Association of Hospital and Provider Types on Sickle Cell Disease Outcomes

WHAT'S KNOWN ON THIS SUBJECT: As more children with sickle cell disease survive into adulthood, they are increasingly hospitalized in both children's and general hospitals and managed by different provider specialists. But it is unknown if hospital type and provider specialty affect patient outcomes.

WHAT THIS STUDY ADDS: Using a large national administrative dataset, this study revealed that general hospitals were associated with higher rates of intubation and longer lengths of stay compared with children's hospitals for adolescents and young adults with SCD admitted with acute chest syndrome.

abstract

OBJECTIVES: Adolescents and young adults (A/YA) with sickle cell disease (SCD) are hospitalized in both children's and general hospitals. We determined the effect of hospital type and provider specialty on outcomes of hospitalized A/YA with SCD and acute chest syndrome (ACS).

METHODS: This retrospective cohort study used the 2007–2009 Premier Database, a large multi-institutional database, to identify 1476 patients ages 16 to 25 years with 2299 admissions with SCD and ACS discharged from 256 US hospitals from 2007 to 2009. Multilevel logistic regression and zero-truncated negative binomial regression were performed after adjustment for patient demographic, clinical, and hospital characteristics to test the association of hospital type and provider specialty on death, endotracheal intubation, simple or exchange transfusion, length of stay (LOS), and 30-day readmission.

RESULTS: Of all admissions, 14 died and 45% were intubated. General hospitals had 13 deaths and were associated with higher intubation rates (predicted probability [PP], 48% [95% confidence interval (CI), 43%–52%]) and longer LOS (predicted mean LOS, 7.6 days [95% CI, 7.2–7.9]) compared with children’s hospitals (PP of intubation, 24% [95% CI, 5%–42%]; and predicted mean LOS, 8.8 days [95% CI, 5.6–5.8]). There was no difference by hospital type or provider specialty in PP of simple or exchange transfusion, or 30-day readmission.

CONCLUSIONS: General hospitals carry higher intubation risks for A/YA with SCD and ACS compared with children’s hospitals. We need to better understand the drivers of these differences, including the role of staff expertise, hospital volume, and quality of ongoing SCD care. Pediatrics 2013;132:854–861

AUTHORS: Sophia Jan, MD, MSHPa,b,c,d Gail Slap, MD, MS,a,e Kim Smith-Whitley, MD, f Dingwei Dai, PhD,g Ron Keren, MD, MPH,a,b,d,g,h and David M. Rubin, MD, MSCEa,c,d

aDepartment of Medicine, and bCenter for Clinical Epidemiology and Biostatistics, Perelman School of Medicine of the University of Pennsylvania, Philadelphia, Pennsylvania. cThe Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, Pennsylvania. dDivision of General Pediatrics, eAdolescent Medicine, fHematology, gThe Center for Pediatric Clinical Effectiveness, and hCHOP PolicyLab, The Children’s Hospital of Philadelphia, Philadelphia, Pennsylvania

KEY WORDS: acute chest syndrome, adolescent, anemia, sickle cell, hospitals, quality of health care, transition to adult care, young adult

ABBREVIATIONS

ACS—acute chest syndrome
APR-DRG—All Patient Refined Diagnosis Related Group
A/YA—adolescents and young adults
CI—confidence interval
LOS—length of stay
PDW—Perspective Data Warehouse
PP—predicted probability
SCD—sickle cell disease

Dr Jan conceptualized the concept and design of the study, analyzed and interpreted the data, drafted the initial manuscript, critically revised the manuscript for important intellectual content, performed the statistical analysis in the study, obtained funding for the study, and supervised the study; Dr Slap conceptualized the concept and design of the study, analyzed and interpreted the data, critically revised the manuscript for important intellectual content, and performed statistical analysis in the study; Dr Smith-Whitley conceptualized the concept and design of the study, critically revised the manuscript for important intellectual content, and provided administrative, technical, and material support; Dr Dai acquired the data, critically revised the manuscript for important intellectual content, and provided administrative, technical, and material support; Dr Keren conceptualized the concept and design of the study, acquired the data, critically revised the manuscript for important intellectual content, and provided administrative, technical, and material support; Dr Rubin conceptualized the concept and design of the study, analyzed and interpreted the data, critically revised the manuscript for important intellectual content, and performed the statistical analysis in the study, and supervised the study; and all authors approved the final manuscript as submitted.

