Open Access Full Text Article

ORIGINAL RESEARCH

Length of stay in hospital and all-cause readmission following elective total joint replacement in elderly men

George Mnatzaganian[1]
Philip Ryan[1,2]
Paul E Norman[3]
David C Davidson[4]
Janet E Hiller[1,5]

[1]School of Population Health and Clinical Practice, Discipline of Public Health, [2]Data Management and Analysis Centre, The University of Adelaide, South Australia; [3]School of Surgery, University of Western Australia, Western Australia; [4]Royal Adelaide Hospital, South Australia; [5]Faculty of Health Sciences, Australian Catholic University, Fitzroy, Victoria, Australia

Correspondence: George Mnatzaganian
Discipline of Public Health
School of Population, Health and Clinical Practice
Mail Drop DX650 511
University of Adelaide 5005
South Australia
Tel +61 08 8313 0664
Fax +61 08 8223 4075
Email mnjorgegm@gmail.com

Background: We retrospectively assessed the independent effects of patient and clinical factors on length of stay and all-cause 90-day, one-year, and two-year readmission following elective total joint replacement. We also evaluated the independent association between length of stay and readmission with postoperative five-year mortality.

Methods: Longitudinal data from 819 men who had had total joint replacement were integrated with validated hospital morbidity data and mortality records. Length of stay, readmission, and mortality following total joint replacement were each modeled using multivariable proportional hazards regression.

Results: Mean age at surgery was 76.3 ± 4.3 years. Median length of stay following total joint replacement decreased by 25% from 12 days in 1997–1998 to nine days in 2005–2007. Age, inhospital complications, total knee replacement, private hospital, and increased body weight were significantly associated with longer stay. A dose-response relationship between weight and length of stay was observed ($P = 0.003$). Crude 90-day, one-year, and two-year readmission rates were 17.3%, 47.4%, and 65.0%, respectively. Ninety-day readmission was associated with comorbidity, inhospital complications, and treatment in public hospitals. Age, comorbidity, socioeconomic disadvantage, and increased weight significantly increased the risk of one-year and two-year readmission. Patients with a body mass index ≥ 30 kg/m^2 were 34% more likely to be readmitted within two years compared with those having a body mass index of 18.5–24.9 kg/m^2. All-cause one-year and two-year readmission rates were significantly higher in patients undergoing a total knee replacement than those undergoing a total hip replacement. No independent associations between length of stay and all-cause readmission or mortality were observed. All-cause 90-day and one-year readmission independently increased the risk of long-term postoperative mortality.

Conclusion: After adjusting for confounding factors, including age, comorbidity, obesity, and inhospital complications, length of stay was not independently associated with post-discharge readmission or death. We report that the obese, those having total knee replacement, and the socioeconomically disadvantaged are the highest consumers of hospital resources following elective total joint replacement in elderly men. Our findings may assist clinicians in better selection of elderly patients for surgery, and informing them about their individual level of risk.

Keywords: elderly, total joint replacement, obesity, length of stay, all-cause readmission

Introduction

As the general population ages and obesity becomes more prevalent, the proportion of patients presenting for elective total joint replacement is increasing.[1] However, length of stay in hospital following this procedure has steadily decreased,[2–4] and concerns have been raised that reductions in length of stay may be associated with higher rates

of adverse events after discharge,[5] longer stay in rehabilitation units,[3] higher short-term readmission,[2] and increased mortality.[6] Nevertheless, the reported association of shorter stay in hospital following an elective total joint replacement with an increased risk of adverse outcomes, including readmission to hospital and increased post-discharge mortality, has not been consistent.[2–7] Cram et al retrospectively assessed a large sample of US Medicare patients undergoing total hip replacement and found that while the median length of stay dropped over a period of 17 years, crude 90-day readmission increased from 5.9% to 8.5% ($P < 0.001$). A significant increase over the years in mean age and comorbidity status of patients selected for total hip replacement was also reported, but a multivariate analysis to assess the independent effect of length of stay on readmission was not attempted.[2] In contrast, another US Medicare study did not find any significant change in short-term readmission rates following total hip replacement despite the decrease in postoperative length of stay over a period of six years.[4]

Conflicting results were also found across studies that assessed the effect of patient and clinical factors on length of stay following elective total joint replacement. Age shows the most consistent associations with longer stay in hospital,[8] while the results for being overweight or obese have been the most inconsistent.[9–11] Differences in the findings of these and other studies may be attributed to various factors, including relatively small sample sizes,[11] differential selection of patients, and lack of or insufficient adjustment for the confounding effect of comorbidity.[10,11]

The main objectives of this cohort study were to assess the independent effect of patient factors (age, body weight or body mass index, socioeconomic status, duration of smoking, insurance type) and clinical factors (presence of comorbidity, inhospital postoperative complications, type of total joint replacement) on length of stay and all-cause 90-day, one-year, and two-year readmission following elective total joint replacement, to determine if length of stay was independently associated with all-cause readmission, and to assess the associations of length of stay and readmission with five-year mortality following this procedure. We hypothesized that, after adjusting for confounding factors including age and comorbidity, length of stay would not be associated with increased post-discharge readmission or mortality.

