Equivalent Lengths of Stay of Pediatric Patients Hospitalized in Rural and Nonrural Hospitals

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ABSTRACT. Background. Many children receive their care at local hospitals outside of a large urban area. There may be differences in the length of stay (LOS) between children hospitalized in rural versus urban hospitals. This study compared the differences in LOS, conditional LOS (CLOS), odds of prolonged stay, and 21-day readmission rates for children with 19 medical conditions and 9 surgical procedures admitted to rural, community, and large urban hospitals.

Methods. Discharge records for the hospitalizations of children 1 to 17 years of age were obtained from the New York Department of Public Health Statewide Planning and Research Cooperative System and the Pennsylvania Health Care Cost Containment Council for April 1996 to July 1998. The 19 medical and 9 surgical conditions were identified with the principal condition and procedure codes. Hospitals were classified into 1 of 5 geographic categories on the basis of United States rural-urban continuum codes, ie, large urban, suburban, moderate urban, small urban, or rural. LOS was defined as the period of time between hospital admission and discharge. Readmission rates were calculated for 21 days after discharge from the hospital. A prolonged stay for each condition was defined as any admission lasting beyond the prolongation point, or the day at which the rate of discharge began to decline, as determined with the Hollander-Proshan statistic. This aspect of LOS describes the ability of providers to treat uncomplicated cases of that specific principle diagnosis. CLOS, as a marker for the management of complicated cases, was defined as the LOS beyond the prolongation point. Cox and logistic regression models were developed to describe the geographic effects on the 4 outcome variables, after severity adjustment with 32 demographic and 11 comorbidity variables and adjustment for hospital clustering.

Results. Medical (N = 114 787) and surgical (N = 29 156) admissions to rural hospitals (N = 12 367) had similar outcomes, compared with all geographic categories except the large urban category. Medical patients admitted to rural hospitals had a shorter LOS (12% increase in discharge rate) and lower odds of prolonged stay (odds ratio: 0.81), compared with those in large urban hospitals.

Surgical patients admitted to rural hospitals had a shorter LOS (12% increase in discharge rate) and lower odds of prolonged stay (odds ratio: 0.81), compared with those in large urban hospitals. For individual conditions, rural hospitals in general had similar or improved LOS, compared with all other hospitals in the 2 states. The addition of hospital-level variables failed to change the results of the primary models.

Conclusions. In their treatment of pediatric hospitalized patients, rural hospitals were not significantly different from hospitals in all geographic regions other than large urban areas. Rural hospitals appear to deliver similar care, compared with nonrural hospitals, for many of the common pediatric conditions included in this study. Additional research is needed to apply these results to other regions or states with different geographic distributions of hospitals and children, in order to determine the overall impact on the regionalization of pediatric care.

PEDIATRICS 2004;114:400–408. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-0891; pediatric hospitalizations, rural hospitals, LOS.

ABBREVIATIONS. LOS, length(s) of stay; CLOS, conditional length(s) of stay; MSA, Metropolitan Statistical Area; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

More than 20% of children in the United States reside in rural communities, and rural hospitals constitute 16% to 34% of all hospital discharges. Whether these children receive efficient treatment when hospitalized is not known. The adult literature indicates that there may be differences between rural and urban locations in the management of some adult diseases. Keeler et al found that, for 5 medical conditions, patients treated at rural hospitals had excess mortality rates and worse quality of care, compared with patients treated at urban hospitals. Similar results were observed for the management of acute myocardial infarction and depression. These differences may center on the amount of technology needed to treat the patient, how quickly knowledge about the disease changes, and how critical specialist management is for appropriate treatment of the patient. However, rural hospitals have been shown to give similar quality of care to adults hospitalized for treatment of community-acquired pneumonia and for general surgical procedures.

Potential differences between rural and urban hospitals may influence the efficiency of care received by hospitalized children. The efficiency of a good or
service is defined as the resources needed to obtain a given level of benefit from a good or service. The efficiency point is the amount of resources allocated to that service at which the marginal benefits of the service equal the marginal costs. At resource levels lower than the efficiency point, a good or service can produce benefits that are worth more than the additional costs needed to obtain those benefits. At resource levels higher than the efficiency point, the benefits produced, although still positive, are worth less than the additional allocated resources. In health care, more expensive care may still be “more efficient” because the improvement in patient outcomes outweighs the added costs; in other cases, the most efficient care is the least expensive, although additional expenditures lead to improvements in some patients’ health. How efficient rural hospitals are in caring for pediatric patients may influence the health policies of a state or region. If care is as efficient at rural hospitals, then parental preferences and decreased travel costs may justify duplicating at rural hospitals services that larger regional centers also provide. However, there are other conditions for which the improvements of outcomes with higher patient volumes necessitate more regionalization of care, irrespective of nonmedical costs and parental preferences.

There are difficulties in applying this definition of efficiency to clinical medicine. Costs are difficult to quantify; many studies rely on hospital charges or payments to the hospital, which do not represent the true costs to either the hospital or society. Although accurately measuring the costs to a third-party payer, payments made to hospitals underestimate the true costs of care to the hospital, which may provide uncompensated care to children without insurance, and to society, which may divert resources away from other services to health care to provide uncompensated care to its citizens. Pediatric care also incurs large nonmedical costs, in the form of lost parental wages and travel time.

