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Outcomes of Inpatients With and Without Sickle Cell Disease After High-Volume Surgical Procedures

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Abstract

In this study, we examined differences in inpatient costs, length of stay, and in-hospital mortality between hospitalizations for patients with and without sickle cell disease (SCD) undergoing high-volume surgical procedures. We used Clinical Classification Software (CCS) codes to identify discharges in the 2002–2005 Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project for patients who had undergone either cholecystectomy or hip replacement. We limited the non-SCD cohort to hospitals where patients with SCD had undergone the same procedure. We compared inpatient outcomes using summary statistics and generalized linear regression analysis to adjust for patient, hospital, and procedural characteristics. Overall, the median age of surgical patients with SCD was more than 3 decades less than the median age of patients without SCD undergoing the same procedure. In recognition of the age disparity, we limited the analyses to patients aged 18 to 64 years. Nonetheless, patients with SCD undergoing cholecystectomy or hip replacement were 12.1 and 14.4 years younger, had inpatient stays that were 73% and 82% longer, and incurred costs that were 46% and 40% higher per discharge than patients without SCD, respectively. Inpatient mortality for these procedures was low, approximately 0.6% for cholecystectomy and 0.2% for hip replacement, and did not differ significantly between patients with and without SCD. Multivariable regression analyses revealed that higher inpatient costs among patients with SCD were primarily attributable to longer hospital stays. Patients with SCD who underwent cholecystectomy or hip replacement required more health care resources than patients without SCD.

Keywords

Anemia, Sickle Cell; Costs and Cost Analysis; Hospital Mortality; Length of Stay; Surgical Procedures, Operative

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Introduction

Sickle cell disease (SCD) is the most commonly inherited hemoglobinopathy in the United States, and 1 in every 500 African Americans is born with homozygous SCD, the most common form of the disease [1]. It is estimated that sickle cell anemia affects more than 70,000 Americans [2]. Because predominant hemoglobin S (HbS) red cells block blood vessels due to their reduced pliability and increased adhesiveness, patients with SCD have a hospitalization rate 7 to 30 times higher than persons aged less than 60 years [3] and are more likely to undergo surgical procedures to treat persistent or acute organ dysfunction [4–6]. Moreover, surgery-related processes, such as hypoxemia and cytokine release, increase red blood cell sickling and adhesion, anemia, and the frequency of vaso-occlusion. Therefore, patients with SCD undergoing surgical procedures are generally considered to be at higher risk for perioperative and postoperative complications than patients without SCD [7–10].

Concerns about the greater risk of surgery-related complications in patients with SCD have led researchers to investigate the safety and efficacy of preoperative transfusion [5,11]. Although evidence for the efficacy of preoperative transfusion is not conclusive [12], previous studies have suggested that surgical treatment of patients with SCD requires more intensive perioperative care and that these patients may experience higher rates of complications than other patients undergoing the same procedures [13,14]. SCD-related postoperative complications occur in over 30% of patients, even after preoperative transfusion [6].

Recent work by Adam et al [15] has compared the characteristics of patients with SCD who undergo different surgical and obstetric procedures. However, to our knowledge, no studies have compared characteristics and outcomes of patients with and without SCD undergoing similar surgical procedures. Therefore, using the 2002–2005 Nationwide Inpatient Sample (NIS), we examined differences in inpatient costs, length of stay, and in-hospital mortality between patients with and without SCD who underwent cholecystectomy or hip replacement surgery, the most common nonobstetric surgical procedures among patients with SCD in the United States.

Results

A total of 118,187 non-SCD discharges and 887 SCD discharges for cholecystectomy occurred at NIS hospitals where at least 1 patient with SCD had undergone the procedure from 2002 to 2005. Among the non-SCD discharges, 2% of the patients were younger than 18 years and 30% were 65 years or older. By comparison, these percentages were 46% and 2%, respectively, among patients with SCD. A total of 69,670 non-SCD discharges and 321 SCD discharges for hip replacement occurred from 2002 through 2005 in the NIS sample. Among the non-SCD discharges, 0.4% of the patients were younger than 18 years and 59% were 65 years and older. In the SCD cohort, both less than 3%. To increase the comparability of the cohorts with and without SCD, subsequent analyses included only discharges for patients aged 18 through 64 years.

Despite limiting the analyses to patients aged 18 to 64 years, patients with SCD were, on average, more than a decade younger than patients without SCD undergoing the same procedures (Table I). Among discharges for which race was reported in the NIS, approximately 90% of cholecystectomy and hip replacement patients with SCD were black. Patients with SCD were half as likely to have private health insurance and more than twice as likely to have Medicare or Medicaid ($P < 0.001$).