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(Continued on last page)
Acute chest syndrome (ACS) is the leading cause of death in patients with sickle cell disease (SCD) and, after vaso-occlusive pain, the most common reason for hospitalization. The incidence of ACS peaks at 2- to 4-years of age, but an ACS episode has been found to be 4 times more likely to be fatal in an adult than in a child. A prospective study of over 3751 patients with SCD enrolled from birth to age 66 years revealed that 939 (25.0%) patients had at least 1 episode of ACS and that disease severity increased dramatically with age. The diagnosis of ACS requires radiographic evidence of a new pulmonary infiltrate along with chest pain, fever, respiratory symptoms, and/or hypoxemia. In half of hospitalized patients with ACS, these manifestations are either missed or absent on admission. In response to evidence that rapid intervention may halt the progression of ACS, some institutions have implemented clinical guidelines for the diagnosis, treatment, and monitoring of ACS. These guidelines typically call for fluid resuscitation, pain control, antibiotics, bronchodilators, transfusion, and aggressive respiratory support.

Historically, SCD-associated ACS was considered a disease of early childhood. However, comprehensive care for infants and children with SCD has doubled survival to adulthood and increased the numbers of adolescents and young adults (A/YA) with SCD-related complications such as ACS. A prospective study of nearly 1000 individuals with SCD diagnosed at birth and followed-up to 27 years revealed that overall SCD-related mortality rate was 3 times higher in those aged 15 to 27 years of age compared with those aged 14 years and younger. ACS remained the leading cause of death, raising concerns that diagnosis and/or intervention may be delayed as patients with SCD transition from pediatric- to adult-care providers.

Our objective was to explore the effects of hospital type and provider specialty on the management and outcome of ACS in adolescent and young adult patients with SCD. Our primary hypothesis was that patients aged 16 to 25 years with SCD-associated ACS who are cared for in children’s hospitals and/or by hematology-trained providers are less likely to progress to endotracheal intubation or death than those cared for in general hospital and/or by non-hematologists. We also hypothesized that patients cared for in children’s hospitals and/or by hematology-trained providers were more likely to undergo simple or exchange transfusion, have longer lengths of stay, and have lower 30-day readmission rates compared with those cared for in general hospitals and/or by non-hematologists.

METHODS
Data Source and Study Population
We used the Perspective Data Warehouse (PDW), maintained by Premier Inc (Charlotte, NC), as our primary data source. PDW is the largest clinical and operational data warehouse in the nation and contains longitudinal inpatient and ambulatory data from over 600 hospitals representing a broad array of academic medical centers, community-based hospitals, and large systems of multiple hospitals distributed throughout the United States. PDW was previously found to be sufficiently similar to a probability-based sample of pediatric hospitalizations, specifically the Agency for Healthcare Research and Quality Kids’ Inpatient Database. The study population consisted of all patients aged 16 to 25 years admitted from January 1, 2007, through December 31, 2009, with diagnoses of both SCD and ACS noted on admission and/or discharge. SCD was defined as the following diagnostic codes from the International Classification of Diseases, Ninth Revision, Clinical Modification: 282.41 (sickle-cell thalassemia without crisis), 282.42 (sickle-cell thalassemia with crisis), and 282.6x (sickle-cell disease). ACS was defined as diagnostic codes 517.3 (ACS) or pneumonia (480.xx–488.xx).

Patients were excluded if the exposure, hospital type, was missing. Patients were also excluded if the principal diagnosis was a surgical procedure requiring intubation. Surgical procedures requiring intubation were defined as the following All Patient Refined Diagnosis Related Groups (APR-DRGs): 912 (trauma), 540 (cesarean section), 545 (ectopic pregnancy procedure), 309 (hip and femur procedures for nontrauma except joint replacement), 301 (hip joint replacement), 263 (laparoscopic cholecystectomy), 262 (cholecystectomy except laparoscopic), 225 (appendectomy), 191 (cardiac catheterization with circulatory disorder excluding ischemic heart disease), 175 (percutaneous cardiovascular procedures without acute myocardial infarction), and 161 (cardiac defibrillator and heart assist implant).

Because data were de-identified and administrative, the study was exempted from institutional review board review.

