costs of medical services, and the patient-reported health status.

2.2.1. Clinical outcomes

In order to develop patient safety indicators, we used the 'Agency for Healthcare Research and Quality' (AHRQ) construction methodology, Version 5.0 (Table 1) [13]. The AHRQ's quality indicators measure the quality of health care on the basis of medico-administrative data. Only secondary diagnosis codes listed as 'not present on admission' were used to identify complications during stays. In this study, we used the following (Patient Safety) indicators:

The indicators are derived from a list of 25 different indicators, and only those that are more frequent and related to orthopedic care were selected for this study. The construction of the 'infection' indicator involved the identification of codes listed in the 'International Statistical Classification of Diseases and Related Health Problems' Version 10 (ICD 10) mentioning the infectious nature.

The Charlson index [14] was applied to the whole population and to the diagnosis codes present at admission in order to express the level of comorbidity of hospitalised patients. Preference was given to using the Charlson index, rather than the relative weight (case mix index), since the Charlson index includes comorbidities present at admission and not complications encountered during the hospital stay.

Readmissions within 30 days were identified in the medico-administrative data. We considered readmission as a source of pain/discomfort for the patient, which explains why we also allocated a DALY for stays for which readmission occurred within 30 days and was related to the initial reason for hospitalisation.

For the translation of medical complications into 'Disability Adjusted Life Years' (DALYs), we used the same methodology as the one used in a previous study [5]. As a reminder, the DALY is a unit of measurement

Table 1
List of Patient Safety Indicators from AHRQ Version 5.0 used in the study. The Observed Rate presented in this table are nationwide comparative rates for the Agency for Healthcare Research and Quality (AHRQ) Quality Indicators™ QIs. The rates are based on analysis of 45 States from the 2012 AHRQ Healthcare Cost and Utilization Project (HCUP) State Inpatient https://qualityindicators.ahrq.gov/Downloads/Modules/PSI/V50/Version_50_Benchmark_Tables_PSI.pdf.

List of Patient Safety Indicators from AHRQ Version 5.0	Indicators selected for our study	Observed Rate per 1,000 (Overall Population)
PSI 02 Death Rate in Low-Mortality Diagnosis Related Groups (DRGs)	x	0.32
PSI 03 Pressure Ulcer Rate	X	0.5
PSI 04 Death Rate among Surgical Inpatients with Serious Treatable Complications	X	118.62
PSI 05 Retained Surgical Item or Unretrieved Device Fragment Count	NA	
PSI 06 Iatrogenic Pneumothorax Rate	X	0.34
PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate	X	0.21
PSI 08 In Hospital Fall with Hip Fracture Rate	NA	0.04
PSI 09 Postoperative Hemorrhage or Hematoma Rate	X	5.11
PSI 10 Postoperative Acute Kidney Injury Requiring Dialysis Rate	X	0.69
PSI 11 Postoperative Respiratory Failure Rate	X	10.05
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	X	4.99
PSI 13 Postoperative Sepsis Rate	X	9.61
PSI 14 Postoperative Wound Dehiscence Rate	NA	1.86
PSI 15 Abdominopelvic Accidental Puncture or Laceration Rate	NA	1.89
PSI 16 Transfusion Reaction Count	NA	
PSI 17 Birth Trauma Rate-Injury to Neonate	NA	
PSI 18 Obstetric Trauma Rate-Vaginal Delivery With Instrument	NA	133.19
PSI 19 Obstetric Trauma Rate-Vaginal Delivery Without Instrument	NA	20.97
PSI 21 Retained Surgical Item or Unretrieved Device Fragment Rate	NA	
PSI 22 Iatrogenic Pneumothorax Rate	NA	
PSI 23 Central Venous Catheter-Related Blood Stream Infection Rate	NA	
PSI 24 Postoperative Wound Dehiscence Rate	NA	
PSI 25 Accidental Puncture or Laceration Rate	NA	
PSI 26 Transfusion Reaction Rate	NA	
PSI 27 Perioperative Hemorrhage or Hematoma Rate	NA	
PSI 90 Patient Safety and Adverse Events Composite	NA	
NA: not available or inappropriate		

commonly used in health economics to reflect the effectiveness of a treatment or intervention. DALYs are calculated by adding up the number of years of life lost due to premature death or disability for each hospital stay.

The DALYs allow us to weight the complications encountered during stays, with it being understood that they do not all have the same impact on the patient. The use of DALYs in favour of quality-adjusted life years is justified because of the unfavourable impact of medical complications. For this reason, hospital mortality as a function of age is the most important indicator, particularly due to the early loss of a patient.

2.2.2. The costs of medical services

In this study, 'costs' only take into account the services provided and pharmaceutical resources used during hospital stays. In order to make a fair comparison of the costs of these stays, we isolated and subtracted the rehabilitation services from the total services of the stay, as well as deducted the 'day' packages from the financial means budget [15]. The analysis of the financial data presented in this article was conducted from the point of view of social security through billing. Fee supplements were not included in the calculation of the costs of services.

Total cost of inpatient = (cost of medical care for the first admission − cost of rehabilitation service) + cost of medical care after readmission

2.2.3. Patient reported health status

The questionnaire construction used for our study is based on the studies of Mahomed et al. [10] and Vikki et al. [8]. These two articles are based on hip arthroplasty, and the questions related to outcomes were retained for this study. We then introduced an additional question concerning patients' expectations [11,16] in accordance with the literature and the comments of orthopaedic surgeons at the three hospitals. In the end, the questionnaire consisted of eight questions, including three related to the management process at the hospital, two related to the results of the surgical procedure (including three sub-questions), one regarding patients' expectations of the procedure, and one assessing patients' referrals to the hospital.

A final question was introduced in the questionnaire to find out how important each of the three dependent variables (costs, medical complications, and patient outcomes) would be for patients if hospitals were evaluated according to these.

Patients were asked to indicate their level of satisfaction according to a numerical scale from 0 (not at all satisfied) to 10 (fully satisfied) to allow for a high degree of precision.

To maintain a focus on outcome evaluation, only Question 5 was used for the analysis of descriptive variables and for inter-hospital comparisons (Table 2).

A pre-test was conducted on about ten patients to assess the understanding, readability, and completion time of the questionnaire. At the end of this phase, several adjustments were suggested to enhance the quality of the questionnaire.

The questionnaire, which complies with the 'General Data Protection Regulation' (GDPR), was pre-tested in February 2021 with patients who had hip replacement surgery in 2017. The survey took place between March 1, 2021 and May 31, 2021. All patients operated on in 2018 and who had not died by February 2021 were sent a letter informing them of the survey and asking for their consent to participate. Only those patients who agreed to participate received a paper form or an email — according to their stated preferences.

The 104 patients who participated in the study gave their informed consent. All data were collected by an independent evaluator not involved in patient medical care. The study protocol was approved by the ethics committee of the three hospitals involved (B03920202929).

Table 2
The questionnaire of Patient Reported Health Status. is based on the studies of Mahomed et al. [10] and Vikki et al. [8]. The questionnaire is built around six key stages of the patient care process. The final question will help to understand the importance the patient places on costs, medical complications, and patient-reported outcomes.