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Table I shows the comorbid conditions that were prevalent in more than 2% of the study sample. Patients with SCD were significantly more likely to have congestive heart failure, coagulopathy, fluid and electrolyte disorders, neurologic disorders, and pulmonary circulation disorders than patients without SCD ($P < 0.05$). Patients without SCD were more likely to have depression, diabetes mellitus, hypertension, hypothyroidism, and obesity. The prevalence of hypertension, obesity, and diabetes was at least twice as high among non-SCD discharges for both cholecystectomy and hip replacement. For cholecystectomy, the prevalence of obesity was more than four times higher among patients without SCD.

Procedural characteristics and overall inpatient outcomes also varied between the SCD and non-SCD cohorts (Table II). Patients with SCD were more likely to undergo nonelective surgery for both procedures ($P < 0.001$).

Patients with SCD were significantly more likely to receive a blood transfusion during hospitalization for either cholecystectomy (35.6% vs. 3.0%; $P < 0.001$) or hip replacement (46.7% vs. 26.9%; $P < 0.001$).

Unadjusted Inpatient Outcomes

Unadjusted length of stay and inpatient costs were significantly greater among patients with SCD compared with patients without SCD for both surgeries ($P < 0.001$ for all comparisons). Among patients undergoing hip replacement, the mean length of stay was almost twice as long for patients with SCD as for patients without SCD (8.0 vs. 4.4 days). Inpatient costs among patients with SCD undergoing cholecystectomy were 46% higher than for patients without SCD, an absolute difference of approximately $6600 per discharge ($P < 0.001$). Similarly, inpatient costs among patients with SCD undergoing hip replacement were 40% higher than for patients without SCD, an absolute difference of approximately $7000 ($P < 0.001$). In-hospital mortality was low for both surgical procedures (< 1%) and did not differ significantly between patients with and without SCD.

Adjusted Inpatient Outcomes

After adjustment for potentially confounding variables, inpatient costs among patients undergoing cholecystectomy remained 43% (95% CI, 34%–52%) higher for patients with SCD than for patients without SCD (Table III). Costs for patients with pulmonary circulatory disorders, weight loss, or coagulopathy were approximately twofold higher than for patients without these conditions ($P < 0.001$ for all comparisons). Length of stay was 70% (95% CI, 59%–81%) greater for patients with SCD than for patients without SCD ($P < 0.001$). Mortality was not significantly associated with SCD but was greater among patients undergoing open vs. laparoscopic surgery and nonelective vs. elective surgery. After adjustment for patient, procedural, and hospital characteristics for hip replacement discharges, inpatient costs for patients with SCD remained 25% (95% CI, 20%–31%) higher than for patients without SCD ($P < 0.001$). Pulmonary circulation and coagulopathy were associated with 35% or greater increases in cost ($P < 0.001$). Length of stay was 56% (95% CI, 47%–64%) greater for patients with SCD ($P < 0.001$). Mortality was not significantly associated with SCD.

Including discharge disposition in the analyses of length of stay did not change the significance or magnitude of the estimated SCD coefficients. Including length of stay and discharge destination in analyses of inpatient costs largely attenuated the direct association of SCD with costs. In regression models that included length of stay and discharge destination, SCD inpatient costs were only 5% higher relative to non-SCD discharges for hip replacement (95% CI, 1%–9%; $P = 0.02$). Costs remained 12% (95% CI, 8%–17%; $P <$

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0.001) higher for patients with SCD undergoing cholecystectomy than for patients without SCD.

To examine potential causes of increased resource use among patients with SCD, we examined inpatient costs and length of stay in SCD discharges with and without sickle cell crisis. SCD with crisis occurred in 38% of cholecystectomy and 15% of hip replacement discharges of SCD patients, and was absent in non-SCD discharges.

Compared with SCD without crisis, SCD with crisis was associated with 35% (95% CI, 19%–52%; $P < 0.0001$) higher costs and a 53% (95% CI, 34%–74%; $P < 0.001$) greater length of stay among patients undergoing cholecystectomy. Compared with non-SCD controls, SCD with crisis was associated with 69% (95% CI, 54%–87%; $P < 0.001$) higher costs and a 115% (95% CI, 95%–137%; $P < 0.001$) greater length of stay for cholecystectomy discharges.

For hip replacement discharges, SCD with crisis was associated with 27% (95% CI, 13%–43%; $P < 0.001$) higher costs and an 82% (95% CI, 59%–108%; $P < 0.001$) greater length of stay compared with SCD without crisis. Compared with non-SCD controls, SCD with crisis was associated with 53% (95% CI, 37%–71%; $P < 0.001$) higher costs and a 150% (95% CI, 122%–282%; $P < 0.001$) greater length of stay in hip replacement discharges.

Discussion

This study is the first empirical examination of differences in inpatient costs, length of stay, and in-hospital mortality between patients with and without SCD undergoing high-volume surgical procedures. Cholecystectomy and hip replacement are clinically important for patients with SCD, in that the prevalence of cholelithiasis ranges from 30% to 70% in these patients and avascular necrosis of the hips occurs in up to 50% [16–19].

