

Regional Variation in Standardized Costs of Care at Children's Hospitals

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BACKGROUND: Though regional variation in healthcare spending has received national attention, it has not been widely studied in pediatrics.

OBJECTIVES: (1) To evaluate regional variation in costs of care for 3 inpatient pediatric conditions, (2) assess potential drivers of variation, and (3) estimate cost savings from reducing variation.

DESIGN/SETTING/PATIENTS: Retrospective cohort study of hospitalizations for asthma, diabetic ketoacidosis (DKA), and acute gastroenteritis (AGE) at 46 children's hospitals from October 2014 to September 2015.

INTERVENTION/MEASUREMENTS: Variation in trimmed standardized costs were assessed within and across regions. Linear mixed effects models were adjusted for patient- and encounter-level variables to assess drivers of variation.

RESULTS: After adjusting for patient-level factors, variation remained. Using census division clusters, mean trimmed

and adjusted total standardized costs were 120% higher for asthma (\$1920 vs \$4227), 46% higher for DKA (\$7429 vs \$10,881), and 150% higher for AGE (\$3316 vs \$8292) in the highest-cost compared with the lowest-cost region. Comparing hospitals in the same region, standardized costs were significantly different ($P < 0.001$) for each condition in each region. Drivers of variation were encounter-level variables including length of stay and intensive care unit utilization. For this cohort, annual savings from reducing variation would equal \$69.1 million at the interregional level and \$25.2 million at the intraregional level.

CONCLUSIONS: Pediatric hospital costs vary between and within regions. Future studies should examine how much of this variation is avoidable. To the extent that less spending does not compromise outcomes, care models may be adjusted to eliminate unwarranted variation and reduce costs. *Journal of Hospital Medicine* 2017;12:818-825. Published online first September 6, 2017. © 2017 Society of Hospital Medicine

With some areas of the country spending close to 3 times more on healthcare than others, regional variation in healthcare spending has been the focus of national attention.¹⁻⁷ Since 1973, the Dartmouth Institute has studied regional variation in healthcare utilization and spending and concluded that variation is "unwarranted" because it is driven by providers' practice patterns rather than differences in medical need, patient preferences, or evidence-based medicine.⁸⁻¹¹ However, critics of the Dartmouth Institute's findings argue that their approach does not adequately adjust for community-level income, and that higher costs in some areas reflect greater patient needs that are not reflected in illness acuity alone.¹²⁻¹⁴

While Medicare data have made it possible to study variations in spending for the senior population, fragmentation of insurance coverage and nonstandardized data structures make studying the pediatric population more difficult. However, the Children's Hospital Association's (CHA) Pediatric Health In-

formation System (PHIS) has made large-scale comparisons more feasible. To overcome challenges associated with using charges and nonuniform cost data, PHIS-derived standardized costs provide new opportunities for comparisons.^{15,16} Initial analyses using PHIS data showed significant interhospital variations in costs of care,¹⁵ but they did not adjust for differences in populations and assess the drivers of variation. A more recent study that controlled for payer status, comorbidities, and illness severity found that intensive care unit (ICU) utilization varied significantly for children hospitalized for asthma, suggesting that hospital practice patterns drive differences in cost.¹⁷

This study uses PHIS data to analyze regional variations in standardized costs of care for 3 conditions for which children are hospitalized. To assess potential drivers of variation, the study investigates the effects of patient-level demographic and illness-severity variables as well as encounter-level variables on costs of care. It also estimates cost savings from reducing variation.

METHODS

Data Source

This retrospective cohort study uses the PHIS database (CHA, Overland Park, KS), which includes 48 freestanding children's hospitals located in noncompeting markets across

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the United States and accounts for approximately 20% of pediatric hospitalizations. PHIS includes patient demographics, *International Classification of Diseases, 9th Revision* (ICD-9) diagnosis and procedure codes, as well as hospital charges. In addition to total charges, PHIS reports imaging, laboratory, pharmacy, and “other” charges. The “other” category aggregates clinical, supply, room, and nursing charges (including facility fees and ancillary staff services).