Stages	Questions (between 1 and 10)
1. Before surgery	1. How satisfied were you with the clarity of the information given to you before your operation, about the nature of the surgery, its benefits (consequences) and associated risks?
2.Surgery	2. How satisfied were you with the availability of the nursing staff to take care of your pain, mobility, etc. during your stay?
	3. How satisfied were you with the follow-up offered by your surgeon (revalidation, consultation, etc.) after your hospitalisation?
3.After surgery	4. Now, overall, how satisfied are you with the results of your operation?
4.Results	5. How satisfied are you with the results of the intervention to improve?
	- the relief of your daily pain
	- your ability to do domestic work (at home, in the garden, etc.)
	- your ability to engage in leisure activities (sports, etc.)
	6. To what extent do the results of the operation correspond to the expectations you had before the surgery?
5.Referencing	7. If necessary for one of your relatives, would you recommend that he/she have his/her hip prosthesis paid for by our institution?
6.Importance of variables	8. If hospitals were to be evaluated on the management of hip replacements, how important would you personally consider these 3 criteria?
	- The absence of medical complications
	- The importance of costs
	- Patient satisfaction with the outcome of their care.

2.3. Statistical analysis and mathematical modelling

This chapter aims to present the descriptive statistical analyses applied to the entire dataset and introduces the mathematical modeling conducted to standardize inter-hospital comparisons accounting data that do not share the same unit of measurement.

2.3.1. Descriptive analyses

Statistical analyses were performed using 'SPSS' (Version 27) and R software. We used 'mean/standard deviation' descriptive statistics to provide a univariate description of all variables in our study. In spite of the asymmetry of the quantitative variables, we did not use 'median-confidence intervals' because of the impossibility of interpreting small values such as DALYs. Kruskal-Wallis and Mann-Whitney tests were used to verify significant differences dependent variables (costs, DALYs, and Patient reported health status) in relation to the ordinal and dichotomous independent variables.

The independent variables in this analysis are: medical-economic severity, age, route of admission, diagnosis of admission, sex, place of admission before hospitalisation, nature of admission, discharge destination, transfer to a geriatric ward, transfer to an intensive care unit, Charlson index, number of days from admission to surgery, number of days from first physical therapy to surgery, medical complications, readmissions, deaths during stay, and out-of-hospital deaths.

The main results of the comparison between hospitals are structured according to the Donabedian model [17]. This model is the reference model for healthcare facilities. It accurately classifies indicators to suggest a better interpretation. The indicators were constructed, on the one hand, according to the literature review and, on the other hand, according to the information available in our database [18–21].

Finally, and being aware that large differences will exist between the care pathways of one and the same DRG, we suggested two specific indices per hospital site: one for the trauma care pathway and one for the chronic care pathway.

2.3.2. Construction of the composite index

In order to perform an inter-hospital comparison, we based a composite indicator on the three dependent variables of our study: costs, medical complications, and patient outcomes. The R software was used to perform this modelling.

The treatment of missing data was carried out in such a way as to be able to use all available data. In order to fill in the missing information and to use all the data concerning the stays in our sample, we used the average of the variable per hospital. This mainly concerns the 'patient outcomes' variable.

All dependent variables used were scaled by dividing each value of the variable by the maximum value of the variable. All values considered hereafter are therefore between 0 and 1.

The index for stay k was constructed as a weighted average of these variables. Each variable x was used directly if an increase of the variable is favourable to the value of the index, or indirectly (1-x) if the decrease is favourable:

$$I_k = w_{k,T}.(1 - x_{k,T}) + w_{k,D}.(1 - x_{k,D}) + w_{k,S}.x_{k,S} \quad (1)$$

where.

- the cost is $x_{k,T}$.
- clinical complications (DALYs) are $x_{k,D}$.
- patient outcomes are $x_{k,S}$.

The rescaled values were then weighted according to the importance that patients gave to each of the variables on average. As a reminder, this notion of weighting was collected from patients when submitting the questionnaire. The weights w_T, w_D and w_S, are calculated as follows:

$$\overline{w_{k,i}} = \frac{\overline{y_{k,i}}}{\overline{y_{k,T}} + \overline{y_{k,D}} + \overline{y_{k,S}}} \quad (2)$$

where:

- i takes its values in $\{T, D, S\}$
- y_T denotes the importance of costs
- y_D denotes the absence of medical complications
- y_S denotes the importance of patient outcomes.

The average of these indices per hospital is then calculated according to the case mix index of the hospitals using the Charlson index of each stay. The use of the latter to standardize our inter-hospital comparison is preferred to relative weight for the reasons given in section 2.2.1.

$$\bar{I}_e = \frac{1}{\sum_{k\in E} z_{k,C}} \cdot \sum_{k\in E} z_{k,C} \cdot I_k = \sum_{k\in E} \frac{z_{k,C}}{\sum_{k\in E} z_{k,C}} \cdot I_k = \sum_{k\in E} w_{k,C} \cdot I_k \quad (3)$$

where.

- E means all patients in the institution concerned,
- I_k means the patient index k,
- $z_{k,C}$ means the Charlson patient category k,
- $w_{k,C} = \frac{z_{k,C}}{\sum_{k\in E} z_{k,C}}$.

Here is the final formula of the mathematical modelling that was performed to calculate this composite indicator when using formula (1) in the expression (3):

$$\bar{I}_e = \sum_{k\in E} w_{k,C}.\left[w_{k,T}.(1 - x_{k,T}) + w_{k,D}.(1 - x_{k,D}) + w_{k,S}.x_{k,S}\right] \quad (4)$$

3. Results

3.1. Description

There are 342 stays in total, with an average patient age (standard deviation) of 68.9 years (12.6 years), and more than 52% of the population is female (Appendix 1). The rate of complications during the hospital stay is estimated to be 11.4% while the rate of mortality during the stay is 0% (Appendix 1). More than 94% of the stays are of medico-economic severity 1 and 2 (Fig. 2).

As shown in Appendix 1, more than 75% of patients are admitted for chronic reasons (osteoarthritis, etc.). 78.7% of patients are operated on through the anterior approach and 19.3% through the lateral approach. The average length of stay (LOS) (SD) is 6.9 days (6.9 days). This LOS (SD) varies from 4.9 days (2.9 days) to 12.7 days (10.7 days) depending on whether the admission diagnosis is chronic or trauma-related. Over half (54%) of patients undergo surgery on their day of admission to hospital. While we do not record any in-hospital deaths during hospitalisation, there are two out-of-hospital deaths within 30 days of the operation. The indicators PSI 09, post-operative bleeding/haematoma and infection, have the highest incidence with 7.9% and 2.6%, respectively (Table 3). According to the Charlson index for an average index (SD) of 1.09 (1.57) for the whole population, 50.6% of the stays have no comorbidity; 7.6% of stays are readmitted to the same institution within 30 days. The main reasons for readmission are: haemorrhage/haematoma, infection, and mechanical problems regarding the operated hip (Fig. 2). As regards place of stay, 3.2% of stays are in an intensive care unit and 2.6% in a geriatric unit.

3.1.1. Evaluation of the costs of stays

The average cost (SD) of a stay is €4,834 (€3,665) (Appendix 1).

It seems to vary according to the admission diagnosis, going from €4,792 (€4,126) in the chronic category to €4,964 (€1,623) in the trauma category ($p = 0.224$). This cost (SD) also varies with the Charlson index, from €4,505 (€693) for patients in the category 0 to €6,672 (€10,032) for patients with an index greater than 4 ($p = 0.052$). Stays followed by a readmission related to the first stay have a mean (SD) cost of €5,678 (€1,439) ($p < 0.0001$). The mean (SD) cost of readmission is estimated to be €1,211 (€1,336) (Table 3).

The mean (SD) cost of a stay for patients who do not pass through intensive care units is €4,790 (€3,702) while the mean (SD) cost for patients who do pass through intensive care units is €6,165 (€1,947) ($p < 0.0001$). Similarly, the mean (SD) cost of a stay for patients who do not pass through a geriatric unit is €4,770 (€3,674) while the mean (SD) cost for patients who do pass through a geriatric unit is €7,202 (€2,484) ($p < 0.0001$) (Appendix 1).