Patients with SCD who underwent cholecystectomy incurred 46% higher costs and 73% greater length of stay than patients without SCD. Adjustment for patient, procedural, and hospital characteristics mitigated this effect somewhat, but costs remained 43% higher and length of stay 70% greater. Patients with SCD who underwent hip replacement incurred 40% higher unadjusted costs and 82% greater length of stay than patients without SCD. Adjustment for other potentially explanatory variables had a greater impact for hip replacement than for cholecystectomy, but adjusted costs remained significantly higher by 25% and length of stay 56% greater for patients with SCD. When we included length of stay and discharge disposition as covariates in the cost models, the impact of SCD was greatly attenuated, suggesting that the higher costs associated with SCD are due largely to longer inpatient stays. However, it is important to note that a significant association between SCD and inpatient costs persisted, even after adjustment for length of stay.

Inclusion of sickle cell crisis as a covariate in the regression models revealed that sickle cell crisis is responsible for a substantial portion of SCD burden. Among patients with SCD, sickle cell crisis was associated with a 27% or greater incremental increase in costs and a 53% or greater incremental increase in length of stay for both procedures. Nevertheless, even after factoring out the incremental impact of sickle cell crisis, costs and length of stay were significantly greater for patients with SCD.

We restricted this analyses to patients aged 18 to 64 years who were treated at hospitals where at least 1 patient with SCD had undergone one of the procedures of interest. Although we believe the selection criteria strengthened our ability to make valid comparisons, some differences in patient and hospital characteristics remained. For example, the age distributions of patients with and without SCD were significantly different. In addition, the

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comorbid conditions prevalent in the non-SCD cohorts (ie, diabetes mellitus, hypertension, and obesity) reflected the older age of the patients as compared with the SCD cohorts. This observation is consistent with findings by Adams et al [15] that cholecystectomy and hip replacement were not associated with body mass index in patients with SCD, despite such trends in the general population. A study of Medicare beneficiaries with SCD in Tennessee found that men aged 20 to 49 years had significantly higher overall mortality than women [3], which may be partially explained by our observation of a 72% higher mortality rate in men undergoing cholecystectomy compared with women undergoing the same procedure.

The higher prevalence of pulmonary circulatory disorders may reflect the presence of pulmonary hypertension or symptoms of acute chest syndrome, both of which are complications of SCD. It is likely that controlling for comorbid conditions associated with SCD decreased the observed association of SCD with inpatient outcomes in the multivariable analyses. Patients with SCD had much higher rates of coagulation and pulmonary circulatory disorders. These conditions were associated with greater than 100% higher costs for cholecystectomy and 35% higher costs for hip replacement. These comorbid conditions might more appropriately be considered part of the burden of SCD rather than factors to be controlled in a regression model. In addition, some reports have indicated that screening for certain comorbid conditions, such as pulmonary hypertension, may occur more often in patients with SCD [24]. Increased screening in patients with SCD would result in a positive correlation between these conditions and SCD, which would decrease the magnitude of any perceived effect of SCD on costs, length of stay, and mortality. Thus, controlling for comorbid conditions may have resulted in underestimates of the direct effects of SCD on inpatient outcomes.

This study also provided an opportunity to evaluate the use of perioperative transfusion. Although some reports have suggested that laparoscopic cholecystectomy can be performed without transfusion in patients with SCD [20], a recent study found that most children with SCD who undergo either a laparoscopic or open abdominal procedure receive a preoperative or postoperative transfusion [21]. In our study, 35.2% of patients with SCD who underwent laparoscopic cholecystectomy and 46.7% of those who underwent hip replacement received a blood transfusion during the hospital stay. These figures are likely an underrepresentation of the number of patients who received preoperative transfusions, because practitioners may administer transfusions before the hospital admission.

Variables omitted from the regression models could have biased the results if they were correlated with SCD status and reflected the circumstances or severity of the need for surgery, the quality of the procedure, differences in hospital practices, and differences in baseline clinical characteristics that would affect outcomes. To mitigate the effects of hospital characteristics, we limited the analysis to patients with and without SCD from the same hospitals and controlled for remaining differences in hospital characteristics. Other differences between patients with and without SCD, including the expected primary payer, age, and comorbid conditions, were included in the model to adjust for potential confounding. Because there were differences in age distributions between the SCD and non-SCD cohorts even after the exclusion of patients who were not aged 18 to 65 years, we conducted the analyses separately for 3 age groups (18 to 30 years, 31 to 44 years, 45 to 64 years) and had similar results.