Outcomes
The primary outcome death was identified by discharge status. The outcome endotracheal intubation was identified by International Classification of Diseases, Ninth Revision, Clinical Modification procedure code 96.04 (endotracheal intubation), APR-DRG 4 (tracheotomy with long-term mechanical ventilation with extensive procedure), APR-DRG 5 (tracheotomy with long-term mechanical ventilation without extensive procedure), APR-DRG 130 (respiratory system diagnosis with ventilator support 96+ hours), or APR-DRG 133 (pulmonary edema and respiratory failure). The secondary outcome, simple or exchange transfusion during the index
hospitalization, was identified by procedure codes 99.01 (exchange transfusion), 99.02 (transfusion of previously collected autologous blood), 99.03 (other transfusion of whole blood), 99.04 (transfusion of packed cells), or 99.73 (therapeutic erythrocytapheresis). Lengths of stay and 30-day readmission were calculated directly from the data set.

**Exposures**

Hospital type was coded as a dichotomous variable, children’s hospital or general hospital. A hospital was designated a children’s hospital by PDW if the hospital held membership in the National Association of Children’s Hospitals and Related Institutions or was defined as a children’s hospital by the American Hospital Association. All other hospitals were designated general hospitals. The distribution of patient ages and hospital characteristics among children’s hospitals and general hospitals within PDW was comparable to the characteristics among children’s hospitals and other hospitals within the national Kids’ Inpatient Database.

Provider specialty for each hospital admission was coded as a categorical variable, generalist, hematologist, or other. Generalist was defined as general pediatrics, general internal medicine, family medicine, or hospitalist. Hematologist was defined as pediatric hematology-oncology or adult hematology. All other provider specialties were designated as other.

**Covariates**

Hospital-level variables included size (small, <250 beds; medium, 250–499 beds; large, ≥500 beds); region of the country, categorized as North, South, Midwest, and West; teaching status; location in an urban or rural area; and SCD volume (annual admissions of patients aged 16–25 years with SCD). Patient-level variables included age; gender; race, categorized as black or nonblack; and insurance payer, categorized as private or nonprivate. Two standardized case-mix measures derived from the APR-DRG were included in the analyses. The APR-DRG Severity of Illness measure and the APR-DRG Risk of Mortality measure were developed for use in nonelderly populations by the Healthcare Cost & Utilization Project of the Agency for Healthcare Research and Quality. Each measure assigns the patient to a subclass, ranging from 1 to 4 for use in nonelderly populations. For disease severity adjustment, we included the following variables available from the claims data: number of complex chronic conditions beyond SCD, number of hospital admissions and ICU admissions in the 90 days before the index admission; admission type, categorized as elective and nonelective; transfer from another hospital; hydroxyurea use on hospital day 0 to 1; and resource utilization on admission. Hydroxyurea use on day 0 to 1 of the index hospitalization was used as a proxy for outpatient hydroxyurea use before hospitalization. Long-term use of hydroxyurea in adults has been shown to decrease ACS frequency and mortality. Resource utilization on admission was used as a measure of illness severity on admission and was calculated by totaling hospital charges on hospital day 0 and 1 for each patient. To account for variation in resource utilization across different individual hospitals, total hospital charges on admission was then standardized to those of all patients in the same age group admitted to the same hospital.

**Analysis**

Admissions in general hospitals and children’s hospitals were compared for each hospital-level variable, patient-level variable, and outcome variable by using Pearson’s χ² test for categorical variables, Yates corrected χ² or Fisher’s exact test for dichotomous variables, and 1-way analysis of variance for continuous variables. Variables known or theorized to affect risk of adverse outcomes for ACS were included in the model a priori. These included age, number of complex chronic conditions, hydroxyurea use on admission, and hospital SCD volume. Because nearly all covariates were associated with hospital type at P < .05, we adjusted for all covariates in the multilevel regression models exploring the independent associations of hospital type and provider specialty with the outcome measures. When repeated admissions were clustered at the hospital and patient levels, hospital-level design effects on parameter estimation overwhelmed patient-level effects. The final models, therefore, were simplified by accounting only for hospital-level effects. After confirming an interaction effect between hospital type and provider specialty, we then conducted within-group analysis to compare the effect of hospital type on death or intubation within each provider specialty group.

