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The influence of socioeconomic status on utilization and outcomes of elective total hip replacement: a multicity population-based longitudinal study

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Abstract

Objective. In countries with universal health coverage, socioeconomic status is not expected to influence access to effective treatment and its prognosis. We tested whether socioeconomic status affects the rates of elective total hip replacement and whether it plays a role in early and late outcomes.

Design. Multicity population-based longitudinal study.

Settings and participants. From Hospital Registries of four Italian cities (Rome, Milan, Turin, and Bologna), we identified 6140 residents aged 65+ years undergoing elective total hip replacement in 1997–2000.

Main outcome measures. An area-based (census block) income index was used for each individual. Poisson regression yielded rate ratios (RR) of population occurrence by income level. Logistic regression estimated odds ratios (OR) of selected outcomes within 90 days. Cox proportional hazard models evaluated effects of income on rates of revision of total hip replacement and mortality up to 31 December 2004. Analyses were adjusted for age, gender, city of residence, and coexisting medical conditions.

Results. Low-income people were less likely than high-income counterparts to undergo total hip replacement [RR = 0.87, 95% confidence interval (CI) 0.81–0.95]; the effect was stronger among those aged 75+ years (RR = 0.76, 95% CI = 0.66–0.86). Low income was associated with higher risk of acute adverse medical events (*P* trend = 0.05) and of general infections and decubitus ulcer (*P* trend = 0.02) within 90 days. The effects were even higher among those aged 75+ years. No effects were found either for orthopaedic complications within 90 days or for revision and mortality.

Conclusions. Total hip replacement is underutilized among elderly deprived individuals. Disadvantaged patients seem more vulnerable to acute adverse medical events after surgery. The evidence of unmet need and poor prognosis of low social class people has important implications for health care policy.

Keywords: access to health services, administrative data, adverse events, complications, inequalities in health, hip replacement

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In the last years, socioeconomic disparities in health have been documented in many Western countries, and they are increasingly recognized as an important public health issue [1,2]. Mechanisms of inequalities are complex and vary across conditions and populations, because the relationship between socioeconomic position and health is influenced by patterns of risk-related behaviours and by characteristics of health care systems [2,3].

Access to high-quality health services plays an important role in health disparities. In the United States, socioeconomic position is the most powerful determinant of overall health care use even among those with health insurance [4]. A growing health care gap between rich and poor has been highlighted in an independent report on the performance of the National Health Service (NHS) across the United Kingdom [5]. In Italy—where the NHS has universal coverage—unequal opportunities to obtain optimal care have recently been shown using both National Health Surveys data and population- or hospital-based health registries [6]. This subject is receiving growing attention, and efforts are needed to identify and address disparities in a systematic way.

In the context of health care quality, elective surgical procedures—such as major joint arthroplasty—offer an opportunity to assess the role played by patient's obstacles and preferences in health decisions. Total hip replacement (without hip fracture) is an elective surgery performed to improve function and relieve pain among patients with chronic hip joint diseases. Although it is a major surgery, it has excellent outcomes for most patients. The still scarce epidemiological evidence on total hip replacement shows major geographical variations [7], significant divergence from the statement of best practice [8], and underutilization among poor people [9,10]. Socioeconomic impact on adverse events and surgical complications after total hip replacement has not been investigated till now with the exception of a single study conducted in the United States [9].

We conducted a population-based study to determine whether socioeconomic status affects the rates of elective total hip replacement and whether it plays a role in the early and late outcomes.

Methods

Design, setting, and data sources

We conducted a population-based study in four Italian cities (Rome, Milan, Turin, and Bologna). We used Hospital Information System databases to identify cases of primary total hip replacement and selected outcomes. Hospital discharge abstracts include patients' characteristics, diagnoses (up to 6) and surgical procedure codes (up to 6) according to the International Classification of disease, Ninth Revision, Clinical Modification (ICD-9-CM).

Population data were extracted from the population register of each of the participating cities, on the 1st of January of each year during the study period. Data for 1998 are the following: Rome (2.8 million inhabitants), Milan (1.4 million inhabitants), Turin (900 000 inhabitants), and Bologna (400 000 inhabitants).

