Published in final edited form as:

Am J Hematol. 2011 April ; 86(4): 377–380. doi:10.1002/ajh.21977.

Hospital volume, hospital teaching status, patient socioeconomic status, and outcomes in patients hospitalized with sickle cell disease

Timothy L. McCavit^{1,2,*}, Hua Lin³, Song Zhang⁴, Chul Ahn⁴, Charles T. Quinn⁵, and Glenn Flores^{2,3,4}

¹Division of Pediatric Hematology-Oncology, University of Texas Southwestern Medical Center at Dallas, Texas

²Children's Medical Center Dallas, Dallas, Texas

³Division of General Pediatrics, Department of Pediatrics, University of Texas Southwestern Medical Center at Dallas, Texas

⁴Department of Clinical Sciences, University of Texas Southwestern Medical Center at Dallas, Texas

⁵Division of Hematology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

Abstract

Sickle cell disease (SCD) accounts for ~100,000 hospitalizations in the US annually. Quality of care for hospitalized SCD patients has been insufficiently studied. Therefore, we aimed to examine whether four potential determinants of quality care, [1] hospital volume, [2] hospital teaching status, [3] patient socioeconomic status (SES), and [4] patient insurance status are associated with three quality indicators for patients with SCD: [1] mortality, [2] length of stay (LOS), and [3] hospitalization costs. We conducted an analysis of the 2003–2005 Nationwide Inpatient Sample (NIS) datasets. We identified cases using all ICD-9CM codes for SCD. Both overall and SCD-specific hospital volumes were examined. Multivariable analyses included mixed linear models to examine LOS and costs, and logistic regression to examine mortality. About 71,481 SCD discharges occurred from 2003 to 2005. Four hundred and twenty five patients died, yielding a mortality rate of 0.6%. Multivariable analyses revealed that SCD patients admitted to lower SCD-specific volume hospitals had [1] increased adjusted odds of mortality (quintiles 1–4 vs. quintile 5: OR, 1.36; 95% CI, 1.05, 1.76) and [2] decreased LOS (quintiles 1–4 vs. quintile 5, effect estimate –0.08; 95% CI, –0.12, –0.04). These are the first data describing associations between lower SCD-specific hospital volumes and poorer outcomes.

Sickle cell disease (SCD) affects 70,000–100,000 people in the United States, accounting for nearly 100,000 hospitalizations annually [1]. In 2004, the average cost per SCD hospitalization was \$6,223, with an estimated aggregate cost of \$488 million [1]. Despite the large number and cost of hospitalizations in SCD patients, the quality of care (QOC) for these hospitalizations has not been studied sufficiently.

In other medical conditions, frequently studied factors associated with QOC-related outcomes are hospital volume, hospital teaching status, patient socioeconomic status (SES), and patient insurance coverage. Most published reports have demonstrated that higher hospital volumes are associated with improved QOC, [2] an association first established in the surgical literature [3]. More recently, the association of hospital volume and outcomes has been reported for several medical conditions, including acute myocardial infarction (AMI) [4] and HIV/AIDS [5]. Similarly, lower SES and lack of health insurance have been consistently associated with poorer QOC [6–9]. The only published report investigating SES in SCD found no association between indirect SES markers and QOC-related outcomes in children [10]. The association between teaching status and QOC has been inconsistent [11]. To our knowledge, no prior study has investigated the effects of multiple potential determinants of QOC on QOC-related outcomes in SCD.

We hypothesized that higher hospital volumes, specifically greater volume of SCD hospitalizations, are associated with improved QOC outcomes.

Results

Descriptive analyses

A total of 71,481 discharges met inclusion criteria (Table I). In-hospital mortality occurred in 0.6%. Most discharges were from large-volume hospitals, from the largest sickle cell volume quintile, from teaching hospitals, for patients in the lowest income quartile, and covered by Medicaid or Medicare. Nearly three quarters of SCD discharges had an ICD-9CM code for sickle cell anemia (Supporting Information Table I), whereas 20% were for unspecified SCD.