In lieu of detailed resource utilization by patients, studies have examined hospital length(s) of stay (LOS). LOS does not account for geographic variations in hospitalization rates, but does measure another critical step in the treatment of an ill child, ie, the time a child required care in the hospital. LOS is also an effective tool for measurement of hospital performance for conditions for which geographic variations in hospitalization rates do not occur. LOS was 1 outcome measure used in a recent study comparing the delivery of care to pediatric asthma patients in rural and urban hospitals.

This study was designed to compare differences in the LOS of children hospitalized at rural and nonrural hospitals in New York and Pennsylvania for 19 medical conditions and 9 surgical procedures. Each hospitalization was analyzed by using 4 outcome measures that describe different aspects of the hospital stay. We hypothesized that differences would be found in the care given to children at hospitals in different geographic regions.

METHODS

Data Source and Patient Population

We obtained discharge records for all pediatric hospital admissions (patients 1–17 years of age) in Pennsylvania for the period from January 1, 1996, to December 31, 1998, and in New York State for the period from January 1, 1996, to September 30, 1998. Patients admitted to psychiatric or non-acute care hospitals were not included in this study. Both New York and Pennsylvania offer a diverse mixture of large urban hospitals (in cities such as Philadelphia, New York City, and Buffalo), hospitals in moderately large urban areas (such as Syracuse, Albany, and Harrisburg), and many rural hospitals. Data from Pennsylvania were provided through the Pennsylvania Health Care Cost Containment Council. Data from New York were provided through the New York Department of Public Health Statewide Planning and Research Cooperative System data set. Both data sets included hospital admissions linked by patient. For the purposes of this study, we included only admissions between April 1, 1996, and June 30, 1998, to allow calculation of prior hospitalization and readmission rates. The data sets included standard UB92 data elements, with procedures and diagnoses coded with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) nomenclature. Nineteen medical conditions and 9 surgical procedures were identified from the principal procedure and diagnosis codes. We chose those conditions to represent a common set of disease processes for which children are admitted to a variety of hospitals, including both large children’s hospitals and community hospitals. Table 1 shows the medical conditions and surgical procedures included in this study and the ICD-9-CM codes used to identify each diagnosis.

Statistical Methods

Geographic Classification of Hospitals

Each hospital included in the study was categorized into 1 of 5 geographic categories on the basis of United States rural-urban continuum codes for the county in which the hospital was located. These categories were based on prior work that compared rural hospitals with not only large urban centers but also community hospitals, to which they may be more similar. Hospitals located in the central county of a Metropolitan Statistical Area (MSA) with >1 000 000 people were classified as large urban hospitals. Hospitals located in suburban or ring counties of a MSA with >1 000 000 people were classified as suburban. Moderate urban hospitals were located in MSAs with 250 000 to 1 000 000 people. Small urban hospitals were located in MSAs with <250 000 people. Rural hospitals were hospitals located in counties outside of a MSA.

Outcome Definitions and Modeling

This study analyzed each hospitalization with 4 outcomes, measured as defined in previous work, ie, (1) LOS (in days), (2) readmission within 21 days after discharge, (3) odds of a prolonged stay, and (4) conditional LOS (CLOS) (in days). LOS was calculated as the number of days between hospital admission and discharge; it provides insight into the resources used by a provider and hospital. Rates of readmission within 21 days were used to assess potentially inadequate care during the hospitalization. Higher readmission rates could also represent inadequate outpatient care associated with the local health care system.

Earlier work suggested that a hospital stay should be divided into 2 periods, on the basis of the daily rate of discharge for that condition. The daily rate of discharge is the proportion of patients in the hospital at the start of the day who were discharged before the end of the day. We calculated the daily rate of discharge separately for each principal diagnosis, because the dynamics of patient discharge are different for each disease category. The daily rate of discharge typically increases during the few days of hospitalization and then decreases rapidly (Fig 1). This suggests that 2 distinct processes are at work, ie, routine treatment of patients with uncomplicated conditions who are discharged promptly and treatment of patients with special complications that delay discharge. Prior work showed that patients who remain hospitalized into the period with declining discharge rates are very likely to have complications, often serious ones. For 3413 appendectomies and 7777 pneumonia admissions, staying beyond...
The equation indicates that a patient who has already stayed longer than a certain initial period, the remaining time to discharge is extended. Discharge is not extended for any patient on the day of death of the patient. Deaths were coded the LOS of the few children who died as the longest stay in the data set. Because the Cox model is semiparametric, only the rank order of the LOS is important (not the actual values). This technique does not allow hospitals to benefit from shorter LOS resulting from the death of the patient. Deaths were coded as prolonged stays regardless of the day the death occurred.

Adjustment for Hospital Clustering

It was important to control for clustering at the hospital level in the statistical analysis. Because of similarities in practice styles and the organization of the hospital, children treated at the same hospital are more likely to receive similar care than are children treated at different hospitals. Without adequate control for these similarities, SEs may be erroneous, depending on correlations between the outcomes for patients in each hospital cluster. This study used robust variance estimations for cluster-correlated data, with unconditioned models for each of the 4 outcome measures. These techniques control for the clustering of children within a given hospital and modify the SEs obtained with the logistic and Cox regression analyses.