Patients who experience a complication during their stay cost (SD) €5,188 (€1,571), while the other patients cost (SD) €4,789 (€3,853) ($p =$

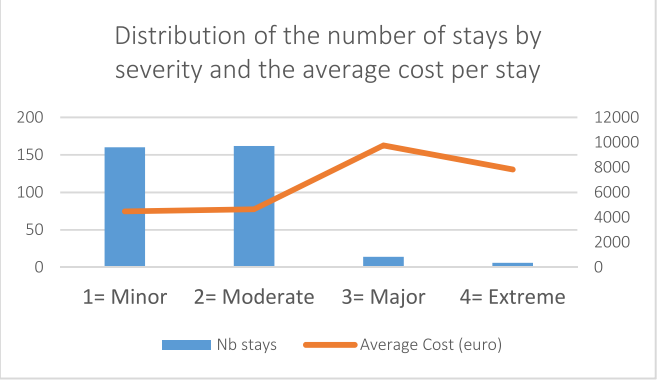


Fig. 2. Distribution of the number of stays by severity category and the average cost per stay.

Table 3
Descriptive data of costs, DALYs, and Patient reported health status for all patients in the study (DRG 301, 2018). The Kruskall-Wallis (**) and Mann-Whitney (*) statistical models were used to test the significance of the data.

Descriptive variables	Cost (euros)						DALYs				Patient Reported Health Status					
	N= 342	%	Avg	SD	Med	Sign	Avg	SD	Med	Sign	N=104	%	Avg	SD	Med	Sign
Infection (n= 342)						0,02 *				<0.0001 *						0.082 *
No	333	97.4%	4,798	3,690	4,418		0.0028	0.0171	0		101	98.5%	8.2	2.2	9.0	
Yes	9	2.6%	6,191	2,348	6,019		0.0061	0.0033	0,005		3	1.5%	4.3	4.5	4.0	
PSI 03 Pressure Ulcer Rate (n= 342)						0.181 *				0.006 *						
No	341	99.7%	4,832	3,671	4,421		0.0020	0.0069	0		104	1	8.1	2.3	9.0	
Yes	1	0.3%	5,651				0.288	0.288	0							
PSI 09 Perioperative Haemorrhage or Haematoma Rate (n= 342)						0.494 *				<0.0001 *						0.329 *
No	315	92.1%	4,834	3,809	4,425		0.0022	0.0174	0		95	92.1%	8.2	2.3	9.0	
Yes	27	7.9%	4,834	1,126	4,418		0.0107	0.0022	0.01		9	7.9%	7.4	2.8	8.0	
PSI 10 Postoperative Physiological and Metabolic Derangement Rate (n= 342)						0.971 *										
No	340	99.4%	4,834	3,676	4,423		0.0028	0.0169	0		104	1	8.1	2.3	9.0	
Yes	2	0.6%	4,909	1,571	4,909		0.0125	0.0035	0.0125							
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate (n= 342)						0.094 *				0.012 *						
No	341	99.7%	4,830	3,700	4,421		0.0025	0.0160	0		104	1	8.1	2.3	9.0	
Yes	1	0.3%	6,659		6,659		0.1042	0.1042								
Complication (n= 342)						0.045 *				<0.0001 *						0.071 *
No	303	88.6%	4,789	3,853	4,402		0.0007	0.0031	0		92	90.5%	8.3	2.1	9.0	
Yes	39	11.4%	5,189	1,571	4,548		0.0191	0.0468	0.01		12	9.5%	6.7	3.4	8.0	
Readmission < 30 days (n= 342)						<0.000 *				<0.0001 *						0.046 *
No	316	92.4%	4,766	3,784	4,375		0.0018	0.0164	0		96	93.7%	8.2	2.3	9.0	
Yes	26	7.6%	5,678	1,440	5,189		0.0151	0.0188	0.0108		8	6.3%	6.6	2.4	6.0	
Mortality rate (n= 342)																
0	342	100%	4,835	3,666	4,423											
Mortality rate < 30 days (n= 342)						0.926 *				0.512 *						
No	340	99.4%	4,837	3,676	4,423		0.0029	0.0169	0							
Yes	2	0.6%	4,536	955	4,536		0	0	0							
PROMS responses (n= 342)						0.57 *				0.97 *						
No	237	69.3%	5,001	4,372	4,466		0.0033	0.0201	0							
Yes	105	30.7%	4,461	695	4,377		0.0018	0.0041	0							

0.006) (Table 3 – Fig. 3).

3.1.2. *Evaluation of medical outcomes — DALYs*

We record a total of 0.987 DALYs (Years of Life Lost + Years Life Disability) in relation to these stays in the three study hospitals (Table 3). The mean (SD) number of DALYs per stay is estimated to be more than 0.0028 (0.017 DALYs). The mean number (SD) of DALYs ranges from 0.0017 (0.008 DALYs) with a Charlson index of 0–0.0099 (0.043 DALYs) when the Charlson index exceeds 4 ($p = 0.005$) (Fig. 4).

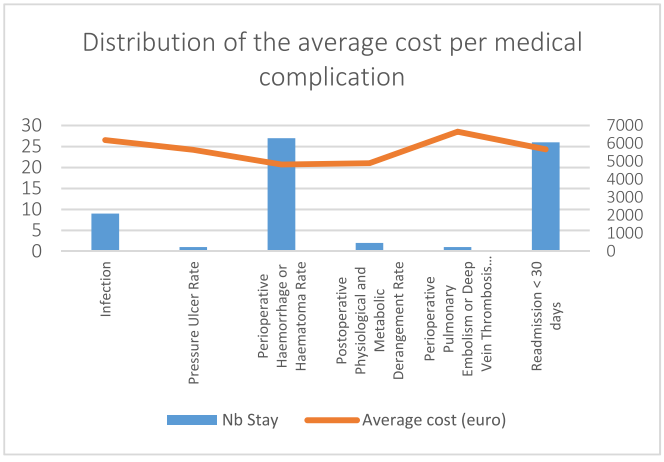


Fig. 3. Distribution of the average cost by medical complication. When a stay involves a complication, the average cost of the stay (€4,834) is greatly exceeded the following complications: Infection, Pressure Ulcer, Perioperative Pulmonary Embolism or Deep Vein Thrombosis and Readmission.

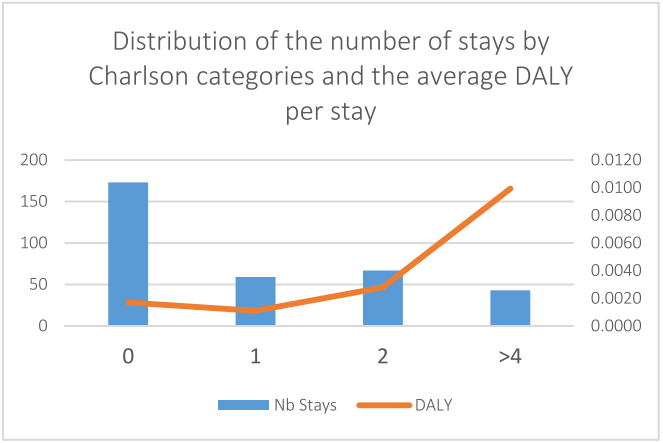


Fig. 4. Distribution of the number of stays by Charlson categories and the average DALY per stay. As a reminder, the DALY is a unit of measurement commonly used in health economics to reflect the effectiveness of a treatment or intervention. DALYs are calculated by adding up the number of years of life lost due to premature death or disability for each hospital stay.