Bivariable analyses

Bivariable analyses (Table II) revealed that the highest quintile of SCD-specific hospital volumes was associated with significantly lower mortality (quintile 5 – 0.5% vs. 0.9% for quintiles 1–4, $P < 0.0001$). Non-teaching hospital status, older age, and higher APS-DRG severity scores also were associated with increased mortality. All independent variables of interest were associated with LOS and costs of hospitalization (Table III), with the lone exception of SES with LOS.

Multivariable analyses

Mortality—In multivariable analyses, lower SCD-specific hospital volumes were associated with significantly higher adjusted odds of mortality (Table III). Older age, earlier year of admission, and higher APS-DRG severity scores also were significantly associated with higher adjusted odds of mortality, whereas admission in 2005 (vs. 2003) was associated

with lower mortality. Among adults only (data not shown) mortality analyses yielded similar results to all patients. There were too few deaths for mortality analyses for children ($n = 19$).

LOS—Lower SCD-specific hospital volume, non-teaching hospital status, uninsurance, younger age, and admission in 2005 were associated with a significantly shorter adjusted LOS (Table III). Public insurance coverage, female gender, and higher APS-DRG severity scores were associated with an increased LOS. Multivariable analysis of LOS limited to adults (data not shown) yielded similar findings to analyses for all patients. Among children, younger age was associated with decreased LOS, whereas higher APS-DRG severity scores were associated with an increased LOS (data not shown).

Cost—Lower SES and younger age were associated with significantly lower hospital costs, whereas higher APS-DRG severity scores were associated with increased costs (Table III). Analyses of costs limited to adults (data not shown) yielded similar results to analyses for all patients. Among children (Supporting Information Table II), age <1 year was associated with lower costs, whereas non-teaching hospital status and higher APS-DRG severity scores were associated with higher costs.

Discussion

In this study, lower SCD-specific hospital volume was associated with significantly higher mortality and decreased LOS. Non-teaching hospital status was associated with decreased LOS. Lower patient SES was associated with lower costs and uninsurance was associated with decreased LOS. These findings persisted even after adjustment for potential confounders.

The association between hospital volumes and outcomes was first described in the early 1980s in the surgical literature. Recent reports of acute and chronic medical conditions, such as HIV and AMI, also have shown an association between low-volume hospitals and mortality. The effect size of hospital volumes on mortality is small but consistent across medical conditions, including, as shown here, SCD. The increased mortality at lower SCD-volume hospitals might be attributable to a lack of high-quality structures and processes available at higher SCD-volume centers, such as hematologists with SCD expertise, clinical practice guidelines, clinical decision support through electronic medical records, experienced nursing staff, and adequate ICU support for critically ill SCD patients. The study findings suggest that low SCD-specific volume centers might consider efforts to improve guideline adherence and to better access appropriate hematologic expertise (when unavailable locally) through telemedicine, consultation, or transfer of care.

The association between SCD-specific hospital volume and mortality also suggests that regionalization of SCD care, especially for adults, may have the potential to improve outcomes. For example, hemophilia treatment centers, established by the Centers for Disease Control and Prevention in 1975, dramatically improve costs, service utilization, and functional outcomes [12]. On the other hand, a recent report which modeled the effect of regionalization of common vascular surgeries concluded that regionalization would be highly disruptive, while only moderately reducing mortality [13]. A modest or relative

regionalization for SCD patients may be feasible, however, given that 90% of SCD patients live in a metropolitan area where higher QOC centers may be as accessible as low-volume, low-quality centers. Validated QOC measures are needed to identify regional centers-of-excellence, and would allow development of a “report card” for hospitals providing SCD patient-care.