Severity Adjustment

Initial severity adjustment used age, gender, race, insurance status, emergency admission, median income (based on patient zip code), distance from the hospital (as a proxy measure of complexity of care), and previous hospitalization rates. Missing values were coded as missing or unknown in each model. A state dummy variable was included in the model to account for differences in hospital discharge rates between Pennsylvania and New York. Only hospitals that treated at least 20 medical or surgical patients were included in the model. We accounted for the presence of diabetes mellitus, sickle cell disease, cerebral palsy, seizures, congenital heart disease, acquired immunodeficiency syndrome, chromosomal anomalies, spina bifida, cystic fibrosis, or congenital muscle, nervous system, or respiratory system anomalies by using ICD-9-CM codes in the secondary diagnosis list. Indicator variables for each condition or procedure were included to account for disease-specific differences in each outcome measure.
RESULTS

We identified 114,747 medical admissions and 29,156 surgical admissions during the 27 months of the study. A total of 323 hospitals met the inclusion criteria, including 55 hospitals in rural regions, 109 in large urban regions, 76 in suburban regions, 66 in moderate urban regions, and 17 in small urban regions. Table 1 shows the number of children admitted with each of the 19 medical conditions and 9 surgical procedures, according to geographic category. Children with asthma made up 33.4% of the studied medical admissions, and appendectomies made up 50.2% of the studied surgical procedures. We did not find differences in the patient case mixture across geographic categories, with the exception of specialized surgical procedures, such as back surgery and tonsillectomy and adenoidectomy, which were more commonly performed at large urban hospitals.

Table 2 presents the characteristics of children admitted with a medical condition, according to geographic category. Because of the large sample size, any difference between rural hospitals and other geographic categories was statistically significant unless otherwise noted. Children admitted to rural hospitals had similar characteristics, compared with children admitted to suburban, moderate urban, and small urban hospitals. Children admitted to large urban hospitals were more likely to be younger, black, and on public insurance. The percentage of children with any comorbid condition was slightly higher in large urban hospitals than in other areas (6.74%, compared with 4.35-5.60% in the other geographic categories). Table 3 shows the same data for

<table>
<thead>
<tr>
<th>Condition or Procedure</th>
<th>ICD-9-CM Definitions</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditions</strong></td>
<td></td>
<td>Rural</td>
</tr>
<tr>
<td>Asthma (age 1–17 y)</td>
<td>493.xx</td>
<td>1998</td>
</tr>
<tr>
<td>Viral pneumonia (age 1–17 y)</td>
<td>480.xx, 487.xx</td>
<td>273</td>
</tr>
<tr>
<td>Bacterial pneumonia (age 1–17 y)</td>
<td>481.xx, 482.xx, 483.0, 483.8, 485.xx, 486.xx</td>
<td>2153</td>
</tr>
<tr>
<td>Seizures (age 1–17 y)</td>
<td>345.1x–345.5x, 345.7x–345.9x, 780.39</td>
<td>280</td>
</tr>
<tr>
<td>Infectious gastroenteritis (age 1–17 y)</td>
<td>003.3, 008.8, 009.xx</td>
<td>381</td>
</tr>
<tr>
<td>Diarrhea (age 1–17 y)</td>
<td>787.91</td>
<td>636</td>
</tr>
<tr>
<td>Croup/bronchitis (age 1–17 y)</td>
<td>464.4, 466.xx</td>
<td>1120</td>
</tr>
<tr>
<td>Diabetes/DKA (age 1–17 y)</td>
<td>250.0x–250.3x</td>
<td>329</td>
</tr>
<tr>
<td>Sickle cell crisis (age 1–17 y)</td>
<td>282.60, 282.62</td>
<td>11</td>
</tr>
<tr>
<td>Pyelonephritis (age 1–17 y)</td>
<td>590.10, 590.80</td>
<td>356</td>
</tr>
<tr>
<td>Urinary tract infection (age 1–17 y)</td>
<td>599.0, 595.0, 595.9, 595.89</td>
<td>200</td>
</tr>
<tr>
<td>Viral meningitis (age 1–17 y)</td>
<td>047.9, 322.9, 047.8, 047.0, 322.0, 049.0, 053.0, 054.0, 047.172</td>
<td>107</td>
</tr>
<tr>
<td>Bacterial meningitis (age 1–17 y)</td>
<td>320.0, 320.1, 320.2, 320.3, 320.9, 320.89, 320.82, 056.0</td>
<td>15</td>
</tr>
<tr>
<td>Cellulitis (age 1–17 y)</td>
<td>681.xx, 682.xx, 376.01, 478.21, 528.3</td>
<td>615</td>
</tr>
<tr>
<td>Concussion (age 1–17 y)</td>
<td>850.xx, 851.69, 852.09, 852.29, 853.09, 853.19, 854.09, 854.19</td>
<td>281</td>
</tr>
<tr>
<td>Poisoning (age 1–17 y)</td>
<td>055.xx, 96.6x, 96xx, 97xx, 98xx, 909.0</td>
<td>629</td>
</tr>
<tr>
<td>Burns (age 1–17 y)</td>
<td>940.xx–949.xx, 906.5, 906.6, 906.7, 906.8, 906.9</td>
<td>79</td>
</tr>
<tr>
<td>Skull injury (age 1–17 y)</td>
<td>800.63–800.99, 801.0–801.99, 803.00–803.86</td>
<td>134</td>
</tr>
<tr>
<td>Spinal injury (age 1–17 y)</td>
<td>805.xx, 806.xx, 952.xx–955.xx</td>
<td>61</td>
</tr>
<tr>
<td>Total medical patients</td>
<td>9653</td>
<td>64400</td>
</tr>
<tr>
<td><strong>Procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendectomy (age 1–17 y)</td>
<td>47.0x</td>
<td>1791</td>
</tr>
<tr>
<td>Open reduction of extremity fracture (age 1–17 y)</td>
<td>79.2x, 79.3x, 79.5x</td>
<td>468</td>
</tr>
<tr>
<td>Cleft palate (age 1–17 y)</td>
<td>27.62, 27.63</td>
<td>16</td>
</tr>
<tr>
<td>Mastoectomy (age 1–17 y)</td>
<td>20.4x, 22.63</td>
<td>51</td>
</tr>
<tr>
<td>Back surgery (age 1–17 y)</td>
<td>81.00–81.08</td>
<td>61</td>
</tr>
<tr>
<td>Thyroid (age 1–17 y)</td>
<td>06.2, 06.3, 06.31, 06.39, 06.4, 06.5, 06.50, 06.51, 06.52, 06.6, 06.7, 06.91, 06.92, 06.93, 06.98</td>
<td>27</td>
</tr>
<tr>
<td>Tonsillectomy and adenoidectomy (age 1–3 y)</td>
<td>28.2, 28.3</td>
<td>124</td>
</tr>
<tr>
<td>Nissen (age 1–17 y)</td>
<td>44.66</td>
<td>31</td>
</tr>
<tr>
<td>Pyloric stenosis (age &lt; 1 y)</td>
<td>750.5 and 43.3 or 537.0 and 43.3</td>
<td>145</td>
</tr>
<tr>
<td>Total surgical patients</td>
<td>2714</td>
<td>13676</td>
</tr>
</tbody>
</table>