Inclusion Criteria

Inpatient- and observation-status hospitalizations for asthma, diabetic ketoacidosis (DKA), and acute gastroenteritis (AGE) at 46 PHIS hospitals from October 2014 to September 2015 were included. Two hospitals were excluded because of missing data. Hospitalizations for patients >18 years were excluded.

Hospitalizations were categorized by using All Patient Refined-Diagnosis Related Groups (APR-DRGs) version 24 (3M Health Information Systems, St. Paul, MN)¹⁸ based on the ICD-9 diagnosis and procedure codes assigned during the episode of care. Analyses included APR-DRG 141 (asthma), primary diagnosis ICD-9 codes 250.11 and 250.13 (DKA), and APR-DRG 249 (AGE). ICD-9 codes were used for DKA for increased specificity.¹⁹ These conditions were chosen to represent 3 clinical scenarios: (1) a diagnosis for which hospitals differ on whether certain aspects of care are provided in the ICU (asthma), (2) a diagnosis that frequently includes care in an ICU (DKA), and (3) a diagnosis that typically does not include ICU care (AGE).¹⁹

Study Design

To focus the analysis on variation in resource utilization across hospitals rather than variations in hospital item charges, each billed resource was assigned a standardized cost.^{15,16} For each clinical transaction code (CTC), the median unit cost was calculated for each hospital. The median of the hospital medians was defined as the standardized unit cost for that CTC.

The primary outcome variable was the total standardized cost for the hospitalization adjusted for patient-level demographic and illness-severity variables. Patient demographic and illness-severity covariates included age, race, gender, ZIP code-based median annual household income (HHI), rural-urban location, distance from home ZIP code to the hospital, chronic condition indicator (CCI), and severity-of-illness (SOI). When assessing drivers of variation, encounter-level covariates were added, including length of stay (LOS) in hours, ICU utilization, and 7-day readmission (an imprecise measure to account for quality of care during the index visit). The contribution of imaging, laboratory, pharmacy, and “other” costs was also considered.

Median annual HHI for patients' home ZIP code was obtained from 2010 US Census data. Community-level HHI, a proxy for socioeconomic status (SES),^{20,21} was classified into categories based on the 2015 US federal poverty level (FPL) for a family of 4²²: HHI-1 = $\leq 1.5 \times \text{FPL}$; HHI-2 = 1.5 to

$2 \times \text{FPL}$; HHI-3 = 2 to $3 \times \text{FPL}$; HHI-4 = $\geq 3 \times \text{FPL}$. Rural-urban commuting area (RUCA) codes were used to determine the rural-urban classification of the patient's home.²³ The distance from home ZIP code to the hospital was included as an additional control for illness severity because patients traveling longer distances are often more sick and require more resources.²⁴

The Agency for Healthcare Research and Quality CCI classification system was used to identify the presence of a chronic condition.²⁵ For asthma, CCI was flagged if the patient had a chronic condition other than asthma; for DKA, CCI was flagged if the patient had a chronic condition other than DKA; and for AGE, CCI was flagged if the patient had any chronic condition.

The APR-DRG system provides a 4-level SOI score with each APR-DRG category. Patient factors, such as comorbid diagnoses, are considered in severity scores generated through 3M's proprietary algorithms.¹⁸

For the first analysis, the 46 hospitals were categorized into 7 geographic regions based on 2010 US Census Divisions.²⁶ To overcome small hospital sample sizes, Mountain and Pacific were combined into West, and Middle Atlantic and New England were combined into North East. Because PHIS hospitals are located in noncompeting geographic regions, for the second analysis, we examined hospital-level variation (considering each hospital as its own region).

Data Analysis

To focus the analysis on “typical” patients and produce more robust estimates of central tendencies, the top and bottom 5% of hospitalizations with the most extreme standardized costs by condition were trimmed.²⁷ Standardized costs were log-transformed because of their nonnormal distribution and analyzed by using linear mixed models. Covariates were added stepwise to assess the proportion of the variance explained by each predictor. Post-hoc tests with conservative single-step stepwise mutation model corrections for multiple testing were used to compare adjusted costs. Statistical analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC). *P* values < 0.05 were considered significant. The Children's Hospital of Philadelphia Institutional Review Board did not classify this study as human subjects research.