The association of lower SCD-specific hospital volumes with decreased LOS may reflect the preponderance of high acuity patients receiving care in high-volume centers, although we attempted to control for this in our models. Alternatively, this finding might be attributable to lack of recognition of SCD complications requiring prolonged hospitalization or inadequate treatment of pain in low-volume centers. In children, the finding that admission to a non-teaching hospital is associated with increased costs is unexpected, as teaching hospitals are commonly associated with increased costs [14–16]. This finding might be attributable to increased availability and expertise of pediatric hematologists within teaching centers, greater use of clinical practice guidelines, or other influences.

Certain study limitations, inherent to a cross-sectional analysis of administrative data, should be noted. First, a small subset of SCD patients are admitted many times per year and their over-representation in the data may have skewed the findings [17]. Second, patient identification relied on ICD-9 code accuracy, which is inherently imperfect. Third, the APS-DRG severity score may have been inadequate to control for referral bias. Finally, the use of median household income by ZIP code may not accurately capture an individual’s SES, which may have led to an over- or under-estimation of association with the dependent variables. No other SES variable, however, was available in the NIS.

In conclusion, this is the first study, to our knowledge, to document that SCD patients cared for in-hospitals serving the highest numbers of SCD patients are less likely to die in the hospital. Our findings suggest that outcomes could be improved for patients with SCD by identifying and highlighting SCD centers-of-excellence and through regionalization of SCD care. Primary care providers and hematologists for adult patients with SCD, in particular, might consider SCD-specific hospital volume when deciding where to admit or refer SCD patients.

Methods

Overview/study design

The data sources were the 2003–2005 Nationwide Inpatient Sample (NIS) databases. The NIS data are collected by multiple state/hospital agencies in the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality. The NIS approximates a 20% stratified sample of US community hospitals and is an all-payer, de-identified patient database.

Subjects

Subjects were identified using ICD-9CM codes for all forms of SCD listed as the primary or any of 14 secondary discharge codes (Table I). We sought a broad sample, so discharges for all ages and both genders were included; no discharges were excluded. This study was

approved by the Institutional Review Board of the University of Texas Southwestern Medical Center.

Definitions and variables

Independent variables. The NIS categorizes overall hospital size as small, medium, or large, based on bed number, geographic region, teaching status, and hospital location (rural vs. urban). SCD-specific hospital volumes were determined by frequency counts of SCD discharges by hospital ID; volumes were then categorized into quintiles. For SES, we used the only available measure in the NIS, an indirect marker, quartiles of the median annual household income for the patient's ZIP code. Patients' insurance coverage was classified using the primary payer: Medicare, Medicaid, private insurance, self-pay (uninsured), no charge, or other. Hospital teaching status was used as defined by the NIS. The all-payer severity-adjusted diagnosis related groups (APs-DRG) severity score was used as a disease-severity variable in which (0) designates no comorbidity, (1) designates a comorbidity/complication, and (2) designates a major comorbidity/complication. Other independent variables included in analyses were age, race/ethnicity, gender, year of admission, and weekend admission.

Dependent variables. In-hospital mortality, length of stay (LOS) in days, and the cost of hospitalization, derived from charges using a cost-to-charge ratio provided by the NIS, were the dependent variables of interest.

Analyses

All analyses were performed using SUDAAN 10.0 (Research Triangle Institute, Research Triangle Park, NC). LOS and cost were log-transformed to adjust for skewness. For bivariable analyses, Pearson's χ^2 test was used to analyze associations with mortality, and the Wilcoxon rank-sum test to analyze associations with LOS and costs. A stepwise multiple logistic regression model was used for mortality, and stepwise mixed linear regression models were used for LOS and costs. Discharge weights were used for bivariable and multivariable analyses; however, the descriptive statistics were unweighted. A dummy variable for each hospital without SCD discharges was created to maintain the database sampling structure, as recommended by HCUP [18]. Missing data were excluded from the analyses; no data were imputed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank Dr. George R. Buchanan for his thoughtful review of the manuscript.

