



Elective Hip Arthroplasty: Are Discharge Destination, Length of Stay and Readmissions Related with Patient Volume?

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Abstract

Background: Quality and experience with providing specialized surgical treatment are related. The objective of this study was to explore to what extent quality as indicated by discharge destination, the length of stay and risk of 30-day readmission are associated with the volume of hip replacement procedures in Irish public hospitals.

Methods: Data on hospital discharges with elective hip joint replacement were obtained for 2011-2016. Multivariate regression models assessed the variation in discharge destination, length of stay and 30-day readmission in public hospitals with high and low (less than 35 procedures annually) volume of patients. Sensitivity analysis tested the robustness of the results by including only patients with total hip joint replacement, only patients with arthropathy as the primary diagnosis, and patients without any recorded comorbidity.

Results: The case-mix of patients at low volume hospitals was different in gender, mean age, revision and comorbidity. After adjustment for these factors low volume hospitals appeared to discharge more patients to other hospitals or nursing homes, had longer length of stay and higher rates of 30-day readmission. These findings were robust when patients with partial or revision procedures, non-arthropathy diagnosis and known comorbidity were excluded.

Conclusion: Low volume hospitals appear to provide hip joint replacement treatments with poorer outcomes than high volume hospitals after adjusting for potentially more complex case-mix of patients.

Keywords: Hip joint replacement; Volume of care; Length of stay; Readmission

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Key Points

- Elective hip joint replacement has during 2011-2016 been performed at 21 Irish hospitals.
- Hospitals with low patient volume (less than 35 replacements per year) discharge more patients to other hospitals and nursing homes, have longer length of stay, and higher readmission rates after adjustment for known covariates relating to demographics, diagnose and comorbidity.
- The reported results provide indications for different hip joint procedures at hospitals with high and low volume of patients, and that concentration of services could standardize admission criteria and improve outcomes from patient treatment.

Introduction

“Cleachtadh a dhéanannmáistreacht” is the Irish version of the old proverb “practice makes perfect” and evokes an idea that trials and tribulations of repeated efforts is needed to learn a new task, and that these repeated efforts are needed to maintain a sufficient skill level. Hip joint replacement (arthroplasty) is a highly successful surgical procedure that provides immense improvement in patients’ pain experience, functional ability, and quality of life. In Ireland, 2011 annual rate of hip joint replacements for individuals aged 65 and over was 101 per 100,000 [1]. The technological development of hip joint replacement procedures began nearly a century ago and is still on-going with clinical outcomes and implant functioning improving over time. There is now a greater than 90% revision-free implant survival at ten years, and greater than 80% probability that the prostheses survive for more than 25 years [2-4]. Many of these developments have proven to be cost-effective,

Table 1: Descriptive analysis of patients with elective hip joint replacement at hospitals with high and low patient volume (<35 procedures per year), number of patients (%), 2011-2016 (n=21848).

	High volume hospitals	Low volume hospitals	<i>p</i> -value
	n=21037	n=811	
Male (%)	11110 (52.8%)	470 (58.0%)	<0.01
Age (mean (sd))	65.7 (11.9)	68.2 (13.7)	<0.01
Procedure			
Total arthroplasty	19216 (91.3%)	627 (77.3%)	<0.01
Partial arthroplasty	16 (<0.1%)	16 (2.0%)	<0.01
Revision	1805 (8.6%)	168 (20.7%)	<0.01
Diagnosis			
Arthropathies	19080 (90.7%)	530 (65.4%)	<0.01
Complications of med&surg care	1594 (7.6%)	132 (16.3%)	<0.01
Other	363 (1.7%)	149 (18.4%)	<0.01
ASA-score (mean, (sd)) n=14.299 (65.5%)	2.1 (0.60)	2.5 (0.61)	<0.01
Charlson comorbidity			
No comorbidity	19604 (93.2%)	690 (85.1%)	<0.01
Index score (mean(sd))	0.1 (0.4)	0.3 (0.9)	<0.01
Discharge destination			
Home	18262 (86.8%)	427 (52.7%)	<0.01
Other hospital	746 (3.6%)	246 (30.3%)	<0.01
Nursing home	2016 (9.6%)	136 (16.8%)	<0.01
Length of stay (mean (sd))	6.2 (7.3%)	12.3 (16.4)	<0.01
Readmissions within 30 days	507 (2.4%)	36 (4.4%)	<0.01

and the general perception of hip joint replacement procedures is that they provide high quality outcomes. Due to the high satisfaction of patients and the overall improved quality of life after surgery, total hip arthroplasty has been described as “the operation of the 20th Century” [5].

