Costs of Venous Thromboembolism, Catheter-Associated Urinary Tract Infection, and Pressure Ulcer

Anthony Goudie, PhD; Linda Dynan, PhD; Patrick W. Brady, MD, MSc; Evan Fieldston, MD, MBA; Kathleen E. Walsh, MD, MS

abstract

**OBJECTIVE:** To estimate differences in the length of stay (LOS) and costs for comparable pediatric patients with and without venous thromboembolism (VTE), catheter-associated urinary tract infection (CAUTI), and pressure ulcer (PU).

**METHODS:** We identified at-risk children 1 to 17 years old with inpatient discharges in the Nationwide Inpatient Sample. We used a high dimensional propensity score matching method to adjust for case-mix at the patient level then estimated differences in the LOS and costs for comparable pediatric patients with and without VTE, CAUTI, and PU.

**RESULTS:** Incidence rates were 32 (VTE), 130 (CAUTI), and 3 (PU) per 10,000 at-risk patient discharges. Patients with VTE had an increased 8.1 inpatient days (95% confidence interval [CI]: 3.9 to 12.3) and excess average costs of $27,686 (95% CI: $11,137 to $44,235) compared with matched controls. Patients with CAUTI had an increased 2.4 inpatient days (95% CI: 1.2 to 3.6) and excess average costs of $7,200 (95% CI: $2,224 to $12,176). No statistical differences were found between patients with and without PU.

**CONCLUSIONS:** The significantly extended LOS highlights the substantial morbidity associated with these potentially preventable events. Hospitals seeking to develop programs targeting VTE and CAUTI should consider the improved turnover of beds made available by each event prevented.

**WHAT’S KNOWN ON THIS SUBJECT:** In adults, there is significant increased length of stay, cost, and/or resource use associated with hospital-acquired conditions. Less is known about the epidemiology and impact of many hospital-acquired conditions in pediatric populations.

**WHAT THIS STUDY ADDS:** We find increased pediatric length of stay and costs due to venous thromboembolism and catheter-associated urinary tract infections. This is essential information for hospital administrators and safety departments who are planning interventions to reduce harm associated with these hospital-acquired conditions.
Eliminating harm to patients caused by health care requires a significant up-front investment in process improvement by health systems. Hospital-acquired conditions such as central line-associated blood stream infection (CLABSI), venous thromboembolism (VTE), catheter-associated urinary tract infection (CAUTI), and pressure ulcer (PU) cause significant harm to hospitalized children. The reduction in the occurrence of these serious conditions improves quality and safety, but in pediatric care less is known about the extent to which hospital-acquired conditions increase the cost of care. Estimating cost savings associated with reduction in harm will help hospital administrators and quality leaders estimate up-front cost and benefits of improvement work, both locally and through participation in improvement networks, and create evidence to evaluate if investment in quality improvement infrastructure improves health care value.

In hospitalized adults, a number of authors have found substantial excess length of stay (LOS), costs, and/or resource use associated with hospital-acquired conditions. For example, Saleh et al. estimated 77% to 92% greater resource use (LOS and costs) for critically ill adults with hospital-acquired conditions compared with those without. Fuller et al. estimated that ~9% of total inpatient costs for Maryland and California are from hospital-acquired conditions. Nero et al. found that PUs in the New York Medicare population contributed to 376,546 excess hospital days per year with a cost of nearly $680 million. However, hospital-acquired conditions in pediatric populations differ from adults by demographic difference in risk pool characteristics (more racially diverse and publicly insured) and by extended impact on families. This raises concerns that estimates of LOS and costs for adult populations, and therefore the business case for quality improvement, may not directly apply to pediatric populations.

Previously, our research team estimated that children with CLABSIs had an increased average LOS of 19 days with an associated excess cost of $85,646 (2011 dollars) compared with similar patients without a CLABSI. Pediatric VTE, CAUTI, and PU can also be identified from administrative data by using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. In this study, we aim to (1) describe the pediatric epidemiology of VTE, CAUTI, and PU; and (2) estimate differences in average LOS and excess costs for pediatric patients experiencing VTE, CAUTI, and PU.