Patients and methods
Data sources and study population
The study population was drawn from the Health In Men Study which arose from a randomized population-based trial of ultrasound screening for abdominal aortic aneurysm in men aged 65–83 years living in Perth, Western Australia.[12] A total of 41,000 men were identified via the Western Australian electoral roll (voting is mandatory in Australia) and randomized into invited and control groups of equal size. Of the men who were invited, 12,203 attended the baseline screening in 1996–1999. At baseline, the participants provided detailed health information and study nurses recorded their weight and height. During 2001–2004, the surviving men of the 12,203 initial participants were invited to a follow-up study during which they were weighed a second time. Electronic record linkage was used to identify admissions to hospital (hospital morbidity data) for total joint replacement, inhospital postoperative complications, and all-cause readmission in the target population.

All 12,203 participants were retrospectively followed from baseline screening until they experienced their first total joint replacement or died, or were right censored at the end of follow-up in March, 2007. Median follow-up was 7.7 years. As described in an earlier analysis,[13] 819 men had an elective total joint replacement after baseline and these were the focus of this analysis. Inhospital complications were ascertained from diagnoses recorded in hospital morbidity data during the index admission for total joint replacement. These diagnoses were classified into major or minor by 13 experienced orthopedic surgeons who were blinded to the outcome of the conditions. We additionally retrieved the principal diagnosis of the first all-cause readmission within 90 days of total joint replacement from hospital morbidity data.

Statistical analysis
Length of stay and all-cause readmission following total joint replacement were ascertained from hospital morbidity data. The Kaplan–Meier method was used to estimate the probabilities of hospital discharge or readmission over time. Differences in the Kaplan–Meier estimates between body mass index categories were evaluated by the log rank test. Length of stay and all-cause 90-day, one-year, and two-year readmission rates following total joint replacement were modeled using Cox proportional hazards regression, as a function of age, Deyo-Charlson Index,[14] weight, and height (or body mass index), years of smoking, socioeconomic status based on Socio-Economic Index For Areas (SEIFA),[15] type of total joint replacement (total hip or knee replacement), insurance type (public versus private hospitals), inhospital complications, year of total joint replacement, and number of past hospitalizations. SEIFA indices indicate relative social advantage of populations living in different geographic areas,

with low scores reflecting disadvantage. Since most of the participants were recruited before 1999, we used the 1996 national census to calculate the index.[16] At baseline screening, the participants provided their residential postcode which lowered the chances of misclassification of SEIFA due to an incorrect postcode. The readmission models also adjusted for length of stay during index admission. The associations of length of stay and all-cause readmission with five-year mortality following total joint replacement were assessed using Cox regressions after adjusting for the abovementioned variables. The proportional hazard assumption of the Cox models was tested using Schoenfeld residuals. All analyses were performed using Stata statistical program (version 11, StataCorp, College Station, TX).

Body weight

Available data did not permit us to control for weight change over time, and therefore we used the body weight of the participants measured at baseline. Time to total joint replacement from baseline (in 1996–1999) was relatively short (mean 4.6 ± 2.7 years) so we assumed that weight measured at baseline remained constant up till surgery. To test this assumption, we compared the weights measured at baseline with the corresponding weights measured five years later in the Health In Men Study follow-up survey in 2001–2004.[12] Of the 819 men who had had total joint replacement, 461 (56.3%) participated in both the baseline and follow-up Health In Men Study surveys. The mean weight of these men at baseline was 82.6 ± 10.8 kg, and their corresponding mean weight five years later was 82.4 ± 11.4 kg (paired t-test, $P = 0.454$), which supported our assumption of relatively constant weight over time in this cohort of older men.

Ethical approval

Ethical approval was obtained from the human research ethics committees of the Health Department of Western Australia and the University of Adelaide prior to commencement of study. All analyses used deidentified data.

Results

Patient characteristics

Of the 819 men (mean age 76.3 ± 4.6 years) who had had total joint replacement, 498 (60.8%) had a total knee replacement and 321 (39.2%) a total hip replacement,[13] with most procedures performed in private hospitals (78.5%). Compared with patients operated in private hospitals (n = 643), those operated in public hospitals (n = 176) were of lower socioeconomic status (47.7% low, 32.9% middle, and

19.3% high for public patients versus 25.4%, 31.9%, and 42.8%, respectively, for private patients, $P < 0.001$), and smoked more (24.9 ± 20.2 years of smoking for public patients versus 21.1 ± 19.6 years for private patients, $P = 0.024$). No statistically significant differences were observed in the characteristics of those who had a total knee or hip replacement (Table 1). Of all men, 462 (56.4%) were overweight (body mass index 25–29.9 kg/m²), and 210 (25.6%) were obese (body mass index ≥30 kg/m²). Compared with patients of normal weight (body mass index 18.5–24.9 kg/m²), the obese were significantly younger at age at surgery (75.4 ± 4.4 years versus 77.2 ± 4.6 years, $P < 0.001$), were of lower socioeconomic status (36.7% low, 32.4% middle, and 30.9% high versus 26.5%, 29.3%, and 44.2%, respectively, $P = 0.028$), and smoked more (23.7 ± 19.8 years of smoking in obese patients versus 19.3 ± 20.2 years of smoking in patients with normal weight, $P = 0.045$).