DKA indicates diabetic ketoacidosis.
children admitted to hospitals in these geographic categories for a surgical procedure. Children admitted to rural hospitals for a surgical procedure were similar to children admitted to non-large urban hospitals. Children admitted to large urban hospitals for a surgical procedure were more likely to be younger, black, and on public insurance.

Tables 2 and 3 also report the overall LOS, CLOS, and proportions of children who had prolonged stays or readmissions within 21 days after discharge, stratified according to the 5 geographic categories. These measures were not adjusted for case severity. Rural hospitals performed as well as hospitals in the non-large urban categories in all 4 outcome measures, with average LOS ranging from 2.2 to 2.39 days for medical conditions and from 2.69 to 2.93 days for surgical procedures. For both medical and surgical admissions, large urban hospitals had longer LOS and CLOS and greater proportions of children with prolonged stays or readmissions, compared with the other 4 geographic categories.

With rural hospitals as the reference group, Table 4 shows the outcomes of children treated for medical conditions at hospitals in each of the geographic categories, as defined with rural-urban continuum codes. After adjustment for case severity and demographic characteristics, rural hospitals had similar LOS, CLOS, odds of a prolonged stay, and 21-day readmission rates, compared with hospitals in all regions except for large urban MSAs. Medical admissions to large urban hospitals continued to have a longer LOS (11% decrease in discharge rate, \(P < .05\)), longer CLOS (12% decrease in discharge rate, \(P < .05\)), and higher odds of a prolonged stay (odds ratio: 1.26; \(P < .05\)), compared with rural hospitals. These findings suggest that the longer LOS seen at large urban hospitals occur both among patients with uncomplicated conditions, who may be discharged quickly, and among patients with complicated conditions, who remain in the hospital for longer periods of time. We found similar results for children admitted for surgical procedures (Table 5). Large urban hospitals had a longer LOS (10% decrease in discharge rate, \(P < .05\)) and higher odds of a prolonged stay (odds ratio: 1.23; \(P < .05\)), compared with rural hospitals.

Table 6 shows the results of the 4 outcome models for each of the 19 medical and 9 surgical conditions. Unlike the combined models, no interaction terms were added to these models, because fewer children were admitted with each condition or procedure. We also grouped all urban hospitals into an urban category and compared this group with rural hospitals. For most of the medical conditions, rural hospitals had similar LOS, compared with nonrural hospitals. The only statistically significant results found longer LOS, longer CLOS, and higher odds of a prolonged stay in nonrural hospitals. Surgical procedures showed more variation in all 4 outcome measures. This variation is likely the result of several condi-
Hospital clustering by using robust estimation techniques for unconditioned models.21,22 Rural location was used as reference. All reported values are point estimates and 95% confidence intervals. Variances were adjusted for out.