Study population

From the Hospital Discharge Registries of the four study cities, we selected all patients aged at least 65 years undergoing primary total hip replacement between 1 January 1997 and 31 December 2000 based on ICD-9-CM procedure code 81.51 (any position). Patients who had been previously hospitalized for hip surgery (codes 81.51, 81.52, and 81.53) between 1 January 1996 and the first total hip replacement found in the study period were not included. We also excluded individuals with codes indicating metastasis or bone cancers, fracture of the hip or femur, or complications of previous total hip replacement according to a validated algorithm [11]. We then excluded patients whose surgery took place in a rehabilitation admission or in a region other than the one of residence. People undergoing two or more total hip replacement in the study period were excluded because of the difficulty of attributing outcomes to the correct surgery. At the end of the selection process, we obtained 6185 primary total hip replacements. Details and codes are reported in the online appendix (Supplementary material).

Hip pathology and coexisting medical conditions

The reason for total hip replacement—defined as hip pathology—was identified (osteoarthrosis, Paget disease, and other degenerative diseases, osteoarthritis/collagen vascular disease, aseptic necrosis, unknown). We defined selected coexisting conditions after a validated coding algorithm (revised Elixhauser AHRQ-Web-ICD-9-CM): diabetes, hypertension, cardiac and circulatory disorders, pulmonary disease, renal disease, liver disease, coagulation deficiency, deficiency anaemia, and obesity [12]. We also studied vein diseases, ischemic heart disease, and cerebrovascular disease, because these can play a role in the outcomes of orthopaedic surgery. We identified conditions on the basis of ICD-9-CM codes registered either in the index hospitalization or in the previous 6-month admissions; in the algorithm, codes related to acute medical events taking place at the index hospitalization and which could be complications of care were not included. Details and codes are reported in the online appendix (Supplementary material).

Indicator of socioeconomic status

As an indicator of the individual socioeconomic status, we used a city-specific index based on the median per capita income within the census block of residence. The median number of inhabitants per census block was 260. Data relative to income earned in 1998 (Italian Tax Register) were linked to Population Registers of the four cities to connect family information to each resident's income data and to calculate the net family income. We obtained the per capita income, weighted for the number of family members, and aggregated data at the census block level to calculate the median income.

To obtain categorical values for the income indicator, we calculated the quintiles of the income distribution by census block, for each city (I, high income; V, low income). Recipients of

primary total hip replacement who were missing values for income index in our cohort (n = 45) were excluded from analyses.

Outcomes of surgery

On the basis of ICD-9-CM codes, registered both in the index hospitalization and in the subsequent 90 days after hospital discharge, we identified three categories of outcomes: (i) acute adverse medical events (including pulmonary embolism, haemorrhagic anaemia, and cardiac complications); (ii) orthopaedic complications (including haematoma, dislocations, and joint infections); and (iii) general infections and decubitus ulcer (including septicaemia, pulmonary, and urinary infections). Details and codes are reported in the online appendix (Supplementary material).

We also studied the rates of revision of total hip replacement (procedure code 81.53 any position) and death (any cause) up to 31 December 2004. Follow-up data on hospital readmissions were obtained by linkage with the Hospital Discharge Registry, whereas information on vital status was obtained through a record linkage procedure with the Municipal Registry of each city.

Data analysis

The rate of occurrence of total hip replacement in the study period was calculated by dividing the number of subjects who had a surgery in a given income quintile by the corresponding eligible population in the same socioeconomic group. All rates were directly standardized for age to the European standard population and expressed as the number of total hip replacement per 1000 inhabitants. Rate ratios (RR) were estimated with Poisson regression to assess the relationship between income level and total hip replacement incidence rates [RR, 95% confidence interval (CI)] on the data set overall as well as separately for men and women. The patient characteristics considered in the Poisson analysis were age, gender, and city of residence. Stratified analyses were run by age group (65–74, 75+ years). Effect modification by age was tested using an interaction term in the regression model and the likelihood ratio test. P-values for linear trend were calculated by Wald test.

To examine the association between income level and outcomes within 90 days, we performed logistic regression analyses [odds ratios (OR)] separately for the three categories. Cox proportional hazard models were used to calculate hazard ratios (HR) of revision and mortality by income level. Covariates were age (linear term), gender, city of residence, and coexisting conditions. Backward stepwise procedures were used to discard those variables that were not associated with the specific outcome ($P > 0.20$). Quintiles of income were considered as a categorical variable, but P-values for linear trend were also calculated. Again, the analyses were performed on the overall data set as well as by age group (65–74, 75+ years). P-values for linear trend were calculated by Wald test.