We used multivariate logistic regression models to assess the association of hospital type and provider specialty with the dichotomous outcome measures, death or intubation, use of simple or exchange transfusion, and readmission within 30 days. Zero-truncated negative binomial multivariate regression models were used to assess the association of the exposures with length of stay (LOS). For ease of interpretation, estimates from these logistic or zero-truncated negative binomial models were marginally standardized as predicted probabilities or predicted margins of each outcome across hospital type and provider specialty. All analyses were performed by using Stata 10.0 (Stata Corp, College Station, TX).
**RESULTS**

During the 3-year study period, there were 2299 admissions of 1476 patients aged 16 to 25 years with ACS. We excluded 77 admissions (3.4% of all admissions) in which the primary exposure, children’s hospital or general hospital, could not be identified. We also excluded 44 admissions (1.9%) where the principal diagnosis was a surgical procedure requiring intubation. The final study sample, therefore, consisted of 2178 admissions of 1379 unique patients to 12 children’s hospitals and 244 general hospitals.

Compared with children’s hospitals, general hospitals tended to have $<250$ beds, be nonteaching hospitals, and have fewer SCD-related admissions per year (Table 1). The mean and median volume of SCD-related admissions for all hospitals was 8.7 and 4 admissions per year. Children’s hospitals averaged 28.6 SCD-related admissions of patients aged 16 to 25 years per year with a median of 4 admissions. Half the hospitals were located in the US south. The mean age in the cohort was 21.1 ± 2.6 years. Fifty-five percent of the cohort was male and 22% had private insurance. Forty-one percent had a complex chronic condition other than SCD, 33% were hospitalized in the past 90 days, and $<2$% required an ICU admission in the past 90 days. Admissions to general hospitals were associated with a complex chronic condition other than SCD and an ICU admission in the last 90 days. There were no significant differences in other disease severity and case-mix measures between admissions to pediatric hospitals versus general hospitals (Table 2).

If admitted to a general hospital, 75% of the cohort were managed by a generalist provider; in contrast, nearly half (46%) of the cohort in children’s hospitals were managed by a hematologist.

A total of 14 patients admitted with ACS died in our sample (0.6% of all hospitalizations). All patients who died were ≥18 years; 10 patients were ≥21 years. Three of 14 were taking hydroxyurea on admission. Nine of 14 had a complex chronic condition beyond SCD. Thirteen of 14 deaths took place in a general hospital. Eleven of 14 deaths were with generalist physicians; 1 of 14 was with a pediatric hematologist; and 2 of 14 were with other specialists (intensivist and pulmonologist).

Nearly half (44.6%) of admissions with ACS underwent endotracheal intubation. The unadjusted probability of intubation was 48% in general hospitals compared with 26% in children’s hospitals ($P < .001$; Table 3). There was no difference in the unadjusted probability of intubation across provider specialties ($P = .898$). In multivariate adjustment, the main effect of hospital type on intubation remained significant. The predicted probability (PP) of intubation was 48% in general hospitals compared with 24% in children’s hospitals ($P = .045$).

Also significant was the interaction between hospital type and provider specialty (Table 4). Within general hospitals, the PP of intubation for generalists (PP, 0.45 [95% CI, 0.39–0.50]) was lower compared with hematologists (PP, 0.60 [95% CI, 0.52–0.69]). Within children’s hospitals, the PP of intubation for generalists (PP, 0.36 [95% CI, 0.16–0.55]) was higher compared with hematologists (PP, 0.18 [95% CI, −0.01 to −0.38]) but was not statistically significant.

Almost half (46%) of ACS admissions received a simple transfusion (43%), exchange transfusion (2%), or both (1%). The unadjusted probability of transfusion was 49% in general hospitals compared with 29% in children’s hospitals (Table 3) but was not significant after multivariate adjustment ($P = .067$). There were no differences in the unadjusted probability of transfusion among the provider specialties. A strong interaction effect was again seen between hospital type and provider.