The skills and techniques required to provide these procedures are highly specialized and require continuously development and maintenance. Specialized competences are required for proper assessment of the most appropriate procedure to patients, the preparation before the surgery, the actual surgical procedure, and the after-care and rehabilitation activities. In that respect, successful outcomes from hip replacements require a team effort, and all phases in the patient trajectory should be optimized to maintain efficiency and achieve high quality outcomes. We hypothesize that procedures in all these phases need to be performed on a regular basis to maintain a sufficient level of competency and efficiency.

There is currently a shortage of systematic reporting systems at a national level in Ireland. All public hospitals are required to provide administrative data to the national Hospital Inpatient Enquiry (HIPE) system. Regular reporting of these data allows clinical departments to compare specific features of their own surgical production with other similar hospital departments. Such performance comparisons enable the managers of individual hospitals to identify potential areas for efficiency improvements. However, the lack of data relating to quality, outcome (in contrast to output), and costs represent a major challenge for the development of usable clinical quality data. Initiatives have been taken to develop audit databases that include measures of treatment quality and patient outcome [6], although such systems have only been implemented in few hospitals. The

Irish National Orthopaedic Registrar is currently being set up to address this problem and will be fully operational by 2019. However, currently national assessments of variation in treatment quality and patient outcomes are therefore not readily available. As most hip joint replacement procedures are provided to patients who have been referred to a waiting list and have been clinically assessed prior to the procedure, it is obvious to use a standardized care regime to ensure low variation in clinical quality and outcomes. This could suggest that process measures such as discharge destination, duration of the hospital stay, and the rate of readmissions after 30 days should be relatively similar across the different hospital departments, and that potential variations may largely relate to variation in practice and organization of services more than features of the individual patients. The frequency of procedures conducted within a hospital department may be an important characteristic of the clinical organization. A high volume of procedures may offer better opportunities for standardizing the patient trajectory, utilize and develop specialist knowledge and generally explore scale efficiencies. The relation between volume and quality of care has been explored previously, and several studies have shown that higher-volume institutions are associated with better outcomes, including lower mortality and complications rates [7,8]. A positive association has been found between the volume of hip joint replacements and overall clinical quality, as defined by Irish pay-for-performance programs [9].

The surgeon volume and the hospital volume have been suggested to be the best indicators of adverse orthopaedic events in patients undergoing THR surgery [10]. Upon analysis of total hip and knee arthroplasties separately, these results confirmed the relationship between hospital and surgical volume and patient outcomes [11,12].

Table 2: Final Model Estimates.

Variable	Discharged to			Length of stay	Readmission
	Home	Other hospital	Nursing home		
	Logistic regression			Gamma regression	Poisson regression
Low volume hospital	-1.761***	2.365***	0.449***	5.324***	0.506**
Comorbidity:		1.895***	0.144	2.382	
Acute Myocardial Infarction	-1.196**				
Congestive Heart Failure	-1.456**	1.328*	0.94	5.416*	
Peripheral Vascular Disease	-1.013	1.748	-0.172		
Cerebrovascular Disease	-2.128***	2.175***	0.812	7.809	
Dementia	-2.25	0.802	1.39	9.462	
Chronic Pulmonary Disease	-0.588**	0.753*	0.389	2.925	
Rheumatologic Disease	-0.899***	1.130**	0.429		
Diabetes without complications	-0.368**	0.549**	0.214	-0.696***	
Diabetes with chronic complications	-0.804***	0.704***	0.677***		
Hemiplegia or Paraplegia	-2.798*	2.745	1.874	74.918	
Renal Disease	-0.322	0.913*	-0.65	1.274	
Metastatic Carcinoma	-1.763*	1.610*	0.2	9.729	
Age	0.170**	-0.12	-0.239***	0.115	-0.043
Age ²	-0.003***	0.003	0.005***	-0.003*	0.001
Age ³	0.000**	0	-0.000***	0.000***	0
Male	0.408***	-0.239***	-0.436***	-0.237**	0.286***
Constant	1.143	-3.306	-0.343	3.133**	-3.562*
Log-likelihood	-7809	-3525	-6315	-61766	-2521
Akaike's information criterion	15654	7085	12666	123563	5055
Bayesian information criterion	15797	7229	12809	123691	5103

Notes: Chx indicate Charlson comorbidity group; *p<0.05; **p<0.01; ***p<0.001.