Limitations

Our study has some limitations. First, the NIS data represent hospital discharges, not individual patients. As a result, patients could have been counted more than once. However, given the procedures of interest, we assumed that this possibility had minimal impact. Also, the NIS is limited to in-hospital outcomes; we could not evaluate rehospitalization rates or

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postdischarge mortality. Therefore, the mortality rates, total costs, and inpatient days associated with surgery may be underestimates.

Compared with other studies using data from the NIS, our sample size is small. This result largely reflects the low prevalence of the combination of SCD with specific surgical procedures. Furthermore, our findings likely underestimate the number of patients with SCD who underwent cholecystectomy or hip replacement, because we excluded patients who were coded as having sickle cell trait only. Although it was our intention to exclude these individuals from the analyses, a previous analysis of children in the NIS reported that at least one third of cases identified with vaso-occlusive and pain crises were coded as having sickle cell trait—presumably in error, as sickle cell trait is not associated with these complications [22]. However, given the large numbers of patients in the non-SCD cohorts, misclassifying some patients as not having SCD is expected to have a small effect on the results.

Finally, we did not apply the NIS sample weights in this study because we did not intend to make national projections. By limiting the non-SCD cohort to patients treated at hospitals where patients with SCD underwent the same procedures, national estimates would not have been meaningful.

Conclusions

Patients with SCD underwent cholecystectomy and hip replacement at much younger ages than patients without SCD. After adjustment for patient, procedural, and hospital characteristics, patients with SCD were hospitalized for longer periods and incurred higher inpatient costs. Nevertheless, risk of in-hospital death was similar among patients with and without SCD. Future studies of length of stay among patients with SCD might help to identify means by which care for these patients can be managed more effectively.

Methods

Data Source

The primary data source for this study was the 2002–2005 NIS, part of the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality (AHRQ) [25]. The NIS includes complete discharge information for 1004 hospitals, representing approximately 20% of all community hospitals in the United States. Information obtained from the NIS includes patient demographic characteristics (though race/ethnicity was not available for Georgia, Illinois, Kentucky, Maine, Minnesota, Nebraska, Nevada, Ohio, Oregon, Washington, and West Virginia); principal and secondary diagnoses and procedures; All Patient Refined Diagnosis Related Group (APR-DRG) mortality and disease severity indices; discharge status; and length of stay. Diagnoses and procedures are coded using both *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and Clinical Classification Software (CCS) codes. The CCS is a classification tool developed by AHRQ that collapses more than 13,000 *ICD-9-CM* diagnosis codes and 3700 *ICD-9-CM* procedure codes into a smaller set of clinically meaningful categories [24]. Twenty-nine comorbid conditions were generated from *ICD-9-CM* diagnosis codes using software developed by AHRQ. These conditions are generated to reflect patient characteristics separate from primary diagnoses and have been shown to affect inpatient outcomes independent of the primary diagnosis [27].

The NIS also includes inpatient charge data for each discharge. To allow for conversion of charges to costs, AHRQ provides estimates of all-payer inpatient cost-to-charge ratios for individual NIS hospitals [28]. We estimated the costs of inpatient care by multiplying the total charge by the hospital-specific cost-to-charge ratio. For years when hospital-specific

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cost-to-charge ratios were not available for specific states, we applied a state-level cost-to-charge ratio to calculate inpatient costs. Texas and Pennsylvania did not have cost information in any year.

Derivation of the Analysis Data Set

We identified patients with SCD based on the presence of CCS code 61 as the principal diagnosis or as 1 of 14 secondary diagnoses. We assumed that all other patients did not have SCD. CCS code 61 includes diagnosis of sickle cell trait, which we did not expect to be clinically relevant in the context of surgery. Therefore, we reclassified discharges having only *ICD-9-CM* diagnosis code 282.5 (sickle cell trait) to the non-SCD group. We classified discharges with *ICD-9-CM* diagnosis code 282.42, 282.62, or 282.64 as SCD with crisis [23], including vaso-occlusive pain crisis, splenic sequestration, acute chest syndrome, or sickle cell crisis not otherwise specified. We then used CCS code 84 to identify patients who underwent cholecystectomy and CCS code 153 to identify patients who underwent hip replacement. These were the 2 most frequent surgical procedures among patients with SCD after we excluded procedures associated with childbirth. We identified patients who underwent laparoscopic cholecystectomy by using *ICD-9-CM* procedure codes 51.23 or 51.24. We used *ICD-9-CM* procedure codes 99.00 to 99.04 recorded for any of the 15 possible procedure codes to identify patients who had received at least 1 blood transfusion during the hospitalization stay.

In previous work using the NIS data, approximately two thirds of hospitalizations of patients with SCD occurred in teaching hospitals [23], suggesting that patients with and without SCD may be treated at systematically different hospitals. To address this issue, for each surgery we limited the analysis of non-SCD cases to hospitals where at least 1 patient with SCD was discharged for the same procedure during the period 2002 through 2005.