Given that no deaths are recorded, no DALYs are assigned for this aspect. The impact of clinical complications is estimated to reach an average (SD) 0.0192 DALYs (0.046) per stay while readmissions represent on average (SD) 0.0152 DALYs (0.018) ($p < 0.0001$) (Table 3).

The average length of stay increases from 6.53 days (6.7 days) in the absence of DALYs to 8.52 days (7.5 days) in the presence of DALYs ($P < 0.001$).

3.1.3. Evaluation of patient outcomes

Of the 342 patients who underwent hip replacement surgery, 104 patients filled in the questionnaire, of which 25 by e-mail and 79 by paper form. This means that 34% of those able to respond actually did. Overall average satisfaction (SD) is 8.6 (1.5) for the e-mail form and 7.97 (2.5) for the paper form. Overall mean (SD) satisfaction for patients who responded is 8.1 (2.3) (Table 4). Of the 342 patients who underwent hip replacement surgery in 2018, 42 (12.28%) died between the year of surgery and the survey year (2021). The average number of days (SD) between the date of surgery and the date of death was 514 days (289 days), or 1.4 years; 62% of patients who died after surgery had been admitted for trauma reasons.

More than 90% of the patients who responded to the survey came to the hospital for a chronic reason. The mean satisfaction (SD) appears to differ between these two groups, ranging from 8.3 (2.3) for chronic patients to 6.8 (1.9) for trauma patients ($p = 0.005$) (Appendix 1).

More than 52% of the patients who responded to the survey were male (NS). The mean (SD) patient satisfaction increases if patients underwent surgery on the day of admission from 8.6 (1.9) to 7.2 (2.8) after one day ($p = 0.035$) (Appendix 1).

Recorded readmissions have an impact on mean satisfaction (SD): it decreases from 8.2 (2.3) for non-readmitted patients to 6.6 (2.4) for readmitted patients ($p = 0.046$). Regarding clinical complications, the analysed data do not suggest any significant difference in mean satisfaction (SD) for patients without complications, reaching 8.3 (2.1), and patients with complications, at 6.7 (3.4) ($p = 0.071$). This effect is probably related to the size of the survey population.

Table 4 shows that, according to patients, satisfaction with their ability to perform leisure activities reaches 6.82 (2.74) on average (SD), while satisfaction with the match between expectations and results of the intervention reaches 7.99 (2.40) on average (SD).

Finally, the last question, which deals with the importance that patients assign to each dependent variable in the evaluation of hospitals, shows a mean (SD) of 8.78 (1.98) for patient satisfaction with the results of their care, 8.45 (2.17) for the absence of medical complications, and 7.60 (2.43) for the importance of costs (Table 4).

3.2. Benchmarking

3.2.1. Structure and process indicators

Hospital 2 has the highest number of admissions for trauma (48%) (Table 5). The surgical approach seems to differ according to the hospital site: Table 5 displays a greater use of the lateral approach in Hospital 3. The average Charlson index (SD) appears to be higher in Hospital 1, with 1.29 (1.64), against 0.76 (1.32) in Hospital 2 and 0.97 (1.57) in Hospital 3.

The average length of stay (LOS) (SD) varies from 5.1 days (5.3 days) for Hospital 1–9.6 days (5.5 days) for Hospital 2. In particular, geriatric management at both hospitals is similar: 2% for Hospital 1 and 3% for Hospitals 2 and 3 (Table 5). Our inter-hospital comparison also shows some variability in the use of geriatric inpatient liaison, ranging from 4% for Hospital 1–27% for Hospital 2. Furthermore, the level of use of the intensive care unit is also highly variable: only 1% of stays in Hospital 1 against 21% of stays in Hospital 3 (Table 5).

The average waiting time is less than 48 h for chronic admissions in all three hospitals. When the reason for admission is trauma, Hospital 1 records an average (SD) of 3.65 days (5.26 days) before operating on the patient.

3.2.2. Outcome indicators: costs, DALYs, and patient outcomes

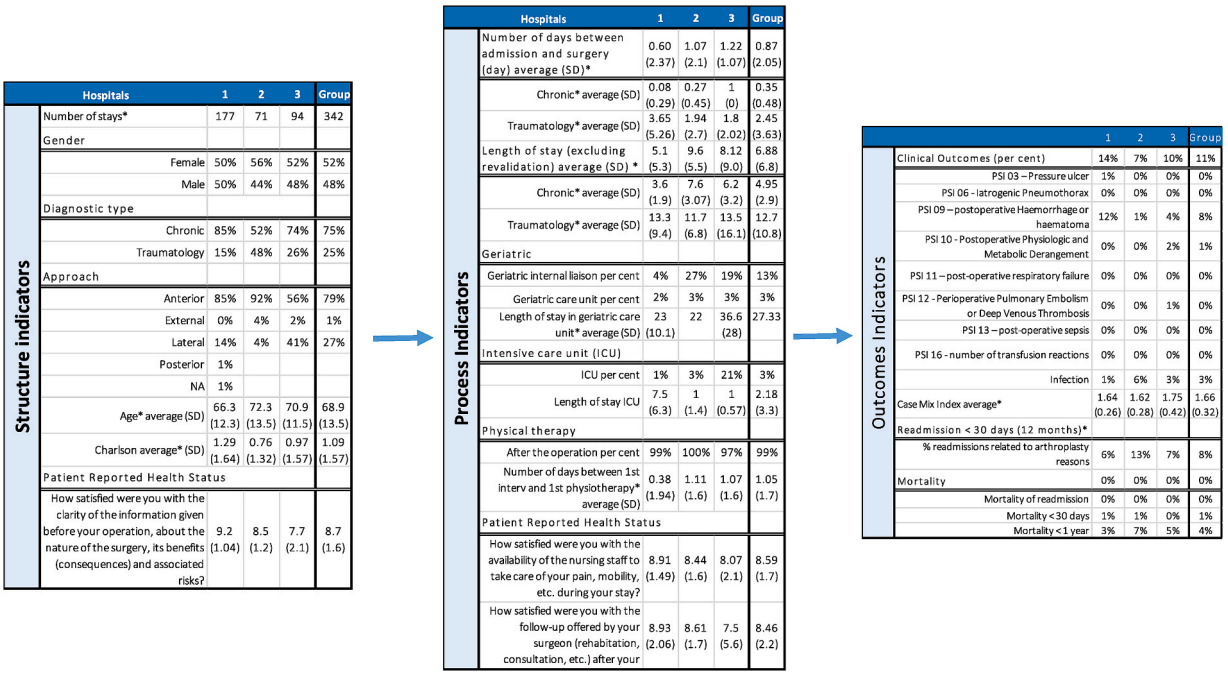
In terms of outcomes, Table 5 shows that Hospital 1 has the highest number of complications, 14%, of which 12% are of the 'Patient Safety Indicator' (PSI) 09 postoperative haemorraghe haematoma rate. This is followed by Hospital 3, with 10%, and Hospital 2, with 6% of complications arising from infections.

Table 6 also shows that the readmission rate appears to be highest in Hospital 2 (13%) and lowest in Hospital 1 (6%). Finally, the one-year mortality rate is estimated to be 7% in Hospital 2, 5% in Hospital 3 and 3% in Hospital 1. All of these complications, apart from mortality within 30 days and within one year (because death occurred outside the hospital), result in a higher mean (SD) DALYs for Hospital 1 of 0.0035 (0.021) and a lower mean (SD) DALYs for Hospital 2 of 0.0018 (0.0042). The average cost (SD) of managing these patients is higher in Hospital 3,

Table 4
Descriptive data of patient outcomes in the study, with a scale ranging from 0 (not at all satisfied) to 10 (totally satisfied).