RESULTS

During the study period, there were 26,430 hospitalizations for asthma, 5056 for DKA, and 16,274 for AGE (Table 1).

Variation Across Census Regions

After adjusting for patient-level demographic and illness-severity variables, differences in adjusted total standardized costs remained between regions ($P < 0.001$). Although no region was an outlier compared to the overall mean for any of the conditions, regions were statistically different in pairwise comparison. The East North Central, South Atlantic, and West South Central regions had the highest adjusted total standardized costs for each of the conditions. The East

TABLE 1. Study Sample Characteristics by Hospitalization

Characteristics	Overall	West	West North Central	West South Central	East North Central	East South Central	North East	South Atlantic	P
Number of encounters	47,760	8467	3849	9235	7140	5664	7792	5613	
Number of hospitals	46	10	4	8	7	5	7	5	
Patient age									<.0001
<1 year	4659 (9.76)	664 (7.84)	425 (11.04)	961 (10.41)	623 (8.73)	713 (12.59)	729 (9.36)	544 (9.69)	
1 to 4 years	18,619 (38.98)	3580 (42.28)	1476 (38.35)	3108 (33.65)	2812 (39.38)	2169 (38.29)	3317 (42.57)	2157 (38.43)	
5 to 12 years	18,190 (38.09)	3208 (37.89)	1410 (36.63)	3935 (42.61)	2716 (38.04)	2058 (36.33)	2736 (35.11)	2127 (37.89)	
>12 years	6292 (13.17)	1015 (11.99)	538 (13.98)	1231 (13.33)	989 (13.85)	724 (12.78)	1010 (12.96)	785 (13.99)	
Gender: male	27,434 (57.44)	4899 (57.86)	2192 (56.95)	5337 (57.79)	4099 (57.41)	3185 (56.23)	4483 (57.53)	3239 (57.71)	.4693
Patient race									<.0001
White	18,179 (38.06)	2779 (32.82)	1769 (45.96)	3455 (37.41)	3361 (47.07)	2718 (47.99)	2653 (34.05)	1444 (25.73)	
Black	15,650 (32.77)	1049 (12.39)	1373 (35.67)	2782 (30.12)	2528 (35.41)	2396 (42.3)	2947 (37.82)	2575 (45.88)	
Hispanic or Latino	9596 (20.09)	3453 (40.78)	344 (8.94)	2521 (27.3)	810 (11.34)	206 (3.64)	1180 (15.14)	1082 (19.28)	
Asian	1006 (2.11)	390 (4.61)	73 (1.9)	102 (1.1)	123 (1.72)	35 (0.62)	173 (2.22)	110 (1.96)	
American Indian or Alaskan Native	128 (0.27)	63 (0.74)	22 (0.57)	15 (0.16)	5 (0.07)	5 (0.09)	10 (0.13)	8 (0.14)	
Native Hawaiian or other Pacific Islander	105 (0.22)	75 (0.89)	4 (0.1)	7 (0.08)	10 (0.14)	5 (0.09)	3 (0.04)	1 (0.02)	
Other	3096 (6.48)	658 (7.77)	264 (6.86)	353 (3.82)	303 (4.24)	299 (5.28)	826 (10.6)	393 (7)	