### Table 1

<table>
<thead>
<tr>
<th>Baseline Hospital Characteristics</th>
<th>Children’s Hospital (N = 12)</th>
<th>General Hospital (N = 244)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital size, No. (%)</td>
<td></td>
<td></td>
<td>.009</td>
</tr>
<tr>
<td>Small, &lt;250 beds</td>
<td>2 (16.7)</td>
<td>79 (32.4)</td>
<td>—</td>
</tr>
<tr>
<td>Medium, 250–499 beds</td>
<td>3 (25.0)</td>
<td>115 (47.1)</td>
<td>—</td>
</tr>
<tr>
<td>Large, ≥500 beds</td>
<td>7 (58.3)</td>
<td>50 (20.5)</td>
<td>—</td>
</tr>
<tr>
<td>Hospital teaching status, No. (%)</td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Teaching</td>
<td>11 (87.1)</td>
<td>72 (29.5)</td>
<td>—</td>
</tr>
<tr>
<td>Nonteaching</td>
<td>1 (8.3)</td>
<td>172 (70.5)</td>
<td>—</td>
</tr>
<tr>
<td>Hospital vicinity to city center, No. (%)</td>
<td></td>
<td></td>
<td>.537</td>
</tr>
<tr>
<td>Urban</td>
<td>11 (87.1)</td>
<td>208 (85.3)</td>
<td>—</td>
</tr>
<tr>
<td>Rural</td>
<td>1 (8.3)</td>
<td>36 (14.8)</td>
<td>—</td>
</tr>
<tr>
<td>Volume of SCD related admissions per year; mean admissions (SD)*</td>
<td>51.9 (14.2)</td>
<td>13.9 (20.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>&lt;50 admissions, No. (%)</td>
<td>7 (58.3)</td>
<td>231 (94.7)</td>
<td>—</td>
</tr>
<tr>
<td>50–99 admissions, No. (%)</td>
<td>3 (25.0)</td>
<td>11 (4.5)</td>
<td>—</td>
</tr>
<tr>
<td>&gt;100 admissions, No. (%)</td>
<td>2 (16.7)</td>
<td>2 (0.8)</td>
<td>—</td>
</tr>
<tr>
<td>Geographic region, No. (%)</td>
<td></td>
<td></td>
<td>.461</td>
</tr>
<tr>
<td>South</td>
<td>6 (50.0)</td>
<td>134 (54.9)</td>
<td>—</td>
</tr>
<tr>
<td>Midwest/West</td>
<td>3 (25.0)</td>
<td>79 (32.4)</td>
<td>—</td>
</tr>
<tr>
<td>Northeast</td>
<td>3 (25.0)</td>
<td>31 (12.7)</td>
<td>—</td>
</tr>
</tbody>
</table>

* For patients aged 16 to 25 y. P values based on chi-squared distribution for categorical variables.
Patient clinical characteristics. Within general hospitals, the PP of transfusion was lower among generalists (PP, 0.46 [95% CI, 0.40–0.51]) compared with hematologists (PP, 0.63 [95% CI, 0.55–0.71]), $P = .001$. Within children’s hospitals, the difference in the PP of transfusion between generalists and hematologists was not significant ($P = .180$).

The mean and median LOS was 7.5 days (SD, 6.3 days) and 6 days, respectively, for all admissions. The unadjusted mean LOS was 7.6 days (median, 6 days) in general hospitals compared with 6.8 days (median, 6 days) in children’s hospitals (Table 3). After adjustment, the predicted LOS remained longer in general hospitals (7.6 days [95% CI, 7.2–7.9 days]) compared with children’s hospitals (6.2 days [95% CI, 5.6–6.8 days]). The unadjusted mean LOS was 7.3 days (median, 6 days) for generalists, 8.0 days (median, 6 days) for hematologists, and 7.9 days (median, 6 days) for other specialists. After adjustment, hematologists continued to have longer predicted LOS (8.5 days [95% CI, 7.8–9.1]) compared with generalists (7.1 days [95% CI, 6.7–7.5 days]) and other specialists (7.2 days [95% CI, 6.4–8.0 days]). There was no significant interaction between hospital type and provider specialty on predicted LOS.

The overall 30-day readmission rate was 8.7%. There were no differences in 30-day readmission rates with respect to differences in hospital type or provider specialty (Table 3).

**DISCUSSION**

In this national all-payer study of adolescent and young adult hospitalizations with SCD and ACS, we found higher rates of intubation and longer lengths of stay in general hospitals compared with children’s hospitals. Across all hospitals, there were no significant differences in intubation or transfusion by provider specialty. The higher intubation risk and longer lengths of stay in general hospitals compared with children’s hospitals may suggest that children’s hospitals have mechanisms and expertise leading to improved outcomes compared with general hospitals. This difference may also suggest that adolescent and young adult patients admitted to general hospitals are sicker at presentation because they are aging out of pediatric care and are having difficulty accessing ongoing adult care. In our study, patients in general hospitals had more complex chronic conditions and previous ICU admissions than those in children’s hospitals.