Stages	Questions (between 1 and 10)	N	Avg	SD	Med
1. Before surgery	1. How satisfied were you with the clarity of the information given to you before your operation, about the nature of the surgery, its benefits (consequences) and associated risks?	104	8.7	1.6	9.0
2. Surgery	2. How satisfied were you with the availability of the nursing staff to take care of your pain, mobility, etc. during your stay?	104	8.6	1.7	9.0
	3. How satisfied were you with the follow-up offered by your surgeon (revalidation, consultation, etc.) after your hospitalisation?	104	8.5	2.2	9.0
3. After surgery	4. Now, overall, how satisfied are you with the results of your operation?	104	8.1	2.3	9.0
4. Results	5. How satisfied are you with the results of the intervention to improve?	103			
	- the relief of your daily pain		8.0	2.5	9.0
	- your ability to do domestic work (at home, in the garden, etc.)		7.5	2.5	8.
	- your ability to engage in leisure activities (sports, etc.)		6.8	2.7	7.
	6. To what extent do the results of the operation correspond to the expectations you had before the surgery?	104	8.0	2.4	9.
5. Referencing	7. If necessary for one of your relatives, would you recommend that he/she have his/her hip prosthesis paid for by our institution?	104	8.5	2.3	9.0
6. Importance of variables	8. If hospitals were to be evaluated on the management of hip replacements, how important would you personally consider these 3 criteria?	99			
	- The absence of medical complications		8.5	2.2	9.0
	- The importance of costs		7.6	2.4	8.0
	- Patient satisfaction with the outcome of their care.		8.8	2.0	10.0

Table 5
Inter-hospital comparison of Donabedian indicators for the management of hip replacement surgery in Belgium. The Kruskall-Wallis (**) and Mann-Whitney (*) statistical models were used to test the significance of the data. This representation allows structuring the indicators and facilitating their reading.



Structure indicators	Hospitals	1	2	3	Group
	Number of stays*	177	71	94	342
	Gender				
	Female	50%	56%	52%	52%
	Male	50%	44%	48%	48%
	Diagnostic type				
	Chronic	85%	52%	74%	75%
	Traumatology	15%	48%	26%	25%
	Approach				
	Anterior	85%	92%	56%	79%
	External	0%	4%	2%	1%
	Lateral	14%	4%	41%	27%
	Posterior	1%			
	NA	1%			
	Age* average (SD)	66.3 (12.3)	72.3 (13.5)	70.9 (11.5)	68.9 (13.5)
	Charlson average* (SD)	1.29 (1.64)	0.76 (1.32)	0.97 (1.57)	1.09 (1.57)
	Patient Reported Health Status				
	How satisfied were you with the clarity of the information given before your operation, about the nature of the surgery, its benefits (consequences) and associated risks?	9.2 (1.04)	8.5 (1.2)	7.7 (2.1)	8.7 (1.6)

Process Indicators	Hospitals	1	2	3	Group
	Number of days between admission and surgery (day) average (SD)*	0.60 (2.37)	1.07 (2.1)	1.22 (1.07)	0.87 (2.05)
	Chronic* average (SD)	0.08 (0.29)	0.27 (0.45)	1 (0)	0.35 (0.48)
	Traumatology* average (SD)	3.65 (5.26)	1.94 (2.7)	1.8 (2.02)	2.45 (3.63)
	Length of stay (excluding revalidation) average (SD) *	5.1 (5.3)	9.6 (5.5)	8.12 (9.0)	6.88 (6.8)
	Chronic* average (SD)	3.6 (1.9)	7.6 (3.07)	6.2 (3.2)	4.95 (2.9)
	Traumatology* average (SD)	13.3 (9.4)	11.7 (6.8)	13.5 (16.1)	12.7 (10.8)
	Geriatric				
	Geriatric internal liaison per cent	4%	27%	19%	13%
	Geriatric care unit per cent	2%	3%	3%	3%
	Length of stay in geriatric care unit* average (SD)	23 (10.1)	22	36.6 (28)	27.33
	Intensive care unit (ICU)				
	ICU per cent	1%	3%	21%	3%
	Length of stay ICU	7.5 (6.3)	1 (1.4)	1 (0.57)	2.18 (3.3)
	Physical therapy				
	After the operation per cent	99%	100%	97%	99%
	Number of days between 1st interv and 1st physiotherapy* average (SD)	0.38 (1.94)	1.11 (1.6)	1.07 (1.6)	1.05 (1.7)
	Patient Reported Health Status				
	How satisfied were you with the availability of the nursing staff to take care of your pain, mobility, etc. during your stay?	8.91 (1.49)	8.44 (1.6)	8.07 (2.1)	8.59 (1.7)
	How satisfied were you with the follow-up offered by your surgeon (rehabilitation, consultation, etc.) after your	8.93 (2.06)	8.61 (1.7)	7.5 (5.6)	8.46 (2.2)

Outcomes Indicators		1	2	3	Group
	Clinical Outcomes (per cent)	14%	7%	10%	11%
	PSI 03 – Pressure ulcer	1%	0%	0%	0%
	PSI 06 - Iatrogenic Pneumothorax	0%	0%	0%	0%
	PSI 09 – postoperative Haemorrhage or haematoma	12%	1%	4%	8%
	PSI 10 - Postoperative Physiologic and Metabolic Derangement	0%	0%	2%	1%
	PSI 11 – post-operative respiratory failure	0%	0%	0%	0%
	PSI 12 - Perioperative Pulmonary Embolism or Deep Venous Thrombosis	0%	0%	1%	0%
	PSI 13 – post-operative sepsis	0%	0%	0%	0%
	PSI 16 - number of transfusion reactions	0%	0%	0%	0%
	Infection	1%	6%	3%	3%
	Case Mix Index average*	1.64 (0.26)	1.62 (0.28)	1.75 (0.42)	1.66 (0.32)
	Readmission < 30 days (12 months)*				
	% readmissions related to arthroplasty reasons	6%	13%	7%	8%
	Mortality	0%	0%	0%	0%
	Mortality of readmission	0%	0%	0%	0%
	Mortality <30 days	1%	1%	0%	1%
	Mortality <1 year	3%	7%	5%	4%

Table 6
The questionnaire of Patient Reported Health Status is built around six key stages of the patient care process. The final question will help to understand the importance the patient places on costs, medical complications, and patient-reported outcomes.

DALYs - COST - PROMs	Hospitals	1	2	3	Group
	Patient Reported Health Status	32%	25%	32%	30%
	N= 104	57	18	29	
	Now, overall, how satisfied are you with the results of your operation? *	8.65 (1.9)	8.39 (1.9)	6.90 (2.8)	8.12 (2.3)
	o the relief of your daily pain	8.61 (1.9)	7.94 (2.1)	6.87 (3.1)	8 (2.5)
	o your ability to carry out domestic work (at home, in the garden, etc.)	8.29 (2.2)	6.94 (1.9)	6.57 (2.6)	7.55 (2.4)
	o your ability to engage in leisure activities (sports, etc.)	7.55 (2.7)	5.94 (2.1)	6 (2.6)	6.82 (2.7)
	DALYS				
	DALY (YLL+YLD) Total	0.627	0.127	0.23	0.987
	DALY (YLL+YLD) Average (SD)	0.0035	0.0018	0.0024	0.0028
		(0.021)	(0.0042)	(0.0112)	(0.0169)
	Cost				
	Total average cost excluding rehabilitation* (SD)	€4,556 (€888)	€4,415 (€781)	€5,340 (€6,796)	€5,119 (€3,721)
	Total average cost including cost of readmission (excluding rehabilitation)* (SD)	€4,631 (€971)	€4,519 (€979)	€5,455 (€6,798)	€5,239 (€3,763)

with €6,023 (€6,893), and lower on average (SD) for Hospital 1 with €4,912 (€1,120) ($p < 0.001$). These estimates display a 22% difference between the costs incurred by Hospital 1 and Hospital 3 (Table 6).