Length of stay in hospital

Median length of stay was 11 days (interquartile range 8–14) varying between 11 days (interquartile range 9–14) for private hospitals and nine days (interquartile range 7–12) for public hospitals, although the overall length of stay dropped over a period of 10 years for both hospital types. Comparing 1997–1998 with 2005–2007, the median length of stay fell by 33.3% in public hospitals (from 12 to 8 days),

Table 1 Patient characteristics by type of total joint replacement

Patient characteristics	TKR n = 498 (60.8%)	THR n = 321 (39.2%)	P value
Age, mean ± SD	76.4 ± 4.4	76.0 ± 4.8	0.250
Deyo-Charlson comorbidity index, mean ± SD	1.03 ± 1.5	1.20 ± 1.7	0.137
Socioeconomic status as SEIFA distribution, %			
Lower	30.1	30.2	
Middle	33.3	30.2	
Higher	36.6	39.6	0.588
Weight (kg), mean ± SD	83.4 ± 11.6	82.5 ± 11.3	0.288
Height (m), mean ± SD	171.4 ± 6.3	172 ± 6.4	0.159
Years of smoking, mean ± SD	21.1 ± 19.9	23.2 ± 19.4	0.131
Insurance type, %			
Private hospital	79.7	76.6	
Public hospital	20.3	23.4	0.294
Presence of an inhospital complication, %	42.0%	38.0%	0.259

Abbreviations: SD, standard deviation; SEIFA, Socio Economic Index For Areas; THR, total hip replacement; TKR, total knee replacement.

compared with a fall of 16.7% in private hospitals (from 12 to 10 days). Time to discharge was significantly longer in overweight or obese patients (Figure 1), those having total knee replacement, and patients with an inhospital complication. Adjusting for the variables listed in Table 2, we found a dose-response relationship between body weight and length of stay. Spearman's correlation coefficient was 0.464 ($P < 0.001$, Figure 2). A test for linear trend in the log hazard-ratios across weight quintiles yielded $P = 0.003$. Increasing age, having total knee replacement, operation in a private hospital, and inhospital complications were also independently associated with a longer length of stay. Patients undergoing total knee replacement were 23% more likely to have a longer stay compared with total hip replacement (adjusted hazards ratio [HR] 1.23, 95% confidence interval [CI] 1.06–1.42). Adjusting for body mass index categories instead of weight and height produced similar findings. The overweight and obese were more likely to stay in hospital longer than those of normal weight (adjusted HR 1.32, 95% CI 1.09–1.59, for the overweight and adjusted HR 1.45, 95% CI 1.17–1.80 for the obese).

Readmission following total joint replacement

Crude all-cause 90-day, one-year, and two-year readmission rates following total joint replacement were 17.3%, 47.4%, and 65.0%, respectively (Table 3). Between 1997–1998 and 2005–2007, all-cause 90-day readmission fell from 22.7% to 15.0%, but this relative decrease of 34.0% was not statistically significant ($P = 0.10$). Similarly, no significant change in one-year or two-year readmission rates was observed over the years.
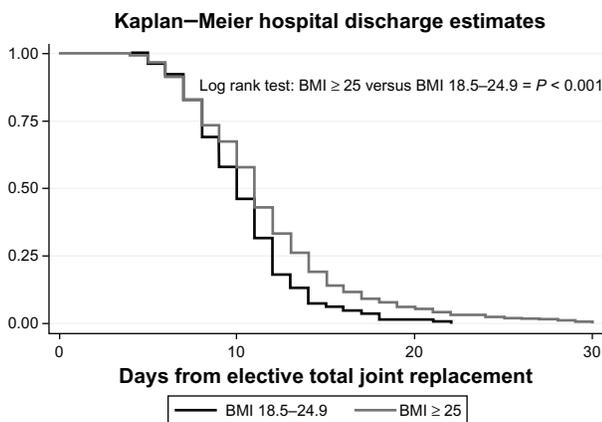
Table 2 Length of stay in hospital following elective total joint replacement in elderly men: Cox multivariable regression model[a]