Singh et al. found that total hip replacement procedures performed at low volume hospitals (<200 arthroplasties/year) were associated with significantly higher adjusted risk of pulmonary embolism within 30-days and higher 1-year mortality [13]. However, until now no such studies have been performed using national data from Ireland. The objective of this study was to explore to what extent quality as indicated by discharge destination, the length of stay, and risk of 30-day readmission are associated with the volume of hip replacement procedures in Irish public hospitals.

Methods

Data material

The National Quality Assurance Intelligence System - Surgery (NQAIS) is an online analytical tool which uses data for patients discharged following a surgical procedure. The system holds individual-based patient data for different surgical specialties at procedure level for all Irish public hospitals [14]. Surgical procedures are described by a primary code and up to 19 secondary codes. Data on patients who have undergone a hip joint replacement during January 2011 until December 2016 were extracted from NQAIS (n=23,770) using the predefined procedure category for hip arthroplasty which comprise of the following procedure codes: 4931500 "Partial hip arthroplasty" (n=241); 4931800 "Total hip arthroplasty" (n=20833), and 4932400 "Revision of total hip arthroplasty" (n=2696). The extraction included hospital discharges coded as day cases (0.1%), elective (92.2%) and acute inpatients (7.7%), and patients who were

admitted as elective (98.0%) or emergency (2%). We excluded day case and acute inpatients (n=1849) from the study sample and kept only elective inpatients (n=21,921). These discharges were admitted at 21 hospitals which remain anonymized in this study.

For each hospital discharge we obtained data on patients' age, gender, hospital, diagnoses, discharge destination, length of stay, and readmission within 30 days of discharge. Based on the 30 possible diagnostic ICD-10 codes we used the Charlson comorbidity categorization to construct 17 different groups of comorbidities [15,16]. As most patients were admitted due to rheumatic diseases we excluded this as a comorbidity category.

Analysis

Hospitals were grouped into low and high volume hospitals depending on the number of procedures performed. Low volume hospitals were defined with less than 35 procedures per year and high volume hospitals with more procedures. Nine hospitals were identified as low volume hospitals. We excluded from the analysis three hospitals with a total of four, 28 and 41 discharges with hip joint replacements during the 6-year period.

Descriptive analysis of the 6-year study population considered difference between low and high volume hospitals by gender, age, principle procedure, principle diagnosis, Charlson comorbidity category, discharge destination, length of stay and readmission within 30 days. Differences between hospitals with low or high volume in the categorical variables were tested using Chi-squared test and t-test for

Table 3: Sensitivity analysis: Estimated differences in discharge destination, length of stay and 30-day readmission rate for hospitals with high and low patient volume. Measure of difference and 95% confidence intervals.

	OR discharge to home	OR discharge to other hosp.	OR discharge to nursing home	Mean length of stay	IRR 30-day readmission
Baseline (n=21,848)	0.17 (0.15-0.20)	10.64 (8.88-12.75)	1.57 (1.27-1.93)	5.32 (4.32-6.32)	1.66 (1.18-2.32)
Only pts with total hip replacement (n=19,843)	0.15 (0.13-0.18)	11.40 (9.30-13.98)	1.76 (1.40-2.23)	4.96 (3.88-6.03)	1.49 (1.00-2.23)
Only pts with arthropathies diagnose (n=19,610)	0.15 (0.13-0.19)	11.60 (9.34-14.38)	1.62 (1.27-2.09)	4.50 (3.65-5.35)	1.50 (0.98-2.32)
Only pts without Charlson comorbidity (n=20,294)	0.16 (0.13-0.19)	11.23 (9.26-13.61)	1.68 (1.35-2.10)	5.75 (4.61-6.89)	1.83 (1.29-2.59)
Only total hip replacement with arthropathies diagnose and no comorbidity (n=17,869)	0.14 (0.11-0.18)	12.66 (9.97-16.05)	1.84 (1.41-2.43)	4.85 (3.81-5.90)	1.69 (1.07-2.69)
Include ASA score as covariate (n=14,299)	0.22 (0.19-0.27)	8.53 (6.97-10.46)	1.22 (0.98-1.54)	4.92 (3.90-5.94)	1.69 (1.18-2.40)

Notes: OR indicates odds-ratio; IRR indicates incidence-rate ratio



Figure 1: Discharge destination. Proportion of patients discharged to home, other hospital or nursing home by annual number of patients with hip joint replacement, 2011-2016.

continuous variables. The raw proportion of patients discharged to home, other hospitals, and nursing home, the mean length of stay, and the raw proportion of readmissions were presented graphically by each hospital's annual patient volume. Trends over time for these quality indicators were tested using logistic regression for the dichotomous variables and with least squares regressions of the log-transformed length of stay variable both with year as a single continuous variable.