With regard to patient satisfaction with their care, we observe a slight variability, since on average (SD) Hospital 1 has a satisfaction score of 8.65 (1.9) and Hospital 3 of 6.9 (2.8) ($p < 0.001$).

It can be seen that the hospitals with the most DALYs are not those that have the highest total costs. This comment is also valid for patient assessments, since the hospital with the highest average number of DALYs (Hospital 1) has the highest level of patient satisfaction.

3.2.3. *Composite indicator*

Table 7 shows the results of our modelling, the aim of which was to create a composite indicator to compare hospitals on the basis of three variables dependent on different units of measurement. The indicator

Table 7
Composite indicator by care pathway according to the Charlson indicator. The hospital is placed on a scale from 0 to 1 according to the care pathway assessed (chronic or trauma). The level of the score indicates how well the hospital is managing the stays.

Diagnostic/hospital	1	2	3
Chronic	0.736	0.719	0.642
Cost	0.154	0.166	0.126
Clinical Outcomes	0.261	0.275	0.270
Patient reported health status	0.308	0.287	0.251
Traumatology	0.664	0.734	0.661
Cost	0.102	0.186	0.138
Clinical Outcomes	0.255	0.271	0.277
Patient reported health status	0.307	0.277	0.245
General	**0.7248**	**0.7275**	**0.6483**

ranges from 0 to 1. The higher the indicator, the more favourable the score is for the hospital. The table also provides some detailed information to enable the hospital concerned to implement operational and sector-specific actions.

As regards chronic care, Hospital 1 has the best index (with a value of 0.736), followed by Hospital 2 (0.719) and Hospital 3 (0.642). The satisfaction level and cost are the two variables that allow Hospital 1 to have the best index (Table 7).

The trend changes somewhat as regards trauma care, since Hospital 2 has the best index (with a value of 0.734), followed by Hospital 1 (0.664) and Hospital 3 (0.661).

Fig. 5 illustrates the above-mentioned findings regarding the positioning of hospitals on the basis of the three dependent variables.

4. Discussion

The objective of this study was to define a methodology for inter-hospital comparison that would deal with indicators of costs, medical complications, and patient outcomes. We wished to test this approach on hip replacement surgery — given the extent of the stays and costs that this procedure gives rise to in the Belgian national budget [22]. It thus seemed essential to us to suggest a threefold methodology for comparing hospitals in conjunction with the growth in the number of stays for hip replacements and the introduction of new financing methods.

Our descriptive analysis was based on international references [18–21] owing to the absence of a good practice guide in Belgium [23,24]. Our study points to a lower average length of hospital stay (6.9 days) than the Belgian technical report (10.7 days) [22]; this is due to the selection of our survey population. The cost data analysed from a social security perspective are in the range reported in the Belgian technical report (4,453€) [25]. The small difference between our study, national feedback, and the literature can probably be explained by the composition of our sample (case mix, readmission, etc.) and management after hospitalisation [26]. Nevertheless, the multiplicity of practices has already been greatly reduced in Belgium thanks to the successive introduction of measures for this type of pathology.

Today, hospitals require evaluation criteria other than costs [27]. Indeed, quality indicators are not yet appreciated in the same way as costs in this new financing method. One Pay for Performance programme was introduced in Belgium in 2018; and it only concerned antibiotic prophylaxis for hip replacements and the hospital mortality rate. Moreover, this programme values quality through a financial incentive without assessing the incentive's financial efficiency [28]. Policymakers should reward the appropriateness of care according to clear objectives rather than in relation to the quantity of treatment provided [29]. In this respect, the haemorrhage/haematoma indicator in our study is frequently found within our hospitals, which is potentially explained by the systematic presence of information regarding post-operative haematoma in the surgeon's operating protocol. Belgian funding rules may in fact encourage some hospitals to over or under-code medical information concerning the stay [30]. Steps must therefore be taken to improve the sensitivity and specificity of this indicator.

On the other hand, findings on infection and readmission rates — and the reasons for these — in our study are similar to those in other studies that we analysed [31,32].

The weighting of clinical complications during the stay through the use of DALYs has made it possible to compare the impacts of these complications, given that they do not all have the same impact on patients. The replacement of DALYs with Quality Adjusted Life Years (QALYs) would be justified by the negative factor that medical complications constitute both for patients and society [33,34]. In this study, we did not record any deaths during hospital stays, which explains a major difference between DALYs impacts uncovered in our study and in other research.

Furthermore, the evaluation of the performance of a treatment should not be limited to costs or medical complications. This is why this study also identified patient outcomes, as suggested by Gjertsen et al. [35]. Our findings are similar to those of the literature regarding pain apprehension and overall satisfaction with a surgical procedure [8,36]. However, they point to large differences between hospitals. For instance, pain management is evaluated at 6.87 for Hospital 3, whereas Hospital 1 has an average estimate of 8.61. This demonstrates the interest of integrating the 'patient outcomes' variable into the evaluation of patient management. As regards chronic care, Hospital 1 has the best index (with a value of 0.736), followed by Hospital 2 (0.719) and Hospital 3 (0.642). The satisfaction level and cost are the two variables that allow Hospital 1 to have the best index.

A greater use of the lateral approach is observed in hospital 3, although it is characterized by a lower number of chronic patients compared to hospital 1. The comorbidity rate remains relatively low, compared to hospital 1. It is noted that the number of days between admission and surgery is higher, particularly for chronic patients, which leads to a longer average length of stay (LOS).

The use of intensive care units (ICU) is more systematic in hospital 3, despite the relatively short LOS in this service. This indicator raises questions about the eligibility criteria for ICU admission in these patients. Moreover, the number of complications, combined with their weight in the calculation of DALY (Disability-Adjusted Life Years), places hospital 3 at a disadvantage. Compared to hospitals 1 and 2, the lateral approach also seems to impact pain management and patients' leisure activities, leading to poorer outcomes for hospital 3 (to be

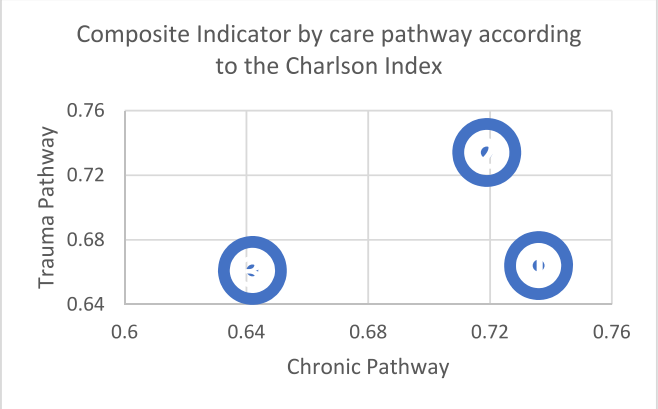


Fig. 5. Each circle corresponds to a hospital. The hospital is placed on a scale from 0 to 1 according to the care pathway assessed (chronic or trauma). The level of the score indicates how well the hospital is managing the stays.

confirmed in a more specific study). The extended LOS and frequent recourse to ICUs and geriatric care generate additional costs for hospital 3. The hospital 2 is quite close to hospital 1 but has a higher proportion of stays, placing it with better results for this population. It may be this category of stays that explains a higher average age, a greater number of readmissions, resulting in an impact on the average DALYs per stay and an easier ability to engage in leisure activities.