Statistical Analyses

We performed analyses for cholecystectomy and hip replacement separately. We used descriptive statistics to summarize patient, procedural, and discharge characteristics and the outcomes among patients with and without SCD for each procedure. We used Rao-Scott chi-square tests [29] and *t* tests, as appropriate, to compare patients with and without SCD. We then used a generalized linear regression model to examine the relationship between SCD and costs, length of stay, and mortality while adjusting for potential confounders. When analyzing costs, we specified the models using gamma distributions and log links. For length of stay, we specified the models using negative binomial distributions and log links. For mortality, we applied binomial distributions and logit links.

Each regression model included a constant term, variables representing SCD, age, sex, primary payer, elective surgery, and laparoscopic surgery (for cholecystectomy only), and dichotomous variables for 29 comorbid conditions. Options for the primary payer variable included Medicare, Medicaid, private insurance, self-pay, no charge, and other. Private insurance was the reference category. For cholecystectomy, we included an indicator variable for laparoscopic surgery.

To evaluate the independent effect of SCD on inpatient costs after accounting for differences in length of stay and discharge disposition, we added a continuous variable representing length of stay and dummy variables representing discharge disposition to the regression model. Similarly, when evaluating the impact of SCD on length of stay, we added covariates representing discharge disposition to the regression model.

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We used SAS software version 9.1.3 (SAS Institute Inc, Cary, North Carolina) for all analyses. The institutional review board of the Duke University Health System approved the study.

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Table I

Characteristics of Patients With or Without Sickle Cell Disease Undergoing Cholecystectomy or Hip Replacement

Characteristic	Cholecystectomy			Hip Replacement		
	Sickle Cell Disease (n = 467)	No Sickle Cell Disease (n = 79,683)	*P* Value	Sickle Cell Disease (n = 306)	No Sickle Cell Disease (n = 28,015)	*P* Value
Age, mean (SE), y	31.0 (0.52)	43.1 (0.05)	< 0.001	37.6 (0.67)	52.0 (0.06)	< 0.001
Age, median (IQR), y	27 (21–39)	44 (32–54)	—	37 (29–47)	54 (47–59)	—
Age group, No. (%)			< 0.001			< 0.001
18 to 30 years	271 (58.0)	15,916 (20.0)		96(31.4)	766 (2.7)	
31 to 44 years	129 (27.6)	24,864 (31.2)		117 (38.2)	4703 (16.8)	
45 to 64 years	67 (14.4)	38,903 (48.8)		93 (30.4)	22,546 (80.5)	
Male, No. (%)	200 (42.8)	22,607 (28.3)	< 0.001	111 (36.3)	14,270 (50.9)	< 0.001
Race, No. (%)			< 0.001			< 0.001
Black	360 (77.1)	11,397 (14.3)		197 (64.4)	2862 (10.2)	
Other*	25 (5.4)	54,693 (68.6)		20 (6.5)	17,686 (63.1)	
Missing	82 (17.6)	13,593 (17.1)		89 (29.1)	7467 (26.7)	
Primary expected payer, No. (%)			< 0.001			< 0.001
Private insurance	144 (30.8)	49,535 (62.2)		93 (30.4)	20,539 (73.3)	
Medicare	83 (17.8)	5884 (7.4)		106 (34.6)	3688 (13.2)	
Medicaid	185 (39.6)	12,233 (15.4)		95 (31.1)	2074 (7.4)	
Other†	52 (11.1)	11,905 (14.9)		11 (3.6)	1680 (6.0)	
Comorbid conditions, No. (%)						
Alcohol abuse	≤ 10 (≤ 2.1)	1520 (1.9)	0.10	≤ 10 (≤ 3.3)	632 (2.3)	0.13
Deficiency anemia	37 (7.9)	3799 (4.8)	0.001	19 (6.2)	2998 (10.7)	0.01
Rheumatoid arthritis/collagen vascular disease	≤ 10 (≤ 2.1)	950 (1.2)	0.13	≤ 10 (≤ 3.3)	1483 (5.3)	0.11
Congestive heart failure	20 (4.3)	1647 (2.1)	< 0.001	12 (3.9)	502 (1.8)	0.006
Chronic obstructive pulmonary disease	34 (7.3)	7554 (9.5)	0.11	31 (10.1)	3230 (11.5)	0.45
Coagulopathy	30 (6.4)	1410 (1.8)	< 0.001	11 (3.6)	419 (1.5)	0.003
Depression	16 (3.4)	4345 (5.5)	0.05	11 (3.6)	2272 (8.1)	0.004