Outcomes of Medical Conditions According to Site of Treatment

**TABLE 4.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural</th>
<th>Large Urban</th>
<th>Suburban</th>
<th>Moderate Urban</th>
<th>Small Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>2714</td>
<td>13,676</td>
<td>5429</td>
<td>6353</td>
<td>984</td>
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<tr>
<td>Demographic features</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y, mean ± SD</td>
<td>11.1 ± 4.9</td>
<td>9.0 ± 5.5</td>
<td>10.8 ± 4.8</td>
<td>10.2 ± 5.3</td>
<td>11.1 ± 4.9</td>
</tr>
<tr>
<td>Male gender, %</td>
<td>61.6</td>
<td>59.8</td>
<td>62.2*</td>
<td>60.2*</td>
<td>62.4*</td>
</tr>
<tr>
<td>Race, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>95.0</td>
<td>53.3</td>
<td>78.2</td>
<td>81.8</td>
<td>83.5</td>
</tr>
<tr>
<td>Black</td>
<td>1.4</td>
<td>18.3</td>
<td>7.3</td>
<td>4.5</td>
<td>1.5*</td>
</tr>
<tr>
<td>Other</td>
<td>1.8</td>
<td>22.4</td>
<td>8.8</td>
<td>3.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Insurance status, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninsured</td>
<td>6.6</td>
<td>5.6</td>
<td>5.1</td>
<td>5.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Public insurance</td>
<td>21.0</td>
<td>30.1</td>
<td>14.2</td>
<td>17.8</td>
<td>22.4*</td>
</tr>
<tr>
<td>Commercial</td>
<td>54.0</td>
<td>35.7</td>
<td>43.4</td>
<td>45.2</td>
<td>47.0</td>
</tr>
<tr>
<td>HMO</td>
<td>12.4</td>
<td>22.3</td>
<td>30.0</td>
<td>25.2</td>
<td>17.0</td>
</tr>
<tr>
<td>Income, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$25 000</td>
<td>6.4</td>
<td>17.7</td>
<td>2.0</td>
<td>4.0</td>
<td>6.9*</td>
</tr>
<tr>
<td>$25 000-$50 000</td>
<td>89.6</td>
<td>55.9</td>
<td>28.0</td>
<td>75.5</td>
<td>88.3*</td>
</tr>
<tr>
<td>&gt;$50 000</td>
<td>0.9</td>
<td>23.4</td>
<td>68.5</td>
<td>18.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Previous hospitalization, %</td>
<td>12.0</td>
<td>18.0</td>
<td>15.1</td>
<td>12.0*</td>
<td>7.9</td>
</tr>
<tr>
<td>Comorbidities, %</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Any</td>
<td>3.46</td>
<td>6.73</td>
<td>2.82*</td>
<td>5.19</td>
<td>2.24*</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.29</td>
<td>0.25*</td>
<td>0.33*</td>
<td>0.27*</td>
<td>0.41*</td>
</tr>
<tr>
<td>Sickle cell disease</td>
<td>0</td>
<td>0.13*</td>
<td>0.04*</td>
<td>0.02*</td>
<td>0*</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>0.70</td>
<td>1.57</td>
<td>0.64*</td>
<td>1.26</td>
<td>0.51*</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>0.07</td>
<td>0.21*</td>
<td>0.15*</td>
<td>0.36</td>
<td>0*</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>0.37</td>
<td>0.61*</td>
<td>0.24*</td>
<td>0.57*</td>
<td>0.10*</td>
</tr>
<tr>
<td>Immunocompromised</td>
<td>0.15</td>
<td>0.14*</td>
<td>0.10*</td>
<td>0.14*</td>
<td>0.10*</td>
</tr>
<tr>
<td>Chromosomal anomaly</td>
<td>0.11</td>
<td>0.57*</td>
<td>0.19</td>
<td>0.38*</td>
<td>0.20</td>
</tr>
<tr>
<td>Congenital muscle disorder</td>
<td>0.44</td>
<td>0.89</td>
<td>0.17</td>
<td>0.39*</td>
<td>0.10*</td>
</tr>
<tr>
<td>Congenital nervous system disorder</td>
<td>0.18</td>
<td>0.62</td>
<td>0.13*</td>
<td>0.38*</td>
<td>0*</td>
</tr>
<tr>
<td>Congenital respiratory system disorder</td>
<td>0.18</td>
<td>0.23*</td>
<td>0.11*</td>
<td>0.22*</td>
<td>0*</td>
</tr>
<tr>
<td>LOS, d, mean ± SD</td>
<td>2.70 ± 0.04</td>
<td>3.43 ± 0.03</td>
<td>2.93 ± 0.03</td>
<td>2.74 ± 0.03</td>
<td>2.69 ± 0.06</td>
</tr>
<tr>
<td>CLOS, d, mean ± SD</td>
<td>2.22 ± 0.08</td>
<td>2.98 ± 0.05</td>
<td>2.56 ± 0.08</td>
<td>2.59 ± 0.07</td>
<td>2.08 ± 0.14</td>
</tr>
<tr>
<td>Prolonged stay, %</td>
<td>32.8</td>
<td>40.4</td>
<td>37.0</td>
<td>32.0</td>
<td>35.4</td>
</tr>
<tr>
<td>21-d readmission rate, %</td>
<td>2.65</td>
<td>4.45</td>
<td>3.30</td>
<td>3.04</td>
<td>2.03</td>
</tr>
</tbody>
</table>

HMO indicates health maintenance organization.
* Not statistically significant, compared with rural cohort at $P = .05$ level.