Finally, the combination of patient-reported outcomes with cost indicators and medical complications seems to be a concrete approach towards allowing actors to translate their daily actions. This method is intended to be progressive, since the analysis allows us to move from the macro level (via the inter-hospital sphere) to the micro level (through the analysis of patient data).

- The first step in the (macro) analysis is to start with the composite indicator. This indicator synthetically identifies the best performing hospitals on the basis of cost data, medical complications, and patient outcomes according to each hospital case mix.
- The second (meso) step of our methodology consists in detailing the composite indicator in order to understand the dependent variables that might point to difficulties: costs, medical complications, and patient outcomes (see Table 6). In this case, our study shows that Hospital 3 is struggling with two dimensions: Patient reported health status and costs of chronic pathologies.
- Lastly, the pragmatic description of care through the Donabedian model [37] is a third (micro) step that is essential if all actors are to understand the positioning of each dependent variable (see Tables 3 and 4). The Donabedian model has been used because of the significant improvement in outcomes in hospitals, especially when the comparison of structure, process, and outcome indicators is conducted by providers [38]. In particular, this participatory step aims to analyse problematic stays in order to enhance improvement objectives, for instance, improving pain management for Hospital 3 patients.

We believe that this composite indicator, as well as the suggested methodology, is relatively simple, transparent, easily calculated, understandable, and easily interpreted by those working in the field. These criteria seem essential to us if we aim for this approach to be introduced into everyday hospital practice. Moreover, this approach affects all stakeholders, from carers to managers and patients. However, in the light of our experience, we believe that a good practice guide should be drawn up to facilitate the definition of improvement objectives by the players (e.g. orthogeriatric management, length of time between admission and operation date, etc.).

Despite the interesting perspective provided by this approach, it does have some limitations. In particular, it was impossible to carry out the study from a 'hospital cost' point of view since one of the three hospitals involved does not participate in hospital cost benchmarking (PACHA) [39].

As a reminder, the weighting of the various factors during the final construction of the indicator was inspired by surveyed patients. This is an important element for us since we are looking to bring value to patients. In a future study, we could improve the weighting of the indicators by seeking the opinions of carers and managers as well, using the Discrete Choice Experiment (DCE) method. DCEs are specifically designed to elicit and quantify preferences, thus allowing the exploration of trade-offs between the characteristics of a treatment or service [40,41].

Concerning the Patient reported health status, we had started introducing a questionnaire *before* and *after* hip replacement surgery at the three hospital sites in 2020. Unfortunately, restrictions concerning elective interventions in connection with the COVID-19 pandemic did not allow us to complete this analysis.

We are also aware of the difficulty for patients to recall their hospital experiences of three years earlier. This is why we only considered Question 5 in the patient questionnaire when we created the patient outcome dimension of the composite indicator.

In addition, despite the fact that the findings were only applicable to a 'chronic' population (osteoarthritis type), we still retained our stays of traumatic origin to check the consistency of our results.

The actual impact on DALYs is probably greater than what we estimated, given the hospital setting of our study. Furthermore, it would seem essential to enhance these weighting keys in order to improve the quality of inter-hospital comparisons.

5. Conclusion

Our study proposed a methodology for comparing hospitals by combining management cost data, medical complications (Patient Safety indicators), and quality perception by patients (Patient reported health status and PROM'S) with regard to a surgical procedure (here, hip arthroplasty). In our opinion, the combination of these parameters makes it possible to obtain an overall assessment of the societal impact of a given pathology and, thus, to provide a more objective basis for inter-hospital benchmarking [42]. This threefold approach also offers the flexibility of being able to adjust the weighting coefficients to the requirements or interests of supervisory and funding authorities, patients, surgeons, or hospital managers. In our opinion, this experience — estimating the value provided by a hospital to a patient — may be viewed as the beginnings of Value Based Purchasing in Belgium.

Based on the findings and methodology presented in this study, several perspectives can be proposed for hospitals to improve their operations, patient outcomes, and overall performance.

First, hospitals should implement comprehensive evaluation metrics, adopting a multi-dimensional evaluation system that includes costs, medical complications, and patient outcomes, ensuring that all critical aspects of patient care are considered, beyond just financial metrics [43,44]. Second, hospitals can adopt a composite indicator for performance assessment: utilizing the composite indicator developed in this study, hospitals can identify their strengths and weaknesses across different domains (cost, complications, patient outcomes). This allows for targeted interventions and resource allocation to areas needing improvement [45,46]. Additionally, improving data collection and analysis is essential to ensure the accuracy and comprehensiveness of data collection, particularly regarding medical complications and patient-reported outcomes. High-quality data will enhance the reliability of the performance assessments and comparisons.

Furthermore, a focus on Patient-Centered outcomes is crucial. Hospitals should incorporate patient-reported outcomes, such as pain management and satisfaction levels (as in our study), into regular performance evaluations and prioritize interventions that improve these outcomes [47].

The development of best practice guides based on successful interventions and methodologies identified in this study can help standardize care and improve outcomes across hospitals [42,48,49].

Promoting inter-hospital comparison and collaboration is also beneficial, as sharing best practices, data, and insights can lead to more standardized care practices and overall healthcare quality improvement [50]. Hospitals should strive to optimize resource allocation by analyzing cost data in conjunction with patient outcomes to ensure efficient use of resources while maintaining high-quality care [47,51].

Regular training and development for healthcare providers are important to emphasize the importance of accurate coding, data entry, and patient care practices, highlighting their impact on hospital performance and patient outcomes [48].

Engagement with policymakers is another critical perspective. Hospitals should advocate for policy changes that reward the quality and appropriateness of care rather than the quantity of treatments, working with policymakers to develop incentives that promote high-quality, patient-centered care [52,53].

Moreover, hospitals can develop customized improvement plans based on specific performance metrics. For instance, if a hospital is struggling with pain management, targeted training and protocol adjustments can be implemented [42,43].

Finally, hospitals can integrate the Donabedian model to systematically analyse and improve care processes. This model helps in understanding the relationships between the structure of care, the process of care, and patient outcomes, leading to more effective interventions [46,49].

By implementing these perspectives, hospitals can enhance their overall performance, leading to better patient outcomes, more efficient use of resources, and higher satisfaction among patients and healthcare providers and the society.

Conflict of interest

The authors declare that they have no conflict of interest.

Declaration of competing interest

- Ethics approval and consent to participate yes, I have it:
- All methods were carried out in accordance with relevant guidelines and regulations were approved by a named institutional and/or licensing committee
  - o NUB: B039202042929. Comité d'éthique CHU UCL Namur, site Godinne.
- Informed consent was obtained from all subjects.
- Availability of data and material: the datasets generated and/or analysed during the current study are not publicly available, because this study is partly based on cost data from a hospital benchmarking of cost by pathology; however, they are available from the relevant author upon reasonable request and after anonymisation. Point of contact for Data Availability Request: Fabian Dehanne (fabian.dehanne@uclouvain.be).
- There is no potential conflict of interest.
- Funding: not applicable.
- Generative AI in scientific writing: not applicable
- Authors' contributions:
  - o Background: FD
  - o Methods: FD, MG, PL, MP, BL, FB, EC
  - o Data: FD, EC
  - o Interpretation of results: FD, MG, MP
  - o Revised discussion: FD, MG, MP, PL, FB, EC, BL
  - o Revised conclusion: FD, MG, MP
- All authors have read and approved the manuscript.

Data availability

Data will be made available on request.