Most children with SCD in the United States are followed at SCD centers in large academic children’s hospitals. They age out of these centers as A/YA

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**TABLE 2** Demographic and Clinical Characteristics of Patients Aged 16 to 25 y With SCD and ACS Admitted to Children’s Hospitals and General Hospitals Within the Premier Database From 2007 to 2009

<table>
<thead>
<tr>
<th>Attending physician specialty, No. (%)</th>
<th>Children’s Hospital Admissions (N = 332)</th>
<th>General Hospital Admissions (N = 1846)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematologist</td>
<td>152 (45.8)</td>
<td>271 (14.7)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Generalista</td>
<td>149 (44.9)</td>
<td>1392 (75.4)</td>
<td>—</td>
</tr>
<tr>
<td>Otherb</td>
<td>31 (9.3)</td>
<td>183 (9.9)</td>
<td>—</td>
</tr>
</tbody>
</table>

**Patient demographic characteristics**

- Age, mean years (SD): 19.8 (2.8) vs. 21.4 (2.5) for children’s vs. general hospitals, $<.001$.
- 16–17 y, No. (%): 81 (24.4) vs. 131 (7.1) for children’s vs. general hospitals.
- 18–20 y, No. (%): 127 (38.3) vs. 538 (29.1) for children’s vs. general hospitals.
- 21–25 y, No. (%): 124 (37.4) vs. 1177 (63.8) for children’s vs. general hospitals.
- Male gender, No. (%): 196 (59.0) vs. 1008 (54.6) for children’s vs. general hospitals.
- African American race, No. (%): 319 (96.1) vs. 1613 (87.4) for children’s vs. general hospitals.
- Payer, No. (%): .003
  - Public/charity/indigent/self-pay: 256 (77.1) vs. 1408 (76.3) for children’s vs. general hospitals.
  - Other: 31 (9.3) vs. 183 (9.9) for children’s vs. general hospitals.

- Number of complex chronic conditions beyond SCD, No. (%): .002
  - 0: 222 (66.9) vs. 1067 (57.8) for children’s vs. general hospitals.
  - ≥1: 110 (33.1) vs. 486 (42.2) for children’s vs. general hospitals.

- Any hospital admission in previous 90 d, No. (%): .001
  - Any ICU admission in previous 90 d, No. (%): .019
  - Transfer from another hospital, No. (%): 25 (7.5) vs. 44 (2.4) for children’s vs. general hospitals, $<.001$.

- Nonelective admission, No. (%): .002
  - Nonelective admission, No. (%): 309 (83.1) vs. 1689 (91.9) for children’s vs. general hospitals.
  - Hydroxyurea use on admission, No. (%): 125 (62.4) vs. 527 (28.6) for children’s vs. general hospitals, $<.001$.

- Standardized resource utilization on admission, z score (SD): .003
  - Standardized resource utilization on admission, z score (SD): 0.04 (0.03) vs. 0.12 (0.09–0.16) for children’s vs. general hospitals, $<.001$.

- APR-DRG severity of illness, No. (%): .797
  - Minor: 36 (10.8) vs. 186 (10.1) for children’s vs. general hospitals.
  - Moderate: 151 (45.5) vs. 884 (48.0) for children’s vs. general hospitals.
  - Major: 111 (33.4) vs. 575 (31.2) for children’s vs. general hospitals.
  - Extreme: 34 (10.2) vs. 197 (10.7) for children’s vs. general hospitals.

- APR risk of mortality, No. (%): .433
  - Minor: 208 (62.7) vs. 1156 (62.8) for children’s vs. general hospitals.
  - Moderate: 81 (24.4) vs. 395 (21.4) for children’s vs. general hospitals.
  - Major: 29 (8.7) vs. 205 (11.1) for children’s vs. general hospitals.
  - Extreme: 14 (4.2) vs. 86 (4.7) for children’s vs. general hospitals.

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**a** Includes internal medicine, pediatrics, hospitals, and family medicine physicians.

**b** Other physicians included internal medicine subspecialties (N = 108), obstetrics and gynecology (51), other (26), pediatric subspecialties (10), emergency medicine (8), general surgery or surgical subspecialties (6), critical care medicine or anesthesia (5), psychiatry (3), and physical medicine and rehabilitation (1). P values based on chi-squared distribution for categorical variables.