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Characteristic	Cholecystectomy			Hip Replacement		
	Sickle Cell Disease (n = 467)	No Sickle Cell Disease (n = 79,683)	*P* Value	Sickle Cell Disease (n = 306)	No Sickle Cell Disease (n = 28,015)	*P* Value
Diabetes mellitus	14 (3.0)	8877 (11.1)	< 0.001	11 (3.6)	2432 (8.7)	0.002
Drug abuse	11 (2.4)	938 (1.2)	0.02	≤ 10 (≤ 3.3)	320 (1.1)	0.18
Hypertension	55 (11.8)	21,489 (27.0)	< 0.001	59 (19.3)	11,140 (39.8)	< 0.001
Hypothyroidism	≤ 10 (≤ 2.1)	3976 (5.0)	< 0.001	≤ 10 (≤ 3.3)	1975 (7.1)	< 0.001
Liver disease	12 (2.6)	4398 (5.5)	0.005	≤ 10 (≤ 3.3)	493 (1.8)	0.87
Fluid/electrolyte disorders	79 (16.9)	7903 (9.9)	< 0.001	26 (8.5)	1420 (5.1)	0.007
Obesity	≤ 10 (≤ 2.1)	7676 (9.6)	< 0.001	≤ 10 (≤ 3.3)	2946 (10.5)	< 0.001
Neurological disorders	21 (4.5)	1717 (2.2)	< 0.001	15 (4.9)	726 (2.6)	0.01
Pulmonary circulation disorders	≤ 10 (≤ 2.1)	337 (0.4)	< 0.001	≤ 10 (≤ 3.3)	139 (0.5)	< 0.001
Renal failure	15 (3.2)	1,409 (1.8)	0.02	≤ 10 (≤ 3.3)	495 (1.8)	0.86
Valvular disease	≤ 10 (≤ 2.1)	1599 (2.0)	0.84	≤ 10 (≤ 3.3)	753 (2.7)	0.14

*"Other" includes Asian or Pacific Islander, Hispanic, Native American, white, and other.

†"Other" includes self-pay, no charge, and other.

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Table II

Procedure-Related Characteristics of Patients With or Without Sickle Cell Disease Undergoing Cholecystectomy or Hip Replacement

Characteristic	Cholecystectomy			Hip Replacement		
	Sickle Cell Disease (n = 467)	No Sickle Cell Disease (n = 79,683)	*P* Value	Sickle Cell Disease (n = 306)	No Sickle Cell Disease (n = 28,015)	*P* Value
Laparoscopic surgery, No. (%)	395 (84.6)	60,788 (76.3)	< 0.001	—	—	—
Elective surgery, No. (%)	103 (22.1)	23,875 (30.0)	0.001	226 (73.9)	24,084 (86.0)	< 0.001
Discharge disposition, No. (%)			< 0.001			< 0.001
Home health care	17 (3.7)	2786 (3.5)		107 (35.1)	11,947 (42.7)	
Routine	428 (92.6)	74,548 (94.2)		88 (28.9)	8083 (28.9)	
Other*	17 (3.6)	1845 (2.3)		110 (35.9)	7925 (28.2)	
Blood transfusion, No. (%)	139 (35.6)	873 (3.0)	< 0.001	143 (46.7)	7528 (26.9)	< 0.001
Hospital size, No. (%)†			< 0.001			< 0.001
Small	39 (8.4)	4164 (5.2)		30 (9.8)	4794 (17.1)	
Medium	107 (22.9)	13,446 (16.9)		74 (24.2)	3908 (14.0)	
Large	321 (68.7)	62,073 (77.9)		202 (66.0)	19,313 (68.9)	
Hospital location, No. (%)			0.04			< 0.001
Rural	27 (5.8)	3119 (3.9)		≤ 10 (≤ 3.3)	27,831 (0.7)	
Urban	440 (94.2)	76,564 (96.1)		297 (97.1)	184 (99.3)	
Hospital ownership, No. (%)			0.29			0.04
Not specified	306 (65.5)	53,466 (67.1)		224 (73.2)	22,089 (78.9)	
Public	44 (9.4)	5978 (7.5)		15 (4.9)	896 (3.2)	
Private	117 (25.1)	20,239 (25.4)		67 (21.9)	5030 (18.0)	
US geographic region, No. (%)			0.002			0.002
Northeast	79 (16.9)	15,037 (18.9)		47 (15.4)	6503 (23.2)	
Midwest	86 (18.4)	11,332 (14.2)		56 (18.3)	4890 (17.5)	
South	262 (56.1)	42,630 (53.5)		178 (58.2)	13,773 (49.2)	
West	40 (8.6)	10,684 (13.4)		25 (8.2)	2849 (10.2)	
Hospital teaching status, No. (%)			0.14			0.001