Covariates	Hazards ratio (95% CI)	P value
Age, continuous	1.03 (1.02–1.05)	<0.001
Charlson comorbidity index, continuous	1.02 (0.97–1.07)	0.401
Weight categories		
1st quintile (<73.3 kg) (ref)	1.00	
2nd quintile (73.3–79.6 kg)	1.12 (0.90–1.39)	0.316
3rd quintile (79.7–84.4 kg)	1.33 (1.06–1.67)	0.015
4th quintile (84.5–91.8 kg)	1.45 (1.15–1.83)	0.002
5th quintile (≥91.9 kg)	1.35 (1.06–1.73)	0.017
Height, continuous	1.01 (0.99–1.02)	0.401
Socioeconomic status[b]		
Low (ref)	1.00	
Middle	0.92 (0.77–1.10)	0.366
High	0.96 (0.80–1.14)	0.626
Years of smoking, continuous	0.99 (0.99–1.00)	0.173
TKR (THR as ref)	1.23 (1.06–1.42)	0.006
Public hospital (Private as ref)	0.61 (0.51–0.73)	<0.001
Inhospital complications		
None (ref)	1.00	
Minor only without major	1.27 (1.06–1.52)	0.009
Major	1.84 (1.52–2.24)	<0.001
Year of TJR, continuous	0.91 (0.88–0.93)	<0.001

Notes: [a]Also controlled for number of past hospitalizations. [b]Socioeconomic status was calculated according to the distribution of the Socio-Economic Index For Areas. **Abbreviations:** CI, confidence interval; THR, total hip replacement; TKR, total knee replacement; TJR, total joint replacement.

Ninety-day readmission was significantly higher among patients treated in public hospitals, patients with an inhospital complication during the index admission, and patients with a high Charlson comorbidity index (Table 4). Of the 142 men who were readmitted within 90 days of total joint replacement, 104 (73.2%) had a single readmission, while 16.9% and 9.9% had two and three or more readmissions, respectively.
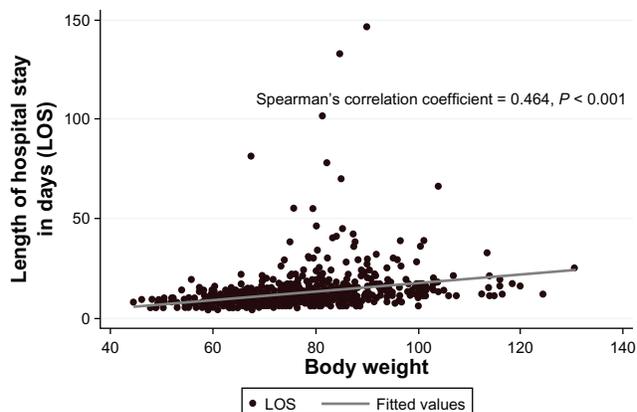

Kaplan–Meier hospital discharge estimates

Log rank test: BMI ≥ 25 versus BMI 18.5–24.9 = $P < 0.001$

Figure 1 Kaplan–Meier estimates of hospital discharge following an elective total joint replacement by body mass index categories: limiting length of stay to 30 days following procedure.
Abbreviation: BMI, body mass index.

Spearman's correlation coefficient = 0.464, $P < 0.001$

Figure 2 Scatter plot of weight in kilograms versus length of stay in days following an elective total joint replacement in men with Spearman correlation coefficient.
Abbreviation: LOS, length of stay.

Table 3 Crude rates of all-cause readmission following elective total joint replacement by selected characteristics

	90-day readmission	One-year readmission	Two-year readmission
Body mass index, kg/m²			
18.5–24.9 (ref)	16.3	44.9	57.8
25–29.9	16.7	45.5	63.2
≥30	19.5	53.3	73.8*
Type of total joint replacement			
Total hip replacement (ref)	17.1	40.5	60.4
Total knee replacement	17.5	51.8*	67.9*
Insurance type			
Private hospital (ref)	14.7	45.1	63.6
Public hospital	22.9*	52.1	67.8
Socioeconomic status[a]			
Low	18.6	50.6*	66.8*
Middle	19.8	52.1*	72.2**
High (ref)	14.2	40.8	57.3
All patients	17.3	47.4	65.0

Notes: **$P < 0.001$; *$0.001 < P < 0.05$. [a]Socioeconomic status was calculated according to the distribution of the Socio-Economic Index For Areas.

The most common principal diagnoses of the first all-cause readmission within 90 days were in the musculoskeletal system (30.3% of all diagnoses), followed by the cardiovascular (16.1%), gastrointestinal (13.4%), and urinary (12.0%) systems (Table 5).

The obese were significantly more likely to be readmitted from all causes following total joint replacement (Figure 3). Controlling for age and Charlson comorbidity index, increasing body weight and lower socioeconomic status were associated with increased risk of all-cause one-year and two-year readmission following the procedure (Table 4). Men with a total knee replacement were significantly more likely to be readmitted compared with those having had total hip replacement. Adjusting for body mass index instead of weight and height produced similar results. The obese (body mass index ≥30 kg/m²) were 34% more likely to return to hospital within two years following the procedure compared with those of normal weight (adjusted HR 1.35, 95% CI 1.03–1.78, $P = 0.029$). No independent associations were found between length of stay during the index total joint replacement admission and 90-day, one-year, or two-year readmission following total joint replacement.