Contract grant sponsor: NIH/NHLBI; Contract grant number: U54 HL0705088-06; Contract grant sponsor: NIH; Contract grant number: UL1 RR024982-03

References

1. Steiner, C.; Miller, J. Agency for healthcare research and quality. Vol. 21. Rockville, MD: HCUP Stat Brief; 2006. Sickle cell disease patients in US hospitals, 2004; p. 1-9.
2. Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med.* 2002; 137:511–520. [PubMed: 12230353]
3. Birkmeyer JD, Stukel TA, Siewers AE, et al. Surgeon volume and operative mortality in the United States. *N Engl J Med.* 2003; 349:2117–2127. [PubMed: 14645640]
4. Thiemann DR, Coresh J, Oetgen WJ, Powe NR. The association between hospital volume and survival after acute myocardial infarction in elderly patients. *N Engl J Med.* 1999; 340:1640–1648. [PubMed: 10341277]
5. Cunningham WE, Tisnado DM, Lui HH, et al. The effect of hospital experience on mortality among patients hospitalized with acquired immunodeficiency syndrome in California. *Am J Med.* 1999; 107:137–143. [PubMed: 10460044]
6. Epstein AM, Stern RS, Tognetti J, et al. The association of patients' socioeconomic characteristics with the length of hospital stay and hospital charges within diagnosis-related groups. *N Engl J Med.* 1988; 318:1579–1585. [PubMed: 3131674]
7. Epstein AM, Stern RS, Weissman JS. Do the poor cost more? A multihospital study of patients' socioeconomic status and use of hospital resources. *N Engl J Med.* 1990; 322:1122–1128. [PubMed: 2108331]
8. O'Connor GT, Quinton HB, Kneeland T, et al. Median household income and mortality rate in cystic fibrosis. *Pediatrics.* 2003; 111:e333–e339. [PubMed: 12671148]
9. Hadley J. Sicker and poorer—The consequences of being uninsured: A review of the research on the relationship between health insurance, medical care use, health, work, and income. *Med Care Res Rev.* 2003; 60:3S–75S. discussion 76S–112S. [PubMed: 12800687]
10. Ellison AM, Bauchner H. Socioeconomic status and length of hospital stay in children with vaso-occlusive crises of sickle cell disease. *J Natl Med Assoc.* 2007; 99:192–196. [PubMed: 17393942]
11. Papanikolaou PN, Christidi GD, Ioannidis JP. Patient outcomes with teaching versus nonteaching healthcare: A systematic review. *PLoS Med.* 2006; 3:e341. [PubMed: 16968119]
12. Baker JR, Crudder SO, Riske B, et al. A model for a regional system of care to promote the health and well-being of people with rare chronic genetic disorders. *Am J Public Health.* 2005; 95:1910–1916. [PubMed: 16195525]
13. Glance LG, Osler TM, Mukamel DB, Dick AW. Estimating the potential impact of regionalizing health care delivery based on volume standards versus risk-adjusted mortality rate. *Int J Qual Health Care.* 2007; 19:195–202. [PubMed: 17562661]
14. Polanczyk CA, Lane A, Coburn M, et al. Hospital outcomes in major teaching, minor teaching, and nonteaching hospitals in New York state. *Am J Med.* 2002; 112:255–261. [PubMed: 11893363]
15. Hauptman PJ, Swindle J, Burroughs TE, Schnitzler MA. Resource utilization in patients hospitalized with heart failure: Insights from a contemporary national hospital database. *Am Heart J.* 2008; 155:978–985. [PubMed: 18513507]
16. Merenstein D, Egleston B, Diener-West M. Lengths of stay and costs associated with children's hospitals. *Pediatrics.* 2005; 115:839–844. [PubMed: 15805353]
17. Platt OS, Thorington BD, Brambilla DJ, et al. Pain in sickle cell disease. Rates and risk factors. *N Engl J Med.* 1991; 325:11–16. [PubMed: 1710777]
18. Houchens, R.; Elixhauser, A. Final Report on Calculating Nationwide Inpatient Sample (NIS) Variances, 2001. U.S. Agency for Healthcare Research and Quality; Jun. 2005 HCUP Methods Series Report #2003-2Online