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Characteristic	Cholecystectomy			Hip Replacement		
	Sickle Cell Disease (n = 467)	**No Sickle Cell Disease (n = 79,683)**	***P* Value**	**Sickle Cell Disease (n = 306)**	**No Sickle Cell Disease (n = 28,015)**	***P* Value**
Non-teaching hospital	209 (44.8)	32,967 (41.4)		99 (32.4)	6856 (24.5)	
Teaching hospital	258 (55.3)	46,716 (58.6)		207 (67.7)	21,159 (75.5)	
In-hospital outcomes						
Costs, $						
Mean (SE)	20,727 (1292)	14,157 (88)	< 0.001	24,603 (1053)	17,608 (63)	< 0.001
Median (IQR)	13,073 (9009–20,566)	9015 (6302–13,745)	—	19,914 (15,103–26,252)	15,852 (12,734–19,829)	
Length of stay, days						
Mean (SE)	9.0 (0.52)	5.2 (0.03)	< 0.001	8.0 (0.48)	4.4 (0.03)	< 0.001
Median	6.5 (3–11)	3 (2–6)	—	5 (4–8)	4 (3–5)	—
Mortality, No. (%)[‡]	≤ 10 (≤ 2.1)	504 (0.6)	0.12	≤ 10 (≤ 3.3)	60 (0.2)	0.53

Abbreviation: IQR, interquartile range; SE, standard error.

[*] "Other" includes transfer to short-term hospital, other transfer, unknown disposition, missing data, and patients who left the hospital against medical advice.

[†] Hospital size categories in the Nationwide Inpatient Sample are based on the number of hospital beds but are specific to the hospital's location and teaching status. A complete description of the hospital size category is available online at http://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp.

[‡] Chi-square test may not be valid because of small expected counts; the Fisher exact test could not be calculated.

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Table III

Multivariate Regression of Costs, Length of Stay, and Mortality Among Patients With or Without Sickle Disease Undergoing Cholecystectomy or Hip Replacement*

Variable	Cholecystectomy		Hip Replacement	
	In-Hospital Costs			
	Cost Ratio (95% CI)	*P* Value	Cost Ratio (95% CI)	*P* Value
Constant	14,031 (13,439–14,649)	< 0.001	37,235 (34,903–39,723)	< 0.001
Sickle cell disease	1.43 (1.34–1.52)	< 0.001	1.25 (1.20–1.31)	< 0.001
Laparoscopic surgery	0.50 (0.49–0.50)	< 0.001	—	
Elective surgery	0.83 (0.82–0.84)	< 0.001	0.84 (0.83–0.85)	< 0.001
Age (decades)	1.04 (1.03–1.04)	< 0.001	0.98 (0.98–0.99)	< 0.001
Primary expected payer				
Private	1.00 [Reference]		1.00 [Reference]	
Medicare	1.15 (1.13–1.18)	< 0.001	1.05 (1.04–1.07)	< 0.001
Medicaid	1.16 (1.15–1.18)	< 0.001	1.07 (1.05–1.09)	< 0.001
Self-pay	1.06 (1.04–1.08)	< 0.001	1.03 (0.99–1.07)	0.14
No charge	1.26 (1.21–1.31)	< 0.001	0.99 (0.90–1.08)	0.79
Other	1.07 (1.04–1.09)	< 0.001	1.04 (1.02–1.07)	< 0.001
Male sex	1.20 (1.19–1.22)	< 0.001	1.01 (1.00–1.02)	0.02
Hospital size				
Small	1.00 [Reference]		1.00 [Reference]	
Medium	1.17 (1.14–1.20)	< 0.001	0.84 (0.82–0.85)	< 0.001
Large	1.10 (1.07–1.12)	< 0.001	0.80 (0.79–0.81)	< 0.001
Urban hospital	0.98 (0.96–1.00)	0.10	0.67 (0.64–0.71)	< 0.001
Hospital ownership				
Not specified	1.00 [Reference]		1.00 [Reference]	
Public	1.06 (1.04–1.09)	< 0.001	0.88 (0.85–0.92)	< 0.001
Private	1.12 (1.09–1.14)	< 0.001	0.80 (0.78–0.82)	< 0.001
US geographic region				
Northeast	1.00 [Reference]		1.00 [Reference]	
Midwest	1.04 (1.03–1.06)	< 0.001	0.96 (0.95–0.98)	< 0.001
South	0.99 (0.98–1.01)	0.22	1.07 (1.06–1.09)	< 0.001
West	1.24 (1.22–1.26)	< 0.001	1.25 (1.23–1.27)	< 0.001
Teaching hospital	1.21 (1.19–1.23)	< 0.001	1.00 (0.97–1.02)	0.69
	Length of Stay			
	Length of Stay Ratio (95% CI)	*P* Value	Length of Stay Ratio (95% CI)	*P* Value
Constant	4.95 (4.69–5.22)	< 0.001	5.76 (5.21–6.36)	< 0.001
Sickle cell disease	1.70 (1.59–1.81)	< 0.001	1.56 (1.47–1.64)	< 0.001
Laparoscopic surgery	0.46 (0.46–0.47)	< 0.001	—	—
Elective surgery	0.69 (0.69–0.70)	< 0.001	0.67 (0.66–0.68)	< 0.001
Age (decades)	1.61 (1.06–1.07)	< 0.001	1.01 (1.00–1.02)	0.07