**z** Resource utilization was calculated by totaling hospital charges on hospital day 0 and 1 for each patient, which was then standardized to same hospital charges of all patients in the same age group admitted to the same hospital.
when they are at greatest risk for uninsurance or insurance lapses.24–27 Most encounter difficulty identifying adult providers comfortable managing SCD.28,29 Consequently A/YA have fragmented care at both the provider and hospital level compared with other age groups30 and may be less adherent or not prescribed proven outpatient therapies, such as hydroxyurea.10,12,18–21,28 Although our study is limited by its inability to know which hospitals are SCD centers or to directly observe continuity or quality of outpatient care, we found that patients in general hospitals were less likely to be on hydroxyurea on admission. Although there were few deaths in our sample, other studies have revealed that young adults with SCD experience a sharp increase in age-specific mortality after transition to adult care.31 We may improve outcomes in general hospitals by minimizing insurance lapses, training more adult providers in SCD care, and developing policies that improve care coordination as A/YA transition to adult care.

SCD-specific hospital volume and access to SCD specialists may also partly explain the variation between children’s and general hospitals. We found that general hospitals were more likely than children’s hospitals to have the lowest SCD-specific volume for patients aged 16 to 25 years. Low volume was associated with more intubations and longer LOS compared with hospitals with highest volumes in bivariate analysis. Though volume was not significant in multivariate modeling, we could have underestimated its effect because we could not measure volumes of other age groups. Differences in surgical outcomes are seen between children’s and general hospitals for A/YA with inflammatory bowel disease, which may be related to surgical volume.32

<table>
<thead>
<tr>
<th>Hospital Age</th>
<th>Probability of Intubation, Simple or Exchange Transfusion</th>
<th>LOS</th>
<th>30-day Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>General hospital</td>
<td>0.48 (0.45–0.52)</td>
<td>6.8</td>
<td>0.07 (0.05–0.09)</td>
</tr>
<tr>
<td>Children’s hospital</td>
<td>0.26 (0.23–0.29)</td>
<td>6.4</td>
<td>0.09 (0.07–0.12)</td>
</tr>
<tr>
<td>Attending physician</td>
<td>Generalist</td>
<td>0.49 (0.43–0.54)</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>Hematologist</td>
<td>0.45 (0.39–0.50)</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Other specialty</td>
<td>0.48 (0.42–0.54)</td>
<td>7.9</td>
</tr>
</tbody>
</table>

* P < .05; ** P < .001. * Adjusting for age, gender, race, insurance, admission type, transfer from another hospital, number of complex chronic conditions, hospital or ICU admission in past 90 d, resource utilization on admission, APR-DRG Severity of Illness, APR-DRG Risk of Mortality, hospital volume of SCD-related admissions, hospital size, teaching status, urbanicity, and region of the country. Comparisons with generalists, P < .05; compared with other specialists, P < .001.
McCavit et al.\textsuperscript{33} showed that hospitals with low SCD-specific volumes had higher mortality rates than hospitals with high-volumes. High-volume hospitals may have increased access to specialists (such as pediatric hematologists) and other clinical staff who possess specialized training in managing SCD. General hospitals may improve outcomes through regionalization of SCD care, as has been done with systems of care for adults with cystic fibrosis.

Regionalization of care may also improve our capacity to generate, disseminate, and implement best practices of SCD care, especially among older patients with SCD. For example, the efficacy of transfusion in suspected cases of ACS is not definitive and quality measures, such as 30-day readmissions, are controversial.\textsuperscript{34–36}

Notably, despite current guidelines recommending transfusion in suspected ACS cases, hematologists compared with generalists in children’s hospitals trended toward low transfusion rates and low intubation rates, whereas the opposite effect was seen in general hospitals. This surprising trend may imply that patients admitted to children’s hospitals are well-known to the pediatric hematologists, who may have relative comfort observing rather than transfusing or intubating due to increased familiarity with a patient’s pattern of disease progression or other clinical factors not captured by billing data. We also do not know how pediatric hematologists in these children’s hospitals compare with those of all free-standing children’s hospitals.

Despite the limitations described earlier, this study was able to compare the quality of care for A/YA with SCD across children’s hospitals and general hospitals across the country. Our findings support the need to better understand quality of care variations across different hospital settings, and the impact of ambulatory care on hospital outcomes, particularly for A/YA with SCD who are transitioning to adult services.

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