TABLE I**Patient, Hospitalization, and Hospital Characteristics of SCD Discharges**

Characteristic	Total (n = 71,481)	Adults (≥ 18 yrs) (n = 49,962)	Children (<18 yrs) (n = 21,519)
Female (%)	54.8	57.7	48.1
Age in years, median (5th–95th)	25 (2–52)	31 (19–55)	10 (1–17)
Length of stay, days, median (5th–95th)	4 (0–14)	4 (0–16)	3 (1–9)
Cost, dollars × 10 ³ , median (5th–95th)	4.0 (1.7–18.2)	4.8 (0–19,809.5)	3.1 (1.0–13.3)
Mortality, N (%)	425 (0.6)	406 (0.8)	19 (0.09)
Overall hospital size (%)			
Small	10.9	9.1	15.3
Medium	22.3	23.2	20.2
Large	66.8	67.8	64.4
Sickle volume quintiles (%)			
1–4	22.3	27.7	9.8
5	77.7	72.3	90.2
Teaching hospital (%)	67.4	60.6	83.3
Household income by ZIP code in quartiles (%)			
1	49.6	50.3	47.8
2	23.9	23.9	24.0
3	16.4	16.1	17.2
4	10.1	9.8	11.0
Primary payer (%)			
Self-pay	3.9	4.5	2.5
Medicaid	52.1	46.5	65.2
Medicare	20.1	28.6	0.2
Other	3.4	2.7	4.9
Private/HMO	20.6	17.7	27.2
APS-DRG – severity score (%)			
0	52.8	45.1	71.0
1	35.0	41.4	19.9
2	12.2	13.5	9.1

N – number; APS-DRG – All payer severity-adjusted diagnosis-related group.

TABLE II
Bivariable Analyses of Factors Associated With Mortality, Length of Stay, and Cost

Independent variable	Mortality		Length of stay		Cost	
	%	P	Mean (SD), days	P	Median (5th–95th), dollars × 10 ³	P
Sickle volume quintiles						
1–4	0.9	<0.0001	5.7 (0.1)	<0.0001	4.36 (1.30–19.28)	<0.0001
5	0.5		5.4 (0.1)		4.20 (1.26–18.67)	
Overall hospital size						
Large	0.6	0.53	5.1 (0.3)	<0.0001	4.02 (1.33–17.81)	<0.0001
Medium	0.6		5.3 (0.2)		4.43 (1.34–18.54)	
Small	0.6		5.6 (0.1)		4.21 (1.24–19.07)	
Teaching status						
Nonteaching	0.7	<0.0001	5.9 (0.1)	<0.0001	4.32 (1.31–18.01)	<0.0001
Teaching	0.5		5.3 (0.1)		4.19 (1.25–19.24)	
Household income by ZIP code in quartiles						
1	0.6	0.80	5.4 (0.1)	0.48	4.15 (1.25–17.82)	<0.0001
2	0.6		5.5 (0.1)		4.23 (1.27–18.66)	
3	0.5		5.4 (0.1)		4.31 (1.30–19.97)	
4	0.7		5.5 (0.2)		4.49 (1.30–20.91)	
Primary payor						
Self pay	0.7	0.09	4.8 (0.2)	<0.0001	4.48 (1.33–20.71)	<0.0001
Medicaid/medicare	0.6		5.7 (0.1)		4.25 (1.27–18.59)	
Other	0.4		5.0 (0.3)		4.18 (1.34–19.30)	
HMO/private	0.5		5.0 (0.1)		4.05 (1.23–18.50)	
Age (years)						
0–1	0.09	<0.0001	3.4 (0.2)	<0.0001	2.25 (0.95–9.68)	<0.0001
2–18	0.10		4.1 (0.1)		3.33 (1.05–14.03)	
19–59	0.71		6.1 (0.1)		4.75 (1.47–20.15)	
60	5.7		7.1 (0.2)		6.99 (1.76–34.26)	
Gender						
Female	0.6	0.63	5.6 (0.1)	<0.0001	4.32 (1.30–19.07)	<0.0001