Data sets were prepared using SAS 8.0, and all statistical analyses were performed using the software STATA version 8.0. All P-values reported are two-sided.

Results

We studied 6140 primary total hip replacements among elderly people (aged 65+) in the four cities in 1997–2000. The majority were women, and 40.6% were resident in Rome. The mean age was 72.3 years among men and 73.3 years among women. People in the lowest income level tended to be younger and to have higher probability of coexisting conditions than more privileged persons. Hip pathology differed only slightly across income levels (Table 1).

Total hip replacement was more frequent among women (1.89 per 1000 inhabitants versus 1.31 among men); the rates were lowest in the oldest age group in both genders. Overall, people in the lowest income level were 13% less likely to receive primary total hip replacement than people in the highest level; the relative probability was even lower for those at least 75 years old, especially among women (RR 0.73, 95% CI 0.63–0.85) (Table 2). The interaction term for age was borderline significant ($P = 0.07$), and among the elderly, there was a clear effect modification by gender ($P = 0.02$).

A total of 377 individuals (6.1%) had acute adverse medical events, 335 (5.4%) orthopaedic complications, and 93 (1.5%) general infections and decubitus ulcer. Two hundred and fifty-eight persons (4.1%) had a revision surgery before the end of 2004, and 917 (14.8%) died. About 94.1% of outcomes were found in the index admission. The interaction term for age group by income was significant only for acute adverse medical complications ($P = 0.003$). Overall, low income was associated with higher risk of acute adverse medical events (P trend = 0.050) and of general infections and decubitus ulcer (P trend = 0.02). No association was found for orthopaedic complications and for revision and mortality. Among people aged at least 75 years, the effect of income on early outcomes were stronger than in the whole group and in the younger age group. Low-income people had an increased risk of revision, but the association was not statistically significant. No differences in the risk of dying were observed across income levels. Similar results were obtained in the two different age groups. All results were not substantially modified by adjustment for covariates (data not shown). (Table 3).

Discussion

We found that more disadvantaged people are less likely to undergo primary total hip replacement than the more affluent group; moreover, low-income people have higher probability of negative outcomes after this surgery.

In the United States and Canada, race/ethnic and socioeconomic disparities in the utilization of total hip replacement have been extensively documented especially at the end of life [9,13], whereas data from Europe are still limited [14]. In the United States, rates of total hip replacement are lower in individuals with low income than in those with high income [13], and in African-Americans and Hispanics than in non-Hispanic whites [15]; in addition, longer waiting time is associated with low education [13]. An important unmet need for total hip replacement has been highlighted in the United Kingdom among old and

Table 1 Characteristics of people who underwent total hip replacement by income levels

	Income levels (quintiles)					
	I high *n* = 1217 %	II *n* = 1227 %	III *n* = 1308 %	IV *n* = 1265 %	V low *n* = 1123 %	Total *n* = 6140 %
City of residence						
Rome	42.5	41.6	42.6	38.6	37.4	40.6
Milan	31.2	29.9	29.7	31.5	35.1	31.4
Turin	14.8	16.8	16.6	15.6	14.9	15.7
Bologna	11.5	11.6	11.1	14.4	18.8	12.2
Gender						
Males	32.0	30.8	27.7	30.4	28.0	29.8
Females	67.9	69.2	72.3	69.6	71.9	70.2
Age						
Mean age (SD)	73.6 (5.8)	73.0 (5.7)	73.0 (5.4)	72.8 (5.4)	72.6 (5.3)	73.0 (5.5)
Age 65–74	58.7	62.0	62.6	63.7	65.2	62.4
Age 75+	41.3	37.9	37.4	36.3	34.8	37.6
Hip pathology						
Arthrosis	89.9	89.4	90.7	90.2	91.1	90.3
Paget	4.3	5.7	4.6	4.9	4.1	4.7
Arthritis	0.3	0.8	0.6	0.9	0.5	0.6
Aseptic necrosis	3.0	2.1	1.5	2.0	2.0	2.1
Unknown	2.6	2.0	2.5	2.1	2.4	2.3
Coexisting conditions						
Diabetes	1.8	1.6	2.0	4.4	3.5	2.6
Hypertension	9.7	11.6	13.7	14.8	15.0	12.9
Cardiac and circulatory	3.6	4.2	5.1	4.8	5.4	4.6
Pulmonary	1.8	2.0	2.3	2.7	2.9	2.3
Renal-liver-blood	1.2	1.0	1.2	1.8	1.1	1.2
Tumour	1.0	0.7	0.4	0.3	0.8	0.6
Vein	1.1	2.0	1.7	1.8	2.9	1.9
Obesity	0.2	0.2	0.7	0.6	0.8	0.5
Number of coexisting conditions						
0	83.2	80.5	78.6	76.4	75.3	78.8
1	13.8	16.1	16.6	17.6	18.1	16.4
2+	3.0	3.4	4.8	6.0	6.6	4.8