Using generalized linear regression we tested different specification of models to describe the variation between discharge destination, length of stay and readmission and used graphical inspections of residuals and log-likelihood tests to identify the specification with the best fit to the data. To counter for potential covariance between yearly observations at hospitals we used Huber-White robust estimation specification in all regression analyses. We firstly tested the specification of demographic variables and included age, age to the power of two and three in combination with gender. Secondly, we tested whether inclusion of dichotomous year-variables could provide significant parameters. Thirdly, we tested the association between the Charlson comorbidity categories and the dependent variables. Charlson comorbidity categories with estimated p-values less than 0.1 were included as independent variables in the model. This meant that different comorbidity categories were included in the different models. We then estimated models with the best

specifications of the demographic, year and Charlson comorbidity variables. We considered these models to provide the best fit to the data. Finally, we included a categorical variable for hospital volume (less than 35 procedures annually) as our key variable of interest. The final estimated models are presented in Table 2.

For the discharge destination data the best fitting models were logistic regressions. The length of stay data was best fitted with a model assuming gamma link specification, while readmissions were best fitted with a negative binomial link specification. Demographic variables included age to the power of one, two and three, gender. No interaction between gender and age variables were statistical significant. Dichotomous variables for year were included for the discharge and length of stay models. Using the final model specifications we assessed the marginal difference between low and high volume hospitals, and presented the mean difference in proportions of patients and mean length of stay, estimated 95% confidence intervals, and the ratio between the two ratios/means.

In sensitivity analyses we tested the validity of the results with different restrictions imposed on the patient population. First, we included only patients who underwent a total hip replacement procedure (i.e. not partial or revision procedure), secondly only patients with arthropathy as the primary diagnosis (M00-M25), thirdly only patients with no Charlson comorbidity, fourthly only

patients with all the above restrictions, and fifthly when ASA score was included as a covariate. There were 170 patients with length of stay longer than 30 days (mean 66 days, max 522). We further tested the robustness of the length of stay model by truncating the length of stay for these patients to 30 days, and whether the length of stay for patients discharged to hospitals and nursing homes were different for hospitals with high and low patient volume. For the model of 30-day readmissions we excluded hospitals with no (one hospital) or few readmissions (<5 patients at four hospitals).

Results

A total of 21,848 discharges were included in the analysis. Table 1 summarizes the patient characteristics by hospitals with large or low volume of patients. The case mix of patients were different for the two groups of hospitals with low volume hospitals having older patients, a higher proportion of male patients, more patients with complication after medical or surgical care, with 'other diagnoses', revision procedures, and comorbidity. Patients from low volume hospitals were more likely to be discharged to another hospital or to a nursing home, their length of stay was longer, and they had a higher rate of 30-day readmissions. The proportion of patients discharged to home, other hospitals or nursing homes are shown together with the annual number of patients discharged for each hospital in Figure 1. Figure 2 shows the average length of stay and the rate of 30-day readmissions.

The rate of discharge to home was unchanged ($p=0.20$) during 2011-2016. The rate of discharge to other hospitals increased from 0.031 to 0.050 (10% per year; $p<0.01$), and the rate of discharge to nursing homes reduced from 0.118 to 0.091 (-6.5% per year; $p<0.01$). A negative trend could be observed in mean length of stay with a reduction from 8.0 days in 2011 to 5.8 days in 2016 (annual reduction by 7.4%; $p<0.01$). The readmission rate increased insignificantly during the 6-year period from 0.021 to 0.028 (4.8% per year; $p=0.07$).