Independent variable	Mortality		Length of stay		Cost	
	%	P	Mean (SD), days	P	Median (5th–95th), dollars × 10 ³	P
Male	0.6		5.3 (0.1)		4.11 (1.22–18.51)	
Year of admission						
2003	0.7	0.08	5.6 (0.1)	<0.0001	4.12 (1.21–19.83)	<0.0001
2004	0.7		5.5 (0.1)		4.30 (1.25–19.02)	
2005	0.5		5.3 (0.1)		4.28 (1.34–19.64)	
APS-DRG severity scale						
0	0.05	<0.0001	4.1 (0.1)	<0.0001	3.38 (1.11–11.78)	<0.0001
1	0.5		6.0 (0.1)		4.97 (1.53–19.68)	
2	3.5		10.2 (0.2)		8.67 (2.22–43.68)	

Not shown—weekend admission; race/ethnicity; SD—standard deviation; APS-DRG—all payer severity-adjusted diagnosis-related group.

TABLE III

Multivariable Analysis of Factors Associated With Mortality, Length of Stay^a, and Costs^b in Hospitalized Sickle Cell Disease Patients

Independent variable	Mortality odds ratio (95% C.I.)	Length of stay estimate (95% C.I.); P value	Costs estimate (95% C.I.); P value
Sickle volume—quintiles			
Quintiles 1–4	1.36 (1.05, 1.76)	−0.08 (−0.12, −0.04); <0.0001	NS
Quintile 5 (Referent)	—	—	—
Teaching status			
Nonteaching	NS	−0.10 (−0.14, −0.05); <0.0001	NS
Teaching (Referent)	—	—	—
Household income by ZIP code in quartiles			
1	NS	NS	−0.10 (−0.17, −0.02); <0.0001
2			−0.05 (−0.12, 0.02); 0.125
3			−0.03 (−0.09, 0.02); 0.209
4 (Referent)	—	—	—
Primary payor			
Self pay (uninsured)	NS	−0.10 (−0.15, −0.06); <0.0001	NS
Medicaid/medicare		0.06 (0.04, 0.09); <0.0001	
Other		0.02 (−0.03, 0.07); <0.0001	
HMO/private (referent)	—	—	—
Age			
0–1	0.05 (0.02, 0.15)	−0.53 (−0.60, −0.46); <0.0001	−0.82 (−0.91, −0.73); <0.0001
2–18	0.03 (0.02, 0.05)	−0.31 (−0.38, −0.25); <0.0001	−0.51 (−0.60, −0.41); <0.0001
19–59	0.16 (0.13, 0.21)	−0.03 (−0.08, 0.03); 0.361	−0.25 (−0.31, −0.18); <0.0001
60 (Referent)	—	—	—
Gender			
Female	NS	0.03 (0.01, 0.05); 0.005	NS
Male (Referent)	—	—	—
Year of admission			
2003 (Referent)	—	—	NS
2004	0.91 (0.72, 1.16)	−0.04 (−0.07, 0.00); 0.054	
2005	0.72 (0.56, 0.93)	−0.06 (−0.10, −0.03); 0.001	
APS-DRG severity scale			
0 (Referent)	—	—	—
1	6.89 (4.05, 11.7)	0.24 (0.22, 0.26); <0.0001	0.33 (0.31, 0.35); <0.0001
2	57.7 (34.9, 95.2)	0.73 (0.71, 0.76); <0.0001	0.90 (0.87, 0.93); <0.0001

Adjusted for overall hospital size, weekend admission, and race/ethnicity; NS—not significant; APS-DRG—All payer severity-adjusted diagnosis-related group.

^aTransformed to log length of stay.

^bTransformed to log costs.