Payer									<.0001
Commercial/ private/ employer-based	15,817 (33.12)	3012 (35.57)	1644 (42.71)	2769 (29.98)	2406 (33.7)	1686 (29.77)	2491 (31.97)	1809 (32.23)	
Public	28,963 (60.64)	5165 (61)	2015 (52.35)	5375 (58.2)	4233 (59.29)	3809 (67.25)	4738 (60.81)	3628 (64.64)	
Uninsured	1008 (2.11)	157 (1.85)	68 (1.77)	244 (2.64)	168 (2.35)	95 (1.68)	139 (1.78)	137 (2.44)	
Other	1972 (4.13)	133 (1.57)	122 (3.17)	847 (9.17)	333 (4.66)	74 (1.31)	424 (5.44)	39 (0.69)	
Complex chronic condition(s) present	5923 (12.4)	1090 (12.87)	465 (12.08)	987 (10.69)	1001 (14.02)	608 (10.73)	1037 (13.31)	735 (13.09)	<.0001
Median household income									<.0001
HHI 1 (\$36,375 or less)	20,106 (42.1)	2610 (30.83)	1348 (35.02)	4008 (43.4)	2873 (40.24)	3391 (59.87)	4180 (53.64)	1696 (30.22)	
HHI 2 (\$36,376-\$48,500)	14,257 (29.85)	2661 (31.43)	1094 (28.42)	2696 (29.19)	2601 (36.43)	1449 (25.58)	1898 (24.36)	1858 (33.1)	
HHI 3 (\$48,501-\$72,750)	10,818 (22.65)	2496 (29.48)	1208 (31.38)	1951 (21.13)	1476 (20.67)	693 (12.24)	1311 (16.82)	1683 (29.98)	
HHI 4 (\$72,751 or more)	2579 (5.4)	700 (8.27)	199 (5.17)	580 (6.28)	190 (2.66)	131 (2.31)	403 (5.17)	376 (6.7)	
Severity of illness									<.0001
1	20962 (43.89)	2487 (29.37)	1878 (48.79)	4149 (44.93)	3046 (42.66)	2560 (45.2)	4381 (56.22)	2461 (43.84)	
2	21,649 (45.33)	4784 (56.5)	1575 (40.92)	4215 (45.64)	3332 (46.67)	2447 (43.2)	2738 (35.14)	2558 (45.57)	
3	4728 (9.9)	1100 (12.99)	367 (9.53)	792 (8.58)	696 (9.75)	614 (10.84)	611 (7.84)	548 (9.76)	
4	421 (0.88)	96 (1.13)	29 (0.75)	79 (0.86)	66 (0.92)	43 (0.76)	62 (0.8)	46 (0.82)	
ICU flag	4185 (8.76)	709 (8.37)	162 (4.21)	744 (8.06)	927 (12.98)	603 (10.65)	526 (6.75)	514 (9.16)	<.0001
RUCA code									<.0001
Urban core	40,553 (84.91)	7569 (89.39)	3207 (83.32)	7149 (77.41)	6120 (85.71)	4032 (71.19)	7354 (94.38)	5122 (91.25)	
Sub-urban	3638 (7.62)	425 (5.02)	364 (9.46)	1281 (13.87)	449 (6.29)	585 (10.33)	220 (2.82)	314 (5.59)	
Large rural town	1985 (4.16)	264 (3.12)	98 (2.55)	462 (5)	381 (5.34)	552 (9.75)	145 (1.86)	83 (1.48)	
Small town/isolated rural	1584 (3.32)	209 (2.47)	180 (4.68)	343 (3.71)	190 (2.66)	495 (8.74)	73 (0.94)	94 (1.67)	
Urban area	47,185 (98.8)	8397 (99.17)	3777 (98.13)	9113 (98.68)	7076 (99.1)	5484 (96.82)	7762 (99.61)	5576 (99.34)	<.0001