Mortality

Length of stay was not associated with increased mortality following total joint replacement, whereas all-cause short-term readmission (90-day or one-year) independently increased risk of five-year long-term mortality. Compared with those who were never readmitted, risk of long-term mortality was significantly higher in patients who were hospitalized within 90 days (adjusted HR 2.2, 95% CI 1.4–3.5, $P = 0.001$) or one year of the procedure (adjusted HR 1.68, 95% CI 1.1–2.6, $P = 0.016$). The proportional hazards assumption was not violated by any of the covariates in all Cox models.

Discussion

We found no independent associations between length of stay and short-term readmission or mortality following an elective

Table 4 Risk of 90-day, one-year, and two-year readmission following elective total joint replacement: Cox regressions[a]

Covariate	90-day readmission HR (95% CI), P	1-year readmission HR (95% CI), P	2-year readmission HR (95% CI), P
Age[b]	1.02 (0.98–1.06), 0.40	1.02 (0.99–1.05), 0.15	**1.02 (1.00–1.05), 0.04**
Charlson index[b]	**1.06 (1.00–1.16), 0.04**	**1.08 (1.02–1.14), 0.01**	**1.06 (1.00–1.11), 0.04**
Socioeconomic status			
Low	1.20 (0.78–1.85), 0.41	1.24 (0.96–1.61), 0.09	1.24 (0.99–1.54), 0.06
Middle	1.29 (0.86–1.95), 0.22	**1.33 (1.04–1.71), 0.03**	**1.39 (1.13–1.72), 0.00**
High (ref)	1.00	1.00	1.00
Weight[b]	1.01 (0.99–1.03), 0.24	**1.01 (1.00–1.02), 0.04**	**1.01 (1.00–1.02), 0.00**
Height[b]	1.01 (0.98–1.04), 0.45	1.00 (0.99–1.02), 0.64	0.99 (0.98–1.09), 0.44
Years of smoking[b]	1.00 (0.99–1.01), 0.99	0.99 (0.99–1.00), 0.91	0.99 (0.99–1.00), 0.80
TKR (THR as ref)	1.01 (0.71–1.42), 0.97	**1.35 (1.09–1.68), 0.01**	**1.23 (1.03–1.47), 0.03**
Public hospital (Private as ref)	**1.50 (1.07–2.11), 0.02**	1.14 (0.92–1.42), 0.22	1.07 (0.89–1.28), 0.49
Complication[c], yes (no as ref)	**1.41 (1.00–1.98), 0.04**	1.14 (0.93–1.41), 0.21	1.12 (0.93–1.34), 0.22
Length of stay in index TJR-admission[b]	1.01 (0.99–1.02), 0.45	1.00 (0.99–1.01), 0.54	1.01 (0.99–1.01), 0.16
Year of TJR[b]	0.95 (0.89–1.02), 0.15	0.99 (0.95–1.03), 0.57	0.97 (0.93–1.00), 0.06

Notes: [a]Also controlled for number of past hospitalizations; [b]continuous variable; [c]inhospital complication; socioeconomic status based on the distribution of the Socio-Economic Index For Areas.
Abbreviations: CI, confidence interval; HR, hazards ratio; LOS, length of stay; THR, total hip replacement; TJR, total joint replacement; TKR, total knee replacement.

Table 5 Principal diagnosis of first readmission as recorded in hospital morbidity data within 90 days of elective total joint replacement (n = 142)

System	Condition	n	%
Cardiovascular	Acute myocardial infarction	3	2.1
	Angina pectoris	4	2.8
	Atrial fibrillation	3	2.1
	Congestive heart failure	4	2.8
	Postoperative thromboembolism	8	5.6
	Supraventricular tachycardia	1	0.7
Respiratory	Pneumonia	1	0.7
	Postoperative pulmonary emphysema	2	1.4
Gastrointestinal	Abdominal obstruction	1	0.7
	Abdominal pain	1	0.7
	Acute pancreatitis	1	0.7
	Cholelithiasis and cholecystitis	1	0.7
	Constipation	2	1.4
	Gastritis	4	2.8
	Gastrointestinal bleeding/ulcer	8	5.6
	Hernia	1	0.7
Urinary	Urethral stricture	17	12.0
Neurological	Anxiety/delirium	3	2.1
	CVA/TIA	2	1.4
	Convulsions	1	0.7
Musculoskeletal	Carpal tunnel syndrome	1	0.7
	Cellulitis of hip	1	0.7
	Dehiscence of wound	1	0.7
	Dislocation of joint, fracture of bone and other mechanical complications following procedure	21	14.8
	Foreign body accidently left during procedure	1	0.7
	Hematoma of wound	1	0.7
	Signs and symptoms related to joints (pain, swelling, stiffness)	17	12.0
General	Anemia	1	0.7
	Complications of diabetes mellitus	2	1.4
	General signs and symptoms (malaise, fatigue, headache, syncope)	6	4.2
	Postoperative infection	9	6.3
Other	Cancer-related therapy	3	2.1
	Dental abscess	1	0.7
	Fracture of limb following a fall/injury	2	1.4
	Rehabilitation	7	4.9
All		142	100.0