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Variable	Cholecystectomy		Hip Replacement	
Primary expected payer				
Private	1.00 [Reference]		1.00 [Reference]	
Medicare	1.23 (1.20–1.25)	< 0.001	1.12 (1.10–1.14)	< 0.001
Medicaid	1.27 (1.25–1.29)	< 0.001	1.22 (1.19–1.25)	< 0.001
Self-pay	1.12 (1.10–1.14)	< 0.001	1.19 (1.13–1.25)	< 0.001
No charge	1.19 (1.14–1.24)	< 0.001	1.34 (1.21–1.48)	< 0.001
Other	1.18 (1.14–1.21)	< 0.001	1.17 (1.13–1.21)	< 0.001
Male sex	1.20 (1.18–1.21)	< 0.001	0.95 (0.94–0.96)	< 0.001
Hospital size				
Small	1.00 [Reference]		1.00 [Reference]	
Medium	1.11 (1.08–1.14)	< 0.001	0.94 (0.91–0.96)	< 0.001
Large	1.15 (1.12–1.18)	< 0.001	0.91 (0.89–0.93)	< 0.001
Urban hospital	1.07 (1.04–1.11)	< 0.001	1.05 (0.97–1.14)	0.22
Hospital ownership				
Not specified	1.00 [Reference]		1.00 [Reference]	
Public	1.02 (0.99–1.05)	0.26	0.85 (0.81–0.90)	< 0.001
Private	0.95 (0.93–0.98)	< 0.001	0.91 (0.87–0.95)	< 0.001
US geographic region				
Northeast	1.00 [Reference]		1.00 [Reference]	
Midwest	1.01 (1.00–1.03)	0.16	0.93 (0.91–0.96)	< 0.001
South	1.04 (1.03–1.06)	< 0.001	0.93 (0.91–0.95)	< 0.001
West	0.97 (0.95–0.99)	0.002	0.92 (0.90–0.95)	< 0.001
Teaching hospital	1.06 (1.04–1.08)	< 0.001	0.94 (0.91–0.98)	< 0.001
	In-Hospital Mortality			
	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Constant	0.002 (0.001–0.006)		0	
Sickle cell disease	1.55 (0.58–4.14)	0.39	0.55 (0.06–4.74)	0.59
Laparoscopic surgery	0.16 (0.13–0.20)	< 0.001	—	—
Elective surgery	0.69 (0.55–0.87)	0.001	0.29 (0.15–0.56)	< 0.001
Age (decades)	1.36 (1.23–1.50)	< 0.001	1.24 (0.87–1.77)	0.24
Primary expected payer				
Private	1.00 [Reference]		1.00 [Reference]	
Medicare	1.80 (1.40–2.33)	0.08	4.48 (2.26–8.90)	< 0.001
Medicaid	1.30 (0.97–1.74)	< 0.001	2.86 (1.21–6.77)	0.02
Self-pay	1.22 (0.84–1.77)	0.31	1.70 (0.33–8.64)	0.53
No charge	1.09 (0.44–2.70)	0.85	1.00 (1.00–1.00)	> 0.99
Other	1.34 (0.84–2.14)	0.23	1.95 (0.42–9.01)	0.39
Male sex	1.72 (1.41–2.09)	< 0.001	0.82 (0.46–1.47)	0.49
Hospital size				
Small	1.00 [Reference]		1.00 [Reference]	
Medium	1.31 (0.76–2.27)	0.33	1.68 (0.47–6.01)	0.42

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Variable	Cholecystectomy		Hip Replacement	
Large	1.19 (0.71–1.97)	0.52	1.35 (0.48–3.81)	0.57
Urban hospital	1.36 (0.76–2.46)	0.30	1.00 (1.00–1.00)	—
Hospital ownership				
Not specified	1.00 [Reference]		1.00 [Reference]	
Public	1.35 (0.77–2.38)	0.30	1.11 (0.06–20.91)	0.94
Private	1.07 (0.67–1.72)	0.76	1.65 (0.16–17.32)	0.67
US geographic region				
Northeast	1.00 [Reference]		1.00 [Reference]	
Midwest	0.82 (0.59–1.14)	0.24	1.03 (0.42–2.54)	0.95
South	0.96 (0.72–1.29)	0.81	0.96 (0.42–2.19)	0.93
West	0.85 (0.59–1.24)	0.39	0.18 (0.02–1.58)	0.13
Teaching hospital	0.95 (0.64–1.41)	0.81	2.23 (0.26–19.22)	0.47

Abbreviation: CI, confidence interval.

*Regression models included all of the variables listed plus 29 comorbid conditions.