NOTE: The following are the states included in each region: West (**AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY**), West North Central (**IA, KS, MN, MO, ND, NE, SD**), West South Central (**AR, LA, OK, TX**), East North Central (**IL, IN, MI, OH, WI**), East South Central (**AL, KY, MS, TN**), North East (**CT, MA, ME, NH, NJ, NY, PA, RI, VT**), and South Atlantic (**DC, DE, FL, GA, MD, NC, SC, VA, WV**). States with hospitals represented in the analysis are italicized. Abbreviations: HHI, household income; ICU, intensive care unit; RUCA, rural-urban commuting area.

South Central and West North Central regions had the lowest costs for each of the conditions. Adjusted total standardized costs were 120% higher for asthma (\$1920 vs \$4227), 46% higher for DKA (\$7429 vs \$10,881), and 150% higher for AGE (\$3316 vs \$8292) in the highest-cost region compared with the lowest-cost region (Table 2A).

Variation Within Census Regions

After controlling for patient-level demographic and illness-severity variables, standardized costs were different across hospitals in the same region ($P < 0.001$; panel A in Figure). This was true for all conditions in each region. Differences between the lowest- and highest-cost hospitals within the same region

TABLE 2. Average Total Standardized Costs per Hospitalization Trimmed and Adjusted for Patient-Level Variables for Census Division Analysis and Hospital-Level Analysis

A: Census division regions	Asthma	DKA	AGE
West	\$2621	\$10,307 ^a	\$5360
West North Central	\$1920 ^b	\$8023 ^a	\$4102
West South Central	\$2869	\$10,881 ^a	\$6830
East North Central	\$4227 ^a	\$10,260 ^a	\$8292 ^a
East South Central	\$1932 ^b	\$7429 ^b	\$3316 ^b
North East	\$2710	\$10,584 ^a	\$6451
South Atlantic	\$3482	\$10,681 ^a	\$7649
High-low difference	\$2307	\$3452	\$4976
High-low difference (%)	120%	46%	150%
B: Each hospital as its own region	Asthma	DKA	AGE
High	\$9087	\$28,564	\$23,387
Low	\$721	\$2738	\$1317
High-low difference (%)	1160%	943%	1676%
High (excluding outliers)	\$4678	\$18,780	\$10,281
Difference (excluding outliers)	549%	586%	681%
Interquartile range (after trimming)	\$1748-\$3218	\$5683-\$9481	\$2708-\$5991
Median	\$2339	\$6823	\$4207
Average (all patients)	\$2849	\$4612	\$2855

^aHighest total adjusted standardized costs for the specific condition across the regions.

^bLowest total adjusted standardized costs for the specific condition across the regions.

NOTE: Where multiple cells are designated with an a or b for the same condition, regions were not statistically significantly different. A: Interregional variation using census division regions. Asthma: all regions were different except East South Central compared with West South Central and North East compared with West. DKA: West South Central, South Atlantic, North East and West were not different from each other, but they were all different from West North Central and East South Central. AGE: all regions were different except West South Central compared with North East. B: Interregional variation considering each of the 46 hospitals as its own region. Abbreviations: AGE, acute gastroenteritis; DKA, diabetic ketoacidosis.

TABLE 3. Measures of Intraregional Variation Using Census Division Geographic Clusters (Based on Average Total Standardized Costs Per Hospitalization, Trimmed and Adjusted for Patient-Level Variables)

Region	Asthma				DKA				AGE			
	High	Low	Difference	CV	High	Low	Difference	CV	High	Low	Difference	CV
West	\$3218	\$721	346%	35.5	\$9731	\$4147	135%	22.6	\$9470	\$2841	233%	47.6
West North Central	\$3013	\$1251	141%	39.2	\$12,123	\$2738	343%	56.1	\$5567	\$1859	199%	52.8
West South Central	\$3950	\$1399	182%	37.6	\$18,780 ^a \$14,536	\$3826	391% 280%	47.5	\$10,281	\$1689	509%	57.0
East North Central	\$9087 ^a	\$1749	420%	63.1	\$28,564 ^a	\$5741	398%	81.1	\$23,387 ^a	\$2636	787%	97.9
	\$5977 ^a	\$1749	242%	63.1	\$13,539	\$5741	136%	81.1	\$8038	\$2636	205%	97.9
	\$3680	\$1749	110%	63.1								
East South Central	\$2458	\$1097	124%	31.2	\$9178	\$3741	145%	34.3	\$4120	\$1317	213%	29.1
North East	\$3218	\$1525	111%	26.9	\$9674	\$4806	101%	28.8	\$6475	\$2084	211%	32.1
South Atlantic	\$4678	\$1807	159%	34.7	\$16,192	\$5548	192%	43.0	\$8710	\$3265	167%	33.3

^aThis hospital was a statistical outlier (ie, it was outside of the 95% confidence interval compared to the mean across all hospitals). NOTE: Regions with outlier hospitals include multiple rows to show the effects of removing each outlier. NOTE: Abbreviations: AGE, acute gastroenteritis; CV, coefficient of variation; DKA, diabetic ketoacidosis.

ranged from 111% to 420% for asthma, 101% to 398% for DKA, and 166% to 787% for AGE (Table 3).