The final regression models are shown in Table 2. The estimated parameters for low volume hospitals were statistically significant in all models suggesting that there is a statistically significant difference in all five dependent variables after adjustments for patients' demographic characteristics, year (only discharge destination and length of stay) and comorbidity. In comparison with high volume hospitals the adjusted odds-ratio for low volume hospitals to discharge patients at home was 0.17 (95% CI 0.14-0.29), and the adjusted odds-ratio for discharging patients to other hospitals or nursing homes was 10.6 (95% CI 8.88-12.75) and 1.57 (95% CI 1.27-1.93) (Table 3). The adjusted mean length of stay at low volume hospitals was 5.3 (95% CI 4.3-6.3) days longer than at high volume hospitals, and the incidence-rate ratio of readmissions for low volume hospitals was 1.66 (95% 1.18-2.32).

Restricting the study population to patients with total hip replacements only, arthropathies as primary diagnosis, and without Charlson comorbidity alone or combination did not alter the direction or size of the estimated group differences (Table 3). When we included ASA score as a covariate the sample size reduced dramatically reflecting that valid scores were only available for 65% of the discharges. There was a noticeable difference in the rate of discharge to hospitals and nursing homes, and the mean length of stay which reflects that the ASA score may have strong predictive power. However, inclusion of this variable did not alter the direction of the differences between high and low volume hospital, and the

differences remained statistically significant with the exception of the odds-ratio for discharge to nursing home that became insignificant ($p=0.06$).

When we truncated the length of stays over 30 days to 30 days, the difference in mean length of stay reduced from 5.3 days to 4.2 days ($p<0.01$). Both the mean and median length of stay for patients with stays longer than 30 days were similar for the two groups of hospitals. We further tested the difference in mean length of stay for patients who were discharged to other hospitals and nursing homes. The raw mean length of stay was 7.8 days (n=746) for discharges referred to other hospitals at high volume hospitals and 11.6 days (n=246) at low volume hospitals. In the adjusted analysis the difference reduced from 5.3 days to 3.7 days ($p<0.01$). The mean length of stay for discharges to nursing homes at high volume hospitals was 8.3 days (n=2016) and 16.1 days (n=136) at low volume hospitals, and the adjusted stratified difference increased to 6.1 days ($p>0.01$).

When data from the hospitals with no or few readmissions were removed the difference between low and high volume hospitals became insignificant.

Discussion

This study has explored the relationship between the volume of surgical treatment, discharge destination, length of stay and readmission rates. The analysis indicates that hospitals that conduct few hip joint replacements more often discharge patients to other hospitals or nursing homes have later discharges and more readmissions. This pattern is consistent with several international studies that have shown a similar relationship between volume of work and high quality outcomes in healthcare in terms of complications and mortality, particularly for surgery [11,12,17,18]. Low volume providers of total hip replacement procedures have previously been found to be associated with longer length of stay [19-21]. Providers with low volume have also been associated with higher surgical readmission rates and 30-day mortality [22]. This study has confirmed that a pattern between volume and quality of treatment also exists in Ireland. Discharge to home after a short hospital stay and without need for readmissions should be a priority for clinical managers, policy makers and health politicians. The opposite represents poor treatment quality and inefficient use of resources.

This study has identified that 21 different hospitals have provided elective hip joint replacements. Three of these hospitals were excluded from this analyse due to low number of discharges which could suggest misclassification or wrong data coding. However, further six hospitals provided less than 35 annual hip joint replacements. Such low volume of specialized patient treatment should cause concern relating to inferior treatment quality and poor use of resources. This not only relates to the quality of the surgical procedure but to the whole organization of care for this patient group including the assessment of clinical indications for the procedure, the preoperative assessment and preparation of patients and the important post-operative rehabilitation phase. Hospitals that perform higher volume of procedures may have better opportunities to develop routines and procedures that can prevent postoperative complications and identify when patients are ready for discharge, and engage in readmission-prevention strategies.

These results clearly show the need of discussions on the regionalization of orthopaedic procedures, something that has already been discussed by the Irish Institute of Trauma and Orthopaedic