disadvantaged people, and reducing the waiting time for elective orthopaedic surgery has been recommended [5,16].

The decision of whether a joint arthroplasty will be performed is complex and depends on various factors: clinical characteristics of the hip, physician recommendations, patient's perceptions and preferences, and interactions between doctors and patients. Explanations of the variability in rates across socioeconomic groups may be various [17]. Firstly, lower need among the most disadvantaged is an unlikely cause: persons with lower socioeconomic position not only have worse symptoms and disability [18] but also have a similar willingness to undergo surgery in comparison to those in higher socioeconomic status [13]. Secondly, differences in patients' perceptions, preferences of care and expectations in pain-related outcomes, and subsequent walking ability have been largely considered responsible for the marked race/ethnic differences, as the intent of this surgery is not to prevent death but rather to improve quality of life [19,20]. Lastly, worse general health among poor people may be related to disparate rates because patients with multiple medical problems are not good candidates for an elective procedure [21]. However, even adjusting for comorbidity, there was a greater unmet need to joint arthroplasty among less-educated and/or low-income patients [13].

In our study, total hip replacement among low-income people is unlikely to reflect a lower need, because the prevalence of osteoarthritis in Italy is 1.89 times greater in disadvantaged individuals than in the more affluent category [22]. It is plausible that lack of knowledge about the procedure and its benefits—rather than different health valuation and preferences for care as in the United States—is higher among social disadvantaged groups in our country. Wealthy persons' easier accessibility to private sector care, associated with a shorter waiting list, might be responsible for the observed disparities.

Table 2 Hospitalization for total hip replacement (rates per 1000 inhabitants) and association (rate ratios, RR) with income levels

Income level	Men			Women			Men and Women		
	Rate	RR	95% CI	Rate	RR	95% CI	Rate	RR	95% CI
65+ years of age									
I high	1.19	1.00		1.82	1.00		1.51	1.00	
II	1.27	1.01	0.88–1.17	1.92	1.02	0.93–1.13	1.59	1.02	0.94–1.11
III	1.15	0.91	0.79–1.05	1.88	1.05	0.96–1.15	1.51	1.01	0.93–1.09
IV	1.25	0.99	0.86–1.14	1.88	1.01	0.92–1.11	1.57	1.01	0.93–1.09
V low	1.04	0.85	0.73–0.98	1.59	0.88	0.80–0.97	1.31	0.87	0.81–0.95
P trend		0.04			0.02			0.002	
65–74 years of age									
I high	0.86	1.00		1.23	1.00		1.04	1.00	
II	0.88	1.02	0.86–1.21	1.37	1.08	0.95–1.22	1.12	1.06	0.95–1.17
III	0.84	0.92	0.77–1.09	1.30	1.11	0.98–1.26	1.07	1.04	0.94–1.15
IV	0.87	0.99	0.84–1.18	1.28	1.06	0.93–1.19	1.07	1.03	0.93–1.14
V low	0.74	0.86	0.71–1.02	1.19	1.01	0.89–1.14	0.96	0.96	0.86–1.06
P trend		0.11			0.94			0.36	
75+ years of age									
I high	0.34	1.00		0.58	1.00		0.46	1.00	
II	0.39	1.01	0.78–1.29	0.55	0.96	0.83–1.12	0.47	0.97	0.86–1.11
III	0.31	0.89	0.69–1.14	0.58	0.98	0.85–1.13	0.44	0.96	0.84–1.08
IV	0.38	0.97	0.76–1.25	0.60	0.96	0.83–1.12	0.49	0.96	0.85–1.09
V low	0.30	0.84	0.64–1.09	0.39	0.73	0.63–0.85	0.35	0.76	0.66–0.86
P trend		0.20			<0.001			<0.001	

Rates and RR are standardized for age, gender, and city of residence.