Variation Across Hospitals (Each Hospital as Its Own Region)

One hospital had the highest adjusted standardized costs for all 3 conditions (\$9087 for asthma, \$28,564 for DKA, and

\$23,387 for AGE) and was outside of the 95% confidence interval compared with the overall means. The second highest-cost hospitals for asthma (\$5977) and AGE (\$18,780) were also outside of the 95% confidence interval. After removing these outliers, the difference between the highest- and lowest-cost hospitals was 549% for asthma (\$721 vs

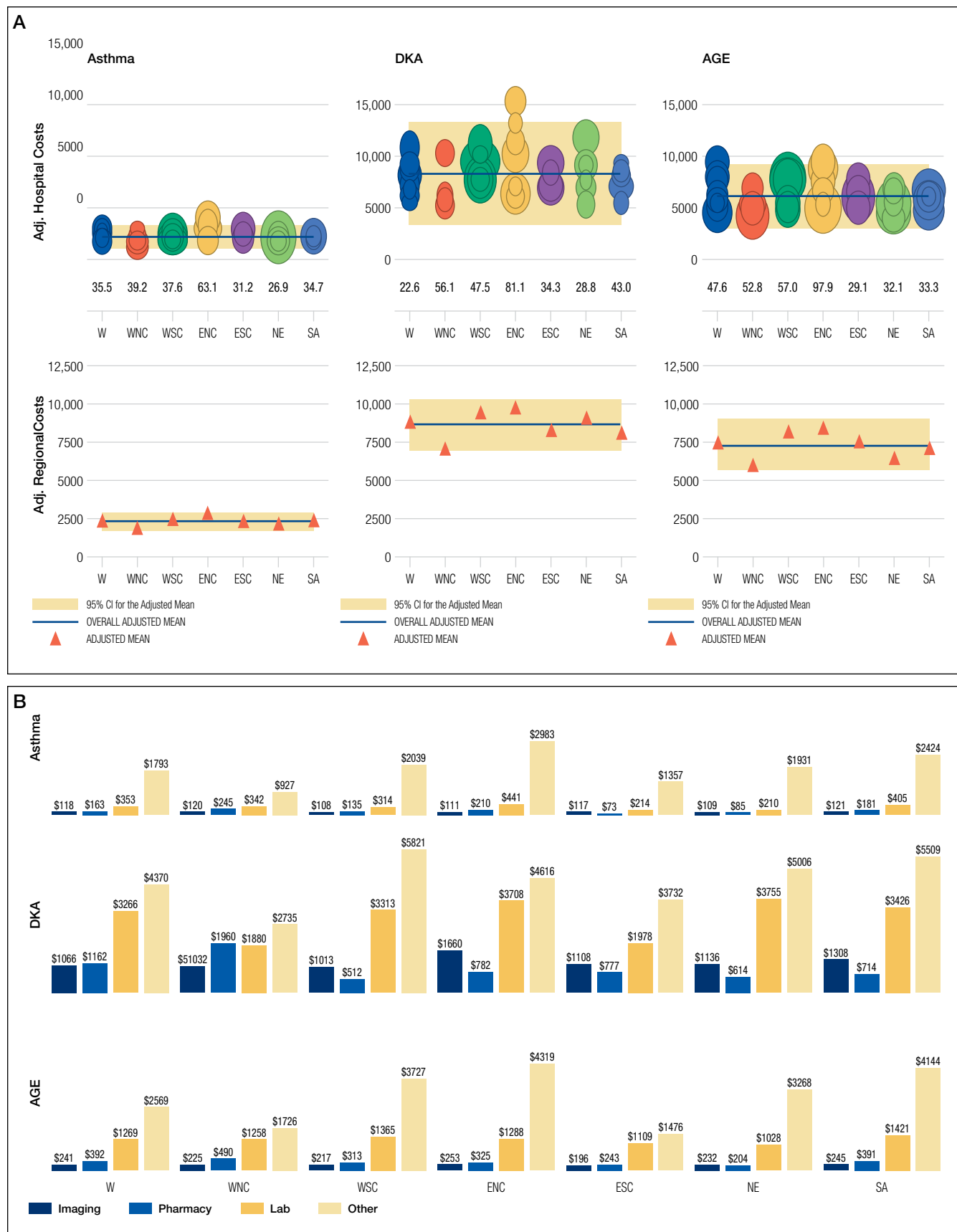


FIG. (A) Average hospital-level and regional-level total standardized costs per hospitalization (trimmed and adjusted). (B) Components of average total standard costs (trimmed and adjusted). NOTE: Abbreviations: AGE, acute gastroenteritis; DKA, diabetic ketoacidosis.