Outcomes of Surgical Procedures According to Site of Treatment

**TABLE 5.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge Ratio for LOS</th>
<th>Discharge Ratio for CLOS</th>
<th>Odds Ratio for Prolonged Stay</th>
<th>Odds Ratio for 21-d Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large urban</td>
<td>0.89 (0.81–0.98)*</td>
<td>0.88 (0.79–0.98)*</td>
<td>1.26 (1.05–1.50)*</td>
<td>0.97 (0.78–1.20)</td>
</tr>
<tr>
<td>Suburban</td>
<td>1.02 (0.92–1.13)</td>
<td>0.97 (0.86–1.09)</td>
<td>1.05 (0.86–1.28)</td>
<td>0.89 (0.70–1.13)</td>
</tr>
<tr>
<td>Moderate urban</td>
<td>0.99 (0.90–1.07)</td>
<td>0.99 (0.88–1.11)</td>
<td>1.05 (0.90–1.24)</td>
<td>0.97 (0.77–1.23)</td>
</tr>
<tr>
<td>Small urban</td>
<td>1.07 (0.97–1.19)</td>
<td>1.01 (0.88–1.16)</td>
<td>0.83 (0.68–1.01)</td>
<td>0.96 (0.70–1.33)</td>
</tr>
</tbody>
</table>

Rural location was used as reference. All reported values are point estimates and 95% confidence intervals. Variances were adjusted for hospital clustering by using robust estimation techniques for unconditioned models.21,22
* $P < .05$.

Because rural hospitals in Pennsylvania and New York are heterogeneous, we next studied whether the addition of hospital-level variables would affect the results of the study. The hospital-level variables included the number of pediatric beds reported to the state health boards, the presence of a pediatric or neonatal intensive care unit, trauma center designation, the total number of beds (both adult and pedi-
No readmissions occurred in the rural hospital group for comparison. DKA indicates diabetic ketoacidosis. Rural hospitals were used as reference. All reported values are point estimates and 95% confidence intervals. Variances were adjusted for results of any model.