Abbreviations: CVA, cerebrovascular accident; TIA, transient ischemic attack.

total joint replacement. Over a period of ten years, length of stay following this elective procedure dropped in both public and private hospitals. However, readmission to hospital and post-discharge mortality did not change significantly over the years. Prolonged length of stay was significantly associated with being overweight or obese, with increasing age, and with the presence of inhospital complications. After these factors were accounted for, the association of length of stay with subsequent readmission or mortality ceased to be significant.

Comparison of length of stay and readmission between hospitals or studies can be difficult because differences in length of stay or readmission rates among patients may not necessarily reflect differences in the quality of care that the patients received. Such differences may be attributed to many factors, including age and comorbidity, as well as administrative and policy differences that are rarely accounted for in such analyses.[17] Additionally, thresholds for readmission may vary between physicians with the same complication treated in an outpatient setting in one hospital but by readmission in another.[18] Nevertheless, length of stay and subsequent short-term all-cause readmission are considered key performance indicators and measures of quality of hospital care, and are often used to compare patients and hospitals.[17] Length of stay is also used to assess hospital management, planning, and efficiency,[17] and is a major determinant of resource use because it determines the number of beds to be provided. Reducing the length of stay may mean that more beds would be available which, in turn, may lead to a substantial reduction in waiting time for surgery. It has been speculated that increasing inpatient efficiency by lowering the length of hospital stay may result in worse outcomes, including increased hospital readmissions and mortality.[2,6] We hypothesized that length of stay was not independently associated with readmission to hospital following an elective total joint replacement or with post-discharge mortality, and that the apparent positive or negative associations of length of stay with readmission or post-discharge death were confounded by factors such as age, comorbidity, obesity, and presence of complications following the procedure. In our study, over a period of ten years, we observed a decrease in length of stay following elective total joint replacement in both private and public hospitals; however, we found no evidence that shorter length of stay was associated with increased readmission to hospital or with higher mortality after discharge. We found that length of stay was significantly associated with patient characteristics, including age and body weight, and clinical factors, such as presence of inhospital complications. After these determinants of longer stay were accounted for, the association of length of stay with readmission or mortality became statistically insignificant, thus confirming our hypothesis.

The reported associations of obesity with prolonged length of stay following total joint replacement have not been consistent.[9,10] A retrospective study of 3309 patients undergoing primary total hip replacement reported a median length of stay that increased from nine days for patients with a normal body mass index to 10 days in
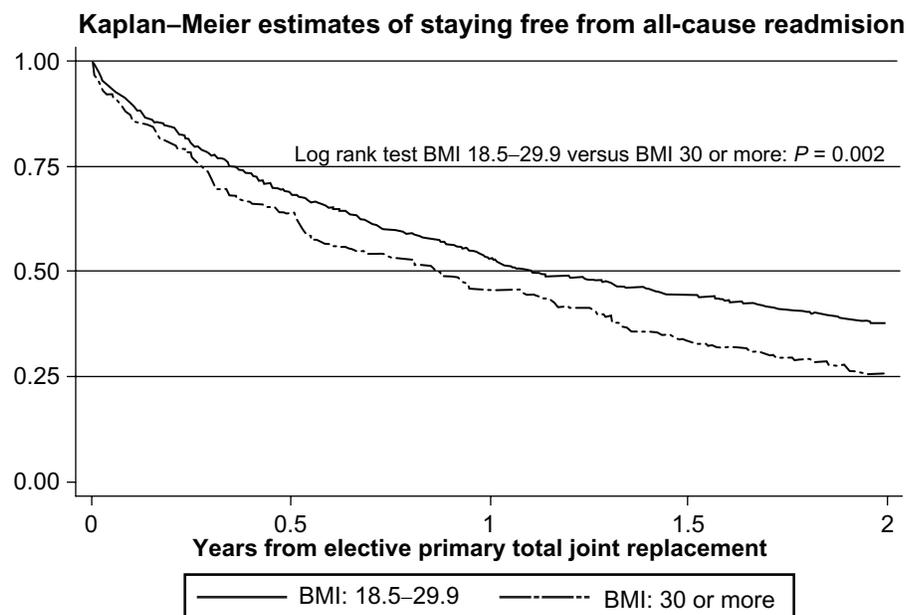
Kaplan–Meier estimates of staying free from all-cause readmision

Figure 3 Kaplan–Meier estimates of staying free from all-cause two-year readmission following an elective total joint replacement by body mass index categories.
Abbreviation: BMI, body mass index.