\$4678), 491% for DKA (\$2738 vs \$16,192), and 681% for AGE (\$1317 vs \$10,281; Table 2B).

Drivers of Variation Across Census Regions

Patient-level demographic and illness-severity variables explained very little of the variation in standardized costs across regions. For each of the conditions, age, race, gender, community-level HHI, RUCA, and distance from home to the hospital each accounted for <1.5% of variation, while SOI and CCI each accounted for <5%. Overall, patient-level variables explained 5.5%, 3.7%, and 6.7% of variation for asthma, DKA, and AGE.

Encounter-level variables explained a much larger percentage of the variation in costs. LOS accounted for 17.8% of the variation for asthma, 9.8% for DKA, and 8.7% for AGE. ICU utilization explained 6.9% of the variation for asthma and 12.5% for DKA; ICU use was not a major driver for AGE. Seven-day readmissions accounted for <0.5% for each of the conditions. The combination of patient-level and encounter-level variables explained 27%, 24%, and 15% of the variation for asthma, DKA, and AGE.

Drivers of Variation Across Hospitals

For each of the conditions, patient-level demographic variables each accounted for <2% of variation in costs between hospitals. SOI accounted for 4.5% of the variation for asthma and CCI accounted for 5.2% for AGE. Overall, patient-level variables explained 6.9%, 5.3%, and 7.3% of variation for asthma, DKA, and AGE.

Encounter-level variables accounted for a much larger percentage of the variation in cost. LOS explained 25.4% for asthma, 13.3% for DKA, and 14.2% for AGE. ICU utilization accounted for 13.4% for asthma and 21.9% for DKA; ICU use was not a major driver for AGE. Seven-day readmissions accounted for <0.5% for each of the conditions. Together, patient-level and encounter-level variables explained 40%, 36%, and 22% of variation for asthma, DKA, and AGE.

Imaging, Laboratory, Pharmacy, and “Other” Costs

The largest contributor to total costs adjusted for patient-level factors for all conditions was “other,” which aggregates room, nursing, clinical, and supply charges (panel B in Figure). When considering drivers of variation, this category explained >50% for each of the conditions. The next largest contributor to total costs was laboratory charges, which accounted for 15% of the variation across regions for asthma and 11% for DKA. Differences in imaging accounted for 18% of the variation for DKA and 15% for AGE. Differences in pharmacy charges accounted for <4% of the variation for each of the conditions. Adding the 4 cost components to the other patient- and encounter-level covariates, the model explained 81%, 78%, and 72% of the variation across census regions for asthma, DKA, and AGE.

For the hospital-level analysis, differences in “other” remained the largest driver of cost variation. For asthma, “oth-

er” explained 61% of variation, while pharmacy, laboratory, and imaging each accounted for <8%. For DKA, differences in imaging accounted for 18% of the variation and laboratory charges accounted for 12%. For AGE, imaging accounted for 15% of the variation. Adding the 4 cost components to the other patient- and encounter-level covariates, the model explained 81%, 72%, and 67% of the variation for asthma, DKA, and AGE.

Cost Savings

If all hospitals in this cohort with adjusted standardized costs above the national PHIS average achieved costs equal to the national PHIS average, estimated annual savings in adjusted standardized costs for these 3 conditions would be \$69.1 million. If each hospital with adjusted costs above the average within its census region achieved costs equal to its regional average, estimated annual savings in adjusted standardized costs for these conditions would be \$25.2 million.

DISCUSSION

This study reported on the regional variation in costs of care for 3 conditions treated at 46 children’s hospitals across 7 geographic regions, and it demonstrated that variations in costs of care exist in pediatrics. This study used standardized costs to compare utilization patterns across hospitals and adjusted for several patient-level demographic and illness-severity factors, and it found that differences in costs of care for children hospitalized with asthma, DKA, and AGE remained both between and within regions.