Table 6. LOS for 19 Medical and 9 Surgical Admission Types in Urban Hospitals

<table>
<thead>
<tr>
<th>Medical conditions</th>
<th>Discharge Ratio for LOS</th>
<th>Discharge Ratio for CLOS</th>
<th>Odds Ratio for Prolonged Stay</th>
<th>Odds Ratio for 21-d Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral pneumonia</td>
<td>0.91 (0.76–1.08)</td>
<td>0.77 (0.63–0.95)*</td>
<td>1.04 (0.72–1.52)</td>
<td>1.09 (0.38–3.09)</td>
</tr>
<tr>
<td>Bacterial pneumonia</td>
<td>0.99 (0.90–1.09)</td>
<td>0.89 (0.79–1.00)</td>
<td>0.97 (0.80–1.19)</td>
<td>1.13 (0.80–1.60)</td>
</tr>
<tr>
<td>Seizures</td>
<td>0.85 (0.86–1.06)</td>
<td>0.80 (0.61–1.05)</td>
<td>1.27 (0.84–1.92)</td>
<td>0.97 (0.62–1.54)</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>0.97 (0.83–1.13)</td>
<td>0.90 (0.60–1.35)</td>
<td>1.37 (0.88–2.14)</td>
<td>2.01 (0.71–5.73)</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>0.94 (0.81–1.10)</td>
<td>0.70 (0.46–1.08)</td>
<td>1.28 (0.85–1.92)</td>
<td>0.47 (0.25–0.88)*</td>
</tr>
<tr>
<td>Group/bronchitis</td>
<td>1.00 (0.89–1.13)</td>
<td>0.98 (0.81–1.16)</td>
<td>1.17 (0.90–1.51)</td>
<td>0.75 (0.45–1.24)</td>
</tr>
<tr>
<td>DKA</td>
<td>0.89 (0.68–1.16)</td>
<td>0.87 (0.65–1.17)</td>
<td>1.21 (0.69–2.12)</td>
<td>1.00 (0.44–2.25)</td>
</tr>
<tr>
<td>Sickle cell</td>
<td>0.45 (0.29–0.68)*</td>
<td>0.42 (0.19–0.93)*</td>
<td>3.83 (0.92–15.87)</td>
<td></td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>0.88 (0.73–1.07)</td>
<td>1.00 (0.75–1.32)</td>
<td>1.52 (0.94–2.46)</td>
<td>0.66 (0.28–1.56)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>0.96 (0.79–1.18)</td>
<td>0.77 (0.58–1.04)</td>
<td>1.01 (0.68–1.51)</td>
<td>0.81 (0.35–1.87)</td>
</tr>
<tr>
<td>Viral meningitis</td>
<td>1.07 (0.83–1.39)</td>
<td>1.43 (1.00–2.03)</td>
<td>1.08 (0.62–1.89)</td>
<td>0.67 (0.27–1.66)</td>
</tr>
<tr>
<td>Bacterial meningitis</td>
<td>0.80 (0.44–1.46)</td>
<td>2.23 (0.70–7.07)</td>
<td>3.32 (0.83–13.28)</td>
<td></td>
</tr>
<tr>
<td>Cellulitis</td>
<td>1.06 (0.96–1.17)</td>
<td>1.06 (0.91–1.23)</td>
<td>0.97 (0.79–1.19)</td>
<td>1.42 (0.73–2.77)</td>
</tr>
<tr>
<td>Concussion</td>
<td>0.82 (0.69–0.98)*</td>
<td>0.77 (0.55–1.11)</td>
<td>1.40 (0.81–2.41)</td>
<td>1.98 (0.73–5.39)</td>
</tr>
<tr>
<td>Poisoning</td>
<td>0.82 (0.71–0.94)*</td>
<td>1.19 (0.96–1.47)</td>
<td>1.66 (1.29–2.13)†</td>
<td>0.86 (0.52–1.42)</td>
</tr>
<tr>
<td>Burns</td>
<td>0.81 (0.54–1.23)</td>
<td>0.91 (0.53–1.56)</td>
<td>1.38 (0.77–2.48)</td>
<td>0.57 (0.19–1.74)</td>
</tr>
<tr>
<td>Skull injury</td>
<td>0.96 (0.72–1.29)</td>
<td>1.02 (0.75–1.38)</td>
<td>1.08 (0.68–1.74)</td>
<td>0.64 (0.24–1.66)</td>
</tr>
<tr>
<td>Spinal injury</td>
<td>1.10 (0.74–1.65)</td>
<td>1.26 (0.91–1.74)</td>
<td>0.93 (0.56–2.29)</td>
<td>0.68 (0.09–5.15)</td>
</tr>
<tr>
<td>Asthma</td>
<td>1.05 (0.94–1.16)</td>
<td>0.96 (0.83–1.11)</td>
<td>0.99 (0.80–1.22)</td>
<td>0.83 (0.56–1.22)</td>
</tr>
<tr>
<td>Surgical procedures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open reduction of fracture</td>
<td>0.88 (0.69–1.12)</td>
<td>0.86 (0.69–1.07)</td>
<td>1.46 (0.93–2.32)</td>
<td>1.84 (0.73–4.60)</td>
</tr>
<tr>
<td>Cleft palate</td>
<td>1.76 (0.98–3.16)</td>
<td>3.77 (1.29–11.02)*</td>
<td>0.52 (0.14–1.90)</td>
<td>0.22 (0.01–4.16)</td>
</tr>
<tr>
<td>Mastoectomy</td>
<td>0.97 (0.76–1.25)</td>
<td>0.79 (0.44–1.43)</td>
<td>1.03 (0.39–2.71)</td>
<td>0.29 (0.10–0.83)*</td>
</tr>
<tr>
<td>Back surgery</td>
<td>1.10 (0.72–1.68)</td>
<td>1.40 (0.87–2.25)</td>
<td>1.15 (0.54–2.47)</td>
<td>2.27 (0.99–5.21)</td>
</tr>
<tr>
<td>Thyroid surgery</td>
<td>1.33 (0.70–2.52)</td>
<td>40.63 (9.02–182.9)*</td>
<td>0.91 (0.19–4.34)</td>
<td>1.15 (0.18–7.32)</td>
</tr>
<tr>
<td>Tonsillotomy and adenoidectomy</td>
<td>0.81 (0.55–1.19)</td>
<td>0.91 (0.55–1.51)</td>
<td>3.12 (0.88–11.06)</td>
<td>7.32 (0.49–109.7)</td>
</tr>
<tr>
<td>Nissen fundoplication</td>
<td>1.11 (0.71–1.73)</td>
<td>1.35 (0.76–2.40)</td>
<td>0.75 (0.25–2.31)</td>
<td>0.31 (0.13–0.71)†</td>
</tr>
<tr>
<td>Pyloric stenosis</td>
<td>1.23 (0.98–1.54)</td>
<td>1.15 (0.80–1.64)</td>
<td>0.84 (0.48–1.47)</td>
<td>0.73 (0.34–1.57)</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>0.96 (0.88–1.04)</td>
<td>0.91 (0.82–1.01)</td>
<td>1.05 (0.88–1.24)</td>
<td>1.31 (0.88–1.94)</td>
</tr>
</tbody>
</table>

Rural hospitals were used as reference. All reported values are point estimates and 95% confidence intervals. Variances were adjusted for hospital clustering by using robust estimation techniques for unconditioned models. DKA indicates diabetic ketoacidosis. *P < .05. †P < .01. ‡No readmissions occurred in the rural hospital group for comparison.

atric), and the average yearly number of pediatric admissions. The addition of these variables failed to change the results of any model by >5%. We performed additional analyses to assess the robustness of the primary results. Adding variables for the hospital’s teaching status, being a children’s hospital, or the home zip code of the child failed to change the results of any model.

**DISCUSSION**

Between 16% and 34% of all pediatric admissions occur at rural institutions. Rural hospitals delivered care to these children at least as well as did their nonrural counterparts for the 19 medical and 9 surgical conditions identified in this study. With adjustment for demographic variables and comorbid conditions, rural hospitals may deliver slightly more efficient care than large urban hospitals, as measured with the LOS, CLOS, and odds of a prolonged stay. Our study supports the findings of previous work on asthma, which found that rural centers had equal LOS and lower charges, compared with urban hospitals. The performance of rural centers is explained additionally by dividing nonrural centers into geographic categories; other regions besides large urban areas had similar LOS, compared with rural areas.