the obese. In a multivariable analysis, the authors showed that increasing body mass index was significantly associated with an increased mean length of stay ($P < 0.001$).[9] In contrast, a prospective study of 1416 patients undergoing total hip replacement found no significant differences in mean length of stay between the nonobese, obese, and morbidly obese patients (9.8 ± 7.2 days, 9.1 ± 4.5 days, and 8.9 ± 3.1 days, respectively, $P = 0.23$).[10] Schwarzkopf et al found a higher risk of readmission (odds ratio 2.00, 95% CI 1.17–3.38) among the morbidly obese (body mass index $\geq$45) who had had total joint replacement, although these authors did not report any significant association between overall body mass index categories and readmission rates ($P = 0.13$).[19] In contrast, we found that both weight and body mass index were independently associated with both longer stay and higher all-cause readmission following total joint replacement. This increased risk of readmission may be related to long-term complications among the obese[20] that have not been accounted for in this analysis.

The association of socioeconomic disadvantage with worse outcomes in patients who undergo total joint replacement has been reported.[21,22] Patients coming from socioeconomic disadvantaged backgrounds often wait longer for surgery,[23] have higher levels of disease severity at the time of surgery,[24] have lower rates of joint replacement despite their often greater need for surgery (as defined by higher levels of pain, joint functional restrictions),[25] and may also experience higher rates of adverse postoperative outcomes.[21]

In an earlier analysis,[13] we have shown that rates of elective total joint replacement vary by socioeconomic status, with the most disadvantaged experiencing significantly lower rates. Hollowell et al reported a socioeconomic gradient in length of stay for patients undergoing total knee replacement (but not total hip replacement), with more socioeconomically advantaged patients having shorter lengths of stay.[22] However, these researchers did not account for the confounding effects of obesity and smoking. In our cohort, compared with the more affluent, the socioeconomically disadvantaged were more likely to be obese and to smoke more. After we adjusted for these factors, no associations were seen between socioeconomic status and length of stay for either total hip replacement or total knee replacement. However, we found that socioeconomically disadvantaged patients were significantly more likely to return to hospital one and two years following the procedure, which may indicate higher rates of late complications in these patients.

In this study, we also found that men undergoing total knee replacement had worse outcomes than those having total hip replacement, manifested in longer stay in hospital, and higher all-cause readmission rates following the procedure. These adverse outcomes were significantly higher in the obese who had had a total knee replacement. The increased risk of readmission may be related to long-term complications (such as late infections) among patients having total knee replacement[26] that have not been accounted for in this analysis.

Strengths of this study include its population-based nature, longitudinal design, and clinical data that were integrated with validated hospital morbidity data. For each participant, any significant morbidity or health-related outcome was retrieved from the linked data in the period 1970 through to 2007 and this enabled us to account better for patient comorbidities. However, the study has some limitations. We had no access to patients' charts and therefore we could not validate these conditions against these charts and we could not account for the severity of the recorded conditions. However, hospital morbidity data for Western Australia have 21 quality-of-data checks that are built into the provision of data from all public and private hospitals and there are periodic audits of random selections of hospital-assigned codes to ensure quality and validity of the data. Besides the audits, several validation studies have shown that hospital morbidity data for Western Australia accurately identifies patients with major comorbidities[16,27] and operations.[16] The sensitivity and positive predictive value of the hospital morbidity data-recorded total joint replacement were both 0.92 and the specificity was 0.98.[16] Finally, our cohort included only men, and the results cannot be generalized for women. Similarly, the study population was relatively old, and our findings may not be generalizable to other younger patient populations.

In conclusion, our study has found that the overweight, the obese, those having total knee replacement, and the socioeconomically disadvantaged are the highest consumers of hospital resources following an elective total joint replacement in elderly men. After adjusting for age, comorbidity, obesity, and inhospital complications, we found no relationship between length of stay and readmission or post-discharge mortality. Our findings may assist hospitals in assessing case-mix, quality of care, and resource allocation, as well as help clinicians in selecting elderly patients for surgery, and informing them about their individual level of risk.

Acknowledgments

Disclosure

The authors declare that there are no conflicts of interests in this work.