Given that women are less likely to be offered total hip replacement in comparison with men despite their higher need [23], our study suggests that lower personal family resources enlarge these discrepancies especially at very old age. Lastly, the lower rates of total hip replacement in most disadvantaged may be related to their worse baseline clinical conditions that could have resulted in a contraindication to surgery; the greater presence of comorbid conditions in low-income people in our study seems to confirm this hypothesis.

Increasing attention has been paid in evaluating complications of surgery and their relationship with socioeconomic status [24,25], but the effect of social factors on outcomes after total hip replacement is largely unknown. In the United States, Mahomed *et al.* [9] studied outcomes within 90 days and found increased risk of death, readmission to hospital, and wound infections—but not pulmonary embolism—in low-income persons. In Japan, agricultural work had a significant relation with prosthetic loosening in a 7.5-year follow-up hospital-based study of 151 patients [26].

To our knowledge, this study is the first in Europe to document the effect of low social class on short- and long-term outcomes after total hip replacement, using data from population-based registries. People in the lower social class—especially in old age—might be more vulnerable to short-term adverse medical events because of their bad comorbidity status, which in general worsen the prognosis after surgery [9,24]. The higher risk of general infections and decubitus ulcer among poor people provides grounds of concern about the quality of hospital care after this surgery. In contrast, short-term orthopaedic complications and long-term revision rates did not differ across socioeconomic groups. These results partially contradict the expectation of a more compromised prognosis in poor people, who in general experience greater waiting times and undergo surgery with more pain and disability [13,16]; however, other studies found great improvement in those with worse conditions before surgery [27]. In comparison with acute adverse medical events, these complications are more strongly related to the ability of the surgeons, technical procedure, and type of prosthesis, factors that seem not to be influenced by socioeconomic status in our study. Interestingly, the lack of social gradient in mortality suggests that those who obtain access to proper health care—like total hip replacement—may experience improved access to the medical system in general or may be more prone to modify unhealthy behaviours.

This study has several strengths: the population-based design, the validated algorithm for cohort selection and variable definitions, and the number of outcomes studied. In this respect, quality of evidence on effectiveness of orthopaedic surgery and variation of practice is poor, and there is a need for greater use of validated outcome measures [8,28]. The revision of surgery is the most commonly reported outcome, even though a number of patients' assessed outcomes on functional status and quality of life have been developed and

Table 3 Association (odds ratios, OR and hazards ratios, HR) between income levels and outcomes of total hip replacement