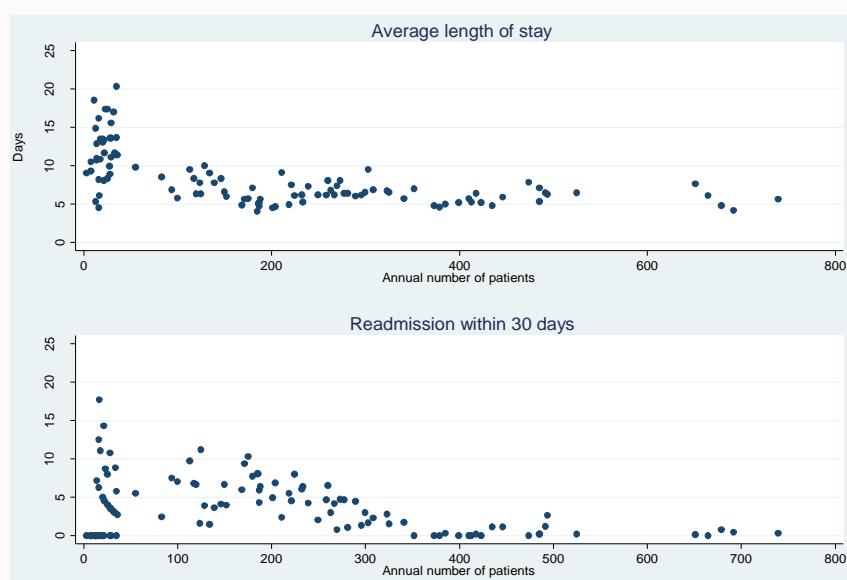


Figure 2: Average length of stay and 30-day readmission rates by annual number of patients with hip joint replacement, 2011-2016.

Surgery (IITOS) [23]. The IITOS recommends 7 major orthopaedic centres throughout the country with 25 surgeons in each. This would give a ratio of approximately 1 surgeon per 24,000 populations. Each centre should have at least Level 2 Trauma capabilities, with a separate elective hospital capable of dealing with adult and paediatric orthopaedics. This organization of hospitals would result in a higher quality of care being provided as more specialized orthopaedic surgeons would be providing the surgical services that are needed [23]. This concept suggests a more centralized provision of care, with a few centres of excellence providing high quality care in the country.

Centralization may be a contentious topic. Given the large current volume of total joint replacement procedures, with the expectation that this figure will increase in the future, centralization could reduce additional mortality and morbidity [24]. However, while centralization has improved patient outcomes in trauma care [25] mortality after joint replacement procedures remains low. Therefore, it must be assessed whether centralization of orthopaedic surgery would be beneficial, economically and practically in the future.

Modern technology and instrumentation along with standardized surgical methods combine to make total hip arthroplasty a highly predictable, cost-effective reconstruction procedure [22]. Due to such standardization it is perhaps surprising that there is such a variation in the quality of service provided in different hospitals across Ireland. The variations in LOS and readmission have cost implications and ineffective use of resources has consequences on health and quality of life.

It might be relevant to further explore which specific factors explain the outcome difference between high and low volume providers. Few investigations have assessed differences in specific clinical processes of care, especially those known to affect outcomes. One study showed that approximately one third of the mortality difference between high and low volume hospitals for acute myocardial infarction could be attributed to more frequent use of proven-effective medications at high-volume hospitals [26]. While hip replacement surgery is a standardized procedure, different hospitals might have different specific treatments and different after-

care programs for their patients. These differences could contribute to the variation of care.

Strength and Weakness

A major strength of this study is the application of national data for a 6-year period which appears to be stable in relation to the number of hip replacements performed. It utilizes individual patient data and allowed adjustment of the variation in patients undergoing these procedures.

The results should be interpreted with the following limitations in mind. The data contains only information about patients treated at public hospitals. Based on a household survey carried out by the Central Statistics Office in 2010, it is estimated approximately 15% of all hospital in-patient activity in Ireland is undertaken in private hospitals [27]. However, this is only an estimate and we have no access to data that indicate the true numbers of procedures performed in each hospital. We are relying on administrative data, which has potential inconsistencies in documentation and missing information on key variables, such as body mass index and patient-reported outcomes, including pre-operative and post-operative pain, functional status, quality of life, and satisfaction. There is also a difficulty in determining the accuracy in some of the coding, in particular, readmission. The lack of a unique national patient number makes it impossible to determine if a patient discharged from one hospital have extended their hospital stay at another hospital.

Some commentators have questioned the use of readmission rates as a measure of quality of care. Due to the inability to match discharges for patients across different hospitals the true readmission rate might be under-reported. It has also been suggested that readmission relates to social and clinical factors that may be unrelated to hospital care. While unable to adjust for social factors in this study, we have adjusted for gender, age and comorbidity which may be interpreted as imperfect proxies for social and clinical factors. The unplanned readmission rate is a national key performance indicator reported by the UK department of Health [28]. However, variable in its raw form may not be a good quality indicator due to lack of accuracy related to unrelated admissions occurring within the specified time-frame [28].

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