These variations are noteworthy, as hospitals strive to improve the value of healthcare. If the higher-cost hospitals in this cohort could achieve costs equal to the national PHIS averages, estimated annual savings in adjusted standardized costs for these conditions alone would equal \$69.1 million. If higher-cost hospitals relative to the average in their own region reduced costs to their regional averages, annual standardized cost savings could equal \$25.2 million for these conditions.

The differences observed are also significant in that they provide a foundation for exploring whether lower-cost regions or lower-cost hospitals achieve comparable quality outcomes.²⁸ If so, studying what those hospitals do to achieve outcomes more efficiently can serve as the basis for the establishment of best practices.²⁹ Standardizing best practices through protocols, pathways, and care-model redesign can reduce potentially unnecessary spending.³⁰

Our findings showed that patient-level demographic and illness-severity covariates, including community-level HHI and SOI, did not consistently explain cost differences. Instead, LOS and ICU utilization were associated with higher costs.^{17,19} When considering the effect of the 4 cost components on the variation in total standardized costs between regions and between hospitals, the fact that the “other” category accounted for the largest percent of the variation is not surprising, because the cost of room occupancy and nursing services increases with longer LOS and more time in

the ICU. Other individual cost components that were major drivers of variation were laboratory utilization for asthma and imaging for DKA and AGE³¹ (though they accounted for a much smaller proportion of total adjusted costs).¹⁹

To determine if these factors are modifiable, more information is needed to explain why practices differ. Many factors may contribute to varying utilization patterns, including differences in capabilities and resources (in the hospital and in the community) and patient volumes. For example, some hospitals provide continuous albuterol for status asthmaticus only in ICUs, while others provide it on regular units.³² But if certain hospitals do not have adequate resources or volumes to effectively care for certain populations outside of the ICU, their higher-value approach (considering quality and cost) may be to utilize ICU beds, even if some other hospitals care for those patients on non-ICU floors. Another possibility is that family preferences about care delivery (such as how long children stay in the hospital) may vary across regions.³³

Other evidence suggests that physician practice and spending patterns are strongly influenced by the practices of the region where they trained.³⁴ Because physicians often practice close to where they trained,^{35,36} this may partially explain how regional patterns are reinforced.

Even considering all mentioned covariates, our model did not fully explain variation in standardized costs. After adding the cost components as covariates, between one-third and one-fifth of the variation remained unexplained. It is possible that this unexplained variation stemmed from unmeasured patient-level factors.

In addition, while proxies for SES, including community-level HHI, did not significantly predict differences in costs across regions, it is possible that SES affected LOS differently in different regions. Previous studies have suggested that lower SES is associated with longer LOS.³⁷ If this effect is more pronounced in certain regions (potentially because of differences in social service infrastructures), SES may be contributing to variations in cost through LOS.

Our findings were subject to limitations. First, this study only examined 3 diagnoses and did not include surgical or less common conditions. Second, while PHIS includes tertiary care, academic, and freestanding children's hospitals, it does not include general hospitals, which is where most pediatric patients receive care.³⁸ Third, we used ZIP code-based median annual HHI to account for SES, and we used ZIP codes to determine the distance to the hospital and rural-urban location of patients' homes. These approximations lack precision because SES and distances vary within ZIP codes.³⁹ Fourth, while adjusted standardized costs allow for comparisons between hospitals, they do not represent actual costs to patients or individual hospitals. Additionally, when determining whether variation remained after controlling for patient-level variables, we included SOI as a reflection of illness-severity at presentation. However, in practice, SOI scores may be assigned partially based on factors determined during the hospitalization.¹⁸ Finally, the use of other regional

boundaries or the selection of different hospitals may yield different results.

CONCLUSION

This study reveals regional variations in costs of care for 3 inpatient pediatric conditions. Future studies should explore whether lower-cost regions or lower-cost hospitals achieve comparable quality outcomes. To the extent that variation is driven by modifiable factors and lower spending does not compromise outcomes, these data may prompt reviews of care models to reduce unwarranted variation and improve the value of care delivery at local, regional, and national levels.

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