Why have studies of differences in rural and urban hospital care found such differing results? The studies that found inequities in care focused primarily on conditions requiring rapid assessment and treatment or complex technical and subspecialty skills. The patients in this study were more similar to those in studies on pediatric asthma and community-acquired pneumonia. These conditions are frequently treated without referrals to large specialty centers and represent typical cases for rural pediatricians or general practitioners. For this study, we assigned the LOS of children transferred to another hospital for their care to the initial admitting hospital. This assignment limited any bias associated with the transfer of patients with complicated conditions to large pediatric referral centers, allowing assessment of rural hospitals within the larger health care system of the state or region.

Care for hospitalized patients does not end when the patient is discharged from the hospital. Adequate outpatient follow-up monitoring and management and provision of a medical home through the consistent use of a primary care physician or medical clinic are critical for preventing hospital readmissions and may influence LOS. In this study, large urban hospitals had more patients who were uninsured. Uninsured children have less access to primary care and outpatient services, both before admission and after discharge from the hospital. Prior studies, however, found no differences between uninsured and insured children in hospitalization rates, or the quality of asthma management. Another difference could be in the availability of a medical home for children in large urban areas.
areas. Ryan et al.\textsuperscript{30} found that adolescents without a medical home had higher emergency department use. Other work\textsuperscript{25,26,31} has shown decreased access to care and more hospitalizations for chronic conditions when a medical home is not present. Although we controlled for insurance status in our regression models, differences in access to care may partly explain the performance of large urban hospitals, compared with rural centers.

Risk adjustment is an important element of any observational study that compares the treatment of patients in different settings. Methods to adjust for the severity of illness have not been well established in pediatric medicine, compared with adult medicine,\textsuperscript{32,33} especially for large administrative data sets. The CLOS outcome measure is less sensitive to the problem of inadequate risk adjustment, compared with other outcome measures. CLOS focuses on the efficiency of care after the hospitalization has passed a defined prolongation point. Prior work\textsuperscript{17,18} showed that these cases are more complicated and thus represent a more homogeneous group of children. If the findings in our study had been the result of rural hospitals caring only for the least complicated cases and if rural hospitals were in fact treating children less effectively, then we would have expected the CLOS for rural hospitals to be longer than those for other geographic categories. Instead, we found that rural hospitals had the same or shorter CLOS, compared with other geographic categories including large urban areas, which contain large pediatric referral centers. These data strengthen our findings that rural hospitals manage many pediatric cases at least as well as do hospitals in other geographic categories.

The policy implications of this research are less clear. Regionalization policies must balance the advantages of centralized care of specialty cases, for which increased volume and the elimination of duplicated services lead to increased efficiency, with increased travel costs and diminished access to care. Studies of neonatal intensive care,\textsuperscript{34} pediatric intensive care,\textsuperscript{35} and cardiac surgery\textsuperscript{36} all suggest that regionalization of highly technical care leads to improved mortality rates at somewhat lower costs. Our study suggests that rural hospitals are capable of serving as the gatekeepers for more common pediatric conditions that lead to hospitalization. One factor in this study was the choice to assign patients to the hospital to which they were initially admitted. The LOS for children who were transferred to a second or third hospital were assigned to the first hospital. This algorithm was used to prevent hospitals from appearing better by transferring all patients with more serious or complicated conditions to a tertiary referral center. Rural and community hospitals were evaluated not only on their direct treatment of children but also on how well they identified children who required more-specialized care at a regional center. Because of this element of the study design, our results indicate that the current level of regionalization in Pennsylvania and New York provides appropriate care to rural children. However, additional efforts to deregionalize pediatric care must assess the ability of smaller hospitals to care for sicker patients whom they currently transfer to more-specialized centers. Such patients may fare more poorly than children currently cared for only at a rural hospital. Also, parental satisfaction with the location and quality of care and the added costs resulting from duplication of specialty services must be addressed by policy makers within a region or state.

We chose to categorize patients according to the location of the hospital rather than the home address of the patient. Many children living in rural communities may receive their care in a more-specialized urban center; such children would not be categorized as rural in this study. The focus of this study was on the hospitals, not individual patients, and use of the home zip codes of the patients to determine rural or urban status in each model failed to change the results. Individual cases were identified with ICD-9-CM codes found in the principal procedure or condition field. Systematic mistakes in this coding could affect the results of this study. Also, without detailed chart abstraction for all 143 943 patients, unmeasured severity or socioeconomic status could be another reason why large urban hospitals had slightly longer LOS, compared with other geographic categories. Although New York and Pennsylvania have a diverse mixture of hospitals in rural and urban areas, the results from these 2 states may not be generalizable to states dominated by 1 large tertiary referral center or with rural areas that are farther away from large urban areas. Finally, large urban MSAs at the county level represent a broad categorization of what constitutes an urban area. Many counties coded as urban have areas of rural land that are misclassified with the MSA designation. For the purposes of this study, however, the overall location of a hospital is representative of the children being admitted for treatment.

Rural hospitals appear to provide competent care for children. This study found no differences in the LOS, CLOS, odds of a prolonged stay, or 21-day readmission rates for children treated at rural versus nonrural hospitals. Many childhood hospitalizations are for treatment of common ailments that can be managed at least initially at the local level. Rural hospitals can serve as the gatekeepers to the health care system in states with a diverse mixture of rural and urban hospitals. Additional research is needed to apply these results to other regions or states with different geographic distributions of hospitals and children to determine the impact of these findings on the regionalization of pediatric care.

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