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Abbreviations

OECD	Organisation for Economic Co-operation and Development
DALY	Disability Adjusted Life Years
QALY	Quality Adjusted Life Years
PACHA	Projet d'Analyse des Coûts des hôpitaux associés
DRG	Diagnosis-related group
AHRQ	Agency for Healthcare Research and Quality
PSI	Patient Safety Indicator
YLL	Years of Life Lost
YLD	Years Lost due to Disability
SD	Standard deviation
INAMI	Institut National d'Assurance Maladie Invalidité
KCE	Belgian Health Care Knowledge Centre
ICD10-PCS	International Classification of Diseases — 10th revision — Procedure Coding System
PROMs	Patient-Reported Outcome Measures

Appendix

Appendix 1

Descriptive data of costs, DALYs, and Patient reported health status for all patients in the study (DRG 301, 2018). The Kruskall-Wallis (**) and Mann-Whitney (*) statistical models were used to test the significance of the data.

Descriptive variables	Cost (euros)						DALYs				Patient reported health status					
	N= 342	%	Avg	SD	Med	Sign	Avg	SD	Med	Sign	N=104	%	Avg	SD	Med	Sign
Severity (n= 342)						<0.0001 **				0.054 **						0.138 **
1= Minor	160	46.8%	4,481	741	4,388		0.0113	0.0032	0		55	52.9%	8.0	2.6	9.0	
2= Moderate	162	47.4%	4,647	1,019	4,384		0.0233	0.0048	0		47	45.2%	8.45	1.7	9.0	
3= Major	14	4.1%	9,760	17,253	5,280		0.0226	0.0764	0		2	1.9%	3.5	5.0	3.5	
4= Extreme	6	1.8%	7,832	2,781	7,123		0.0182	0.0421	0							
Approach (n= 342)						0.058 **				0.131 **						0.076 **
Anterior	269	78.7%	4,847	4,080	4,421		0.00283	0.01795	0		84	82.0%	8.2	2.3	9.0	
External	1	0.3%	8,345				0	0	0							
Lateral	66	19.3%	4,712	1,271	4,352		0.00324	0.01325	0		20	18.0%	7.6	2.3	8.0	
Posterior	5	1.5%	5,031	749	4,852		0.0110	0	0.0110							
NA	1	0.3%	5,152				0	0	0							
Diagnostic (n= 342)						0.284 *				0.097 *						0.005 *
Chronic	257	75.1%	4,792	4,126	4,388		0.0015	0.0038	0		92	88.4%	8.3	2.3	9.0	
Traumatology	85	24.9%	4,964	1,623	4,557		0.0068	0.0331	0		12	11.6%	6.8	1.9	7.0	
Age categories "Year" (n= 342)						0.223 **				0.198 **						0.435 **
18-49	25	10.4%	6,984	13,061	4,280		0.0012	0.0033	0		5	4.8%	8.6	1.5	9.0	99
50-59	53	13.9%	4,455	766	4,307		0.0008	0.0032	0		20	19.2%	7.7	2.6	8.0	
60-69	85	22.6%	4,468	584	4,354		0.0052	0.0312	0		35	33.7%	7.9	2.7	9.0	
70-79	100	28.7%	4,718	854	4,493		0.0027	0.0110	0		33	31.7%	8.3	2.1	9.0	
80-92	79	24.3%	4,953	1,679	4,466		0.0024	0.0050	0		11	10.6%	9.0	1.5	10.0	
Gender (n= 342)						0,485 *				0.164 *						0.068 *
Female	178	52%	4,615	1,000	4,383		0.0025	0.0088	0		51	47.2%	7.8	2.4	9.0	
Male	164	48%	5,074	5,188	4,458		0.0032	0.0227	0		53	52.8%	8.4	2.3	9.0	
Place before admission (n= 342)						0,75 **				0.249 **						0.039 **
Home	318	93%	4,826	3,768	4,426		0.0026	0.0165	0		102	98.1%	8.2	2.3	9.0	
Other hospital	5	1.5%	4,270	796	4,148		0	0	0							
Nursing home	13	3.8%	5,249	2,392	4,226		0.0028	0.0056	0							
Other	6	1.8%	4,853	1,244	4,593		0.0196	0.0417	0		2	1.9%	4.5	0.7	4.5	
Type of admission (n= 342)						0,755 **				0.353 **						0.021 **
Planned	258	75.4%	4,802	4,120	4,389		0.0017	0.0041	0		91	87.5%	8.3	2.3	9.0	
Emergency	81	23.7%	4,953	1,651	4,548		0.0067	0.0339	0		12	11.5%	6.8	1.9	7.0	
Other	3	0.9%	4,474	127	4,530		0	0	0		1	1%	9.0		9.0	
Exit Destination (n=342)						0,07 **				0.551 **						0.045 **
Home	286	83.6%	4,779	3,934	4,373		0.0030	0.0184	0		98	95.2%	8.2	2.2	9.0	
Other hospital	12	3,5%	4,864	618	4,686		0.0014	0.0034	0		1	1%	7.0		7.0	
Nursing home	38	11,1%	5,267	2,069	4,762		0.0025	0.0055	0		2	1.9%	2.5	3.5	2.5	
Other	6	1,8%	4,704	510	4,614		0	0	0		3	2.9%	9.7	0.6	10.0	
Geriatric internal liaison (n= 342)						0,772 *				0.733 *						0.873 *
No	298	87.1%	4,822	3,875	4,420		0.0030	0.0180	0		97	93.3%	8.1	2.4	9.0	
Yes	44	12.9%	4,924	1,687	4,439		0.0016	0.0045	0		7	6.7%	8.4	1.8	9.0	
Intensive care unit (n= 342)						<0,0001 *				0.021 *						
No	331	96.8%	4,791	3,703	4,391		0.0020	0.0072	0		104	100%	8.1	2.3	9.0	
Yes	11	3.2%	6,165	1,947	5,284		0.0288	0.0860	0							
Geriatric care unit (n= 342)						<0,0001 *				0.751 *						
Non	333	97.4%	4,771	3,674	4,399		0.0029	0.0171	0		104	100%	8.1	2.3	9.0	
Oui	9	2.6%	7,202	2,484	6,499		0.0021	0.0047	0							
Charlson categories (n= 342)						0,052 **				0.005 **						0.519 **
0	173	50.6%	4,505	693	4,365		0.0017	0.0085	0		63	60.6%	7.9	2.4	9.0	
1	59	17.3%	4,795	1,082	4,533		0.0011	0.0029	0		14	13.5%	8.2	2.1	9.0	
2	67	19.6%	4,542	727	4,267		0.0028	0.0054	0		21	20.2%	8.5	2.3	9.0	
>4	43	12.6%	6,673	10,033	4,643		0.00993	0.0437	0		6	5.8%	8.3	2.1	9.0	
Number of days between 1st interv and 1st physiotherapy (n= 331)						0,312 **				0.846 **						0.043 **
0 day	115	34.7%	4,476	554	4,329		0.0019	0.0043	0		39	37.5%	8.6	2.2	9.0	
1 day	201	60.7%	4,938	4,673	4,457		0.0036	0.0218	0		60	57.7%	8.0	2.2	9.0	
>2 days	15	4.5%	4,984	1,748	4,344		0.0018	0.0036	0		5	4.8%	6.0	3.7	6.0	
Number of days between admission and surgery (n= 341)						0,007 **				0.162 **						0.035 **
0 day	184	54%	4,472	725	4,330		0.0016	0.0039	0		68	65.4%	8.6	1.9	9.0	
1 day	122	35.8%	5,255	5,955	4,471		0.0016	0.0039	0		35	33.7%	7.2	2.8	8.0	
> 2 days	35	10.3%	5,266	2,051	4,715		0.1385	0.051	0		1	1%	9.0		9.0	

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