Income level	*N*	Acute adverse medical events				Orthopedic complications				Infections and decubitus ulcer				Revision				Mortality			
		n	%	OR	95% CI	n	%	OR	95% CI	n	%	OR	95% CI	n	%	HR	95% CI	n	%	HR	95% CI
65+ years of age																					
I	1217	54	4.4	1.00		73	6.0	1.00		13	1.1	1.00		45	3.7	1.00		184	15.1	1	
II	1227	74	6.0	1.38	0.96–1.98	52	4.2	0.69	0.48–0.99	14	1.1	1.07	0.50–2.28	51	4.2	1.13	0.74–1.74	181	14.7	0.96	0.78–1.18
III	1308	89	6.8	1.57	1.11–2.22	65	4.9	0.82	0.58–1.16	16	1.2	1.15	0.55–2.39	52	3.9	1.10	0.72–1.69	195	14.9	0.98	0.79–1.20
IV	1265	90	7.1	1.65	1.17–2.33	71	5.6	0.93	0.66–1.30	28	2.2	2.10	1.08–4.07	51	4.0	1.09	0.71–1.69	186	14.7	0.97	0.79–1.19
V	1123	67	5.9	1.36	0.94–1.97	69	6.1	1.02	0.73–1.44	20	1.8	1.68	0.83–3.39	56	4.9	1.34	0.87–2.04	160	14.2	0.93	0.75–1.15
P trend	0.050					0.44				0.02				0.25				0.61			
65–74 years of age																					
I	714	29	4.1	1.00		34	4.8	1.00		8	1.1	1.00		25	3.5	1.00		64	8.9	1	
II	761	45	5.9	1.48	0.92–2.39	28	3.7	0.76	0.46–1.27	9	1.2	1.05	0.40–2.75	28	3.7	1.07	0.60–1.89	76	9.9	1.13	0.81–1.58
III	819	55	6.7	1.70	1.07–2.69	38	4.6	0.97	0.60–1.56	8	0.9	0.87	0.32–2.33	33	4.0	1.21	0.69–2.09	91	11.1	1.24	0.89–1.72
IV	806	55	6.8	1.73	1.09–2.74	43	5.3	1.13	0.71–1.79	16	1.9	1.79	0.76–4.20	30	3.7	1.19	0.68–2.06	84	10.4	1.19	0.86–1.66
V	732	25	3.4	0.84	0.48–1.44	34	4.6	0.97	0.59–1.58	11	1.5	1.35	0.53–3.37	31	4.2	1.25	0.71–2.19	73	9.9	1.16	0.82–1.62
P trend	0.90					0.53				0.23				0.38				0.38			
75+ years of age																					
I	503	25	4.9	1.00		39	7.7	1.00		5	0.9	1.00		20	3.9	1.00		120	23.9	1	
II	466	29	6.2	1.26	0.73–2.20	24	5.1	0.65	0.38–1.09	5	1.1	1.08	0.31–3.75	23	4.9	1.24	0.65–2.37	105	22.5	0.89	0.68–1.16
III	489	34	6.9	1.43	0.84–2.43	27	5.5	0.69	0.42–1.15	8	1.6	1.65	0.54–5.09	19	3.9	0.96	0.48–1.89	104	21.3	0.87	0.67–1.14
IV	459	35	7.6	1.58	0.93–2.68	28	6.1	0.77	0.48–1.28	12	2.6	2.30	0.93–7.65	21	4.6	0.98	0.49–1.96	102	22.2	0.89	0.69–1.18
V	391	42	10.7	2.30	1.38–3.84	35	8.9	1.17	0.73–1.88	9	2.3	2.35	0.78–7.05	25	6.4	1.52	0.79–2.91	87	22.2	0.89	0.67–1.17
P trend	0.001					0.50				0.03				0.42				0.44			

OR and HR are crude values (see text for comments).

applied [29,30]. Short-term medical and orthopaedic complications after total hip replacement have also been studied; however, definitions strongly vary across different studies, and comparison is difficult [31,32]. Our preventable adverse outcomes include most of the Agency for Healthcare Research and Quality Safety Indicators which have been recently developed [24,25]; however, we used wider definitions for medical conditions and considered specific orthopaedic items to increase power to detect socioeconomic status-related effects.

Some limits should be considered. We attributed an aggregated indicator of income, measured in 1998, on the basis of the person's place of residence at discharge. Small-area indicators of income, attributed to area-coded health data, have been proved to produce valid and robust estimates in the analysis of socioeconomic inequalities in health; however, attributing an aggregated indicator to the individual can underestimate the true association [33]. As there is no best estimator of socioeconomic status suitable in all settings and each indicator measures different aspects of socioeconomic status, using other measures—e.g. level of education—might have led to different conclusions. Quality of discharge abstract data is a major problem. We were not able to validate the codes used for outcomes and comorbidity. However, different coding practice across hospitals and misclassification errors of comorbidity and complications are unlikely to be associated with socioeconomic status. It is more probable, on the contrary, that true incidence of complications may be higher than reported—because some complications may have gone undetected or undocumented—obscuring socioeconomic disparities. As a last consideration, this study was only able to consider a total hip replacement failure if it had been revised. Moreover, we could not study patients potentially revised in another city or the potential impact on other important outcomes as pain, function, and satisfaction.

In conclusion, this study showed socioeconomic disparities in access to total hip replacement in Italy, where the universal health care system is not expected to produce economic barriers. Moreover, the evidence of worse clinical conditions and of greater vulnerability to operative complications after surgery in more disadvantaged individuals highlights the necessity of taking into account patients' social conditions when evaluating pre-operative status and prognostic factors. This study calls for further research about the potential impacts of technical procedures, type of prosthesis, surgeon ability, and other organizational characteristics of hospitals on socioeconomic disparities in outcomes.

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Conflicting interests

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Supplementary material

Supplementary data are available at http://intqhc.oxfordjournals.org/.

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