References

1. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am*. 2007;89(4):780–785.
2. Cram P, Lu X, Kaboli PJ, et al. Clinical characteristics and outcomes of Medicare patients undergoing total hip arthroplasty, 1991–2008. *JAMA*. 2011;305(15):1560–1567.
3. Forrest GP, Roque JM, Dawodu ST. Decreasing length of stay after total joint arthroplasty: effect on referrals to rehabilitation units. *Arch Phys Med Rehabil*. 1999;80(2):192–194.
4. Vorhies JS, Wang Y, Herndon J, Maloney WJ, Huddleston JI. Readmission and length of stay after total hip arthroplasty in a national medicare sample. *J Arthroplasty*. 2011;26(Suppl 6):119–123.
5. Mauerhan DR, Lonergan RP, Mokris JG, Kiebzak GM. Relationship between length of stay and dislocation rate after total hip arthroplasty. *J Arthroplasty*. 2003;18(8):963–967.
6. Ottenbacher KJ, Smith PM, Illig SB, Linn RT, Ostir GV, Granger CV. Trends in length of stay, living setting, functional outcome, and mortality following medical rehabilitation. *JAMA*. 2004;292(14): 1687–1695.
7. Rahme E, Dasgupta K, Burman M, et al. Postdischarge thromboprophylaxis and mortality risk after hip-or knee-replacement surgery. *CMAJ*. 2008;178(12):1545–1554.
8. Rissanen P, Aro S, Paavolainen P. Hospital- and patient-related characteristics determining length of hospital stay for hip and knee replacements. *Int J Technol Assess Health Care*. 1996;12(2):325–335.
9. Sadr Azodi O, Bellocco R, Eriksson K, Adami J. The impact of tobacco use and body mass index on the length of stay in hospital and the risk of post-operative complications among patients undergoing total hip replacement. *J Bone Joint Surg Br*. 2006;88(10):1316–1320.
10. Andrew JG, Palan J, Kurup HV, Gibson P, Murray DW, Beard DJ. Obesity in total hip replacement. *J Bone Joint Surg Br*. 2008;90(4): 424–429.
11. McLaughlin JR, Lee KR. The outcome of total hip replacement in obese and non-obese patients at 10- to 18-years. *J Bone Joint Surg Br*. 2006; 88(10):1286–1292.
12. Norman PE, Flicker L, Almeida OP, Hankey GJ, Hyde Z, Jamrozik K. Cohort profile: the Health In Men Study (HIMS). *Int J Epidemiol*. 2009;38(1):48–52.
13. Mnatzaganian G, Ryan P, Norman PE, Davidson DC, Hiller JE. Smoking, body weight, physical exercise, and risk of lower limb total joint replacement in a population-based cohort of men. *Arthritis Rheum*. 2011;63(8):2523–2530.
14. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45(6):613–619.
15. Australian Bureau of Statistics. SEIFA: Socio-Economic Indexes for Areas. Available from: www.abs.gov.au/websitedbs/D3310114.nsf/home/ Seifa_entry_page. Accessed November 1, 2011.
16. Mnatzaganian G, Ryan P, Norman PE, Hiller JE. Accuracy of hospital morbidity data and the performance of comorbidity scores as predictors of mortality. *J Clin Epidemiol*. 2011;65(1):107–115.
17. Agency for Healthcare Research and Quality. Available from: http://www.ahrq.gov/qual/hosptools.htm. Accessed June 1, 2011.
18. Turpie AG. Deep vein thrombosis prophylaxis in the outpatient setting: preventing complications following hospital discharge. *Orthopedics*. 1995;Suppl 18:15–17.
19. Schwarzkopf R, Thompson SL, Adwar SJ, Liublinska V, Slover JD. Postoperative complication rates in the "super-obese" hip and knee arthroplasty population. *J Arthroplasty*. 2011;27(3):397–401.
20. Zimmerli W, Trampuz A, Ochsner PE. Prosthetic-joint infections. *N Engl J Med*. 2004;351(16):1645–1654.
21. Agabiti N, Picciotto S, Cesaroni G, et al. The influence of socioeconomic status on utilization and outcomes of elective total hip replacement: a multicity population-based longitudinal study. *Int J Qual Health Care*. 2007;19(1):37–44.

22. Hollowell J, Grocott MP, Hardy R, Haddad FS, Mythen MG, Raine R. Major elective joint replacement surgery: socioeconomic variations in surgical risk, postoperative morbidity and length of stay. *J Eval Clin Pract*. 2010;16(3):529–538.

23. Fitzpatrick R, Norquist JM, Reeves BC, Morris RW, Murray DW, Gregg PJ. Equity and need when waiting for total hip replacement surgery. *J Eval Clin Pract*. 2004;10(1):3–9.

24. Hajat, S, Fitzpatrick, R, Morris, R, et al. Does waiting for total hip replacement matter? Prospective cohort study. *J Health Serv Res Policy*. 2002;7(1):19–25.

25. Yong PF, Milner PC, Payne JN, Lewis PA, Jennison C. Inequalities in access to knee joint replacements for people in need. *Ann Rheum Dis*. 2004;63(11):1483–1489.

26. Husted H, Otte KS, Kristensen BB, Orsnes T, Kehlet H. Readmissions after fast-track hip and knee arthroplasty. *Arch Orthop Trauma Surg*. 2010;130(9):1185–1191.

27. Teng TH, Finn J, Hung J, Geelhoed E, Hobbs M. A validation study: how effective is the Hospital Morbidity Data as a surveillance tool for heart failure in Western Australia? *Aust NZ J Public Health*. 2008; 32(5):405–407.