**METHODS**

**Data Source**

Data were obtained from annual 2009 to 2011 Nationwide Inpatient Sample databases from the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality. The databases contain complete inpatient discharge information for a representative sample of ~20% of US community hospitals each year. Discharge- and hospital-level sample weights allow national estimates of event frequency and incidence rates.

**Inclusion and Exclusion Criteria**

The study sample consisted of all discharge records for children 1 to 17 years of age. We excluded patients with a LOS less than 2 days (because any hospital-acquired condition identified on the discharge record was unlikely to be caused by such a brief hospitalization) and patients who were in hospital due to pregnancy, childbirth or conditions related to puerperium (Medical Diagnostic Category 14). We focused on overall LOS and cost for a complete hospital episode of care hence we also excluded all discharges that indicated that the patient died in hospital, or transferred in from, or out to another hospital. Discharge records with an indication of a present on admission condition were excluded. Because many hospitals and states do not submit present on admission data, we additionally excluded any records with a VTE, CAUTI, or PU listed as the primary diagnosis (where present on admission was suspected). Any discharge records that contained missing values for LOS, total charges, age, gender, year, or primary diagnosis were also excluded.

**Identification of Hospital-Acquired Condition Cases**

Hospital-acquired conditions were identified by using ICD-9-CM codes contained on the discharge record. For VTE, we used the combined ICD-9-CM codes 415.×, 451.×, and 453.× identified by Tamariz et al. with a positive prediction value (PPV) of 55% to 76% for general medical patients. For CAUTI, we used the definition operationalized by Zhan et al. who first identify patients undergoing major surgery as a proxy for undergoing a catheterization procedure and then identify urinary tract infection (UTI) by using 16 ICD-9-CM codes. They found that major surgery codes were more sensitive at identifying catheter use (sensitivity 47.8%, PPV 75.3%) than catheter codes (sensitivity 1.5%, PPV 78.2%). We chose this algorithm over others that did not have PU data or that identified UTIs but not CAUTIs. For PUs we used the Agency for Healthcare Research and Quality Pediatric Quality Indicators (www.qualityindicators.ahrq.gov) definition that included ICD-9-CM codes for PU, stages III and IV. Accounting for present on admission conditions, the sensitivity of PU was estimated to be 78.6% with a specificity of 98.0% by using the analogous patient safety indicators for adult inpatients. For all ICD-9-CM codes used in hospital-acquired condition operationalized definitions, see the Appendix.
Main Outcomes

LOS (in days) and estimated inpatient costs were the main outcomes studied. We converted inpatient charges to estimated standardized costs by using cost-to-charge ratio files obtained from the Healthcare Cost and Utilization Project. Each year of costs was adjusted to 2011 dollars by using the Bureau of Labor Statistics’ consumer price indices for hospital services between 2009 and 2011.17

Main Predictors and Other Covariates

Diagnoses of VTE, CAUTI, and PU were the main exposures and predictors of LOS and cost under study. Estimates of LOS and hospital inpatient costs were derived for each hospital-acquired condition by using separate statistical models. Each model was adjusted for patient-mix covariates (discharge year, age, gender, race/ethnicity, and insurance status). Missing race/ethnicity values were coded as “Other.” We also recategorized Asian or Pacific Islander and Native American children as other because of small category numbers. Insurance status includes categories where the primary payer is private, Medicaid, uninsured (self-pay), and other. The constructed other insurance category includes discharges covered by Medicare, explicitly listed as no charge or other, and missing.

To account for medical complexity of patients, we derived a high dimensional propensity risk score18 for each of the hospital-acquired conditions under study by fitting logistic regression models. Each hospital-acquired condition was the dichotomous dependent variable (acquired or not acquired) and dichotomous indicators of all clinical conditions (using clinical classification software and excluding the condition of study) as covariates.19 A higher propensity risk score for VTE indicates that discharge records with the same clinical conditions had a higher probability of being associated with acquiring VTE, as compared with discharge records with lower risk scores.

Statistical Analyses

In the descriptive analysis, we calculated the incidence and weighted rate of each hospital-acquired condition by patient characteristic categories. For each condition, a greedy matching algorithm20 was used to match discharge records containing the condition of study (case) to 2 discharge records with no indication of the condition (controls) by age group, year of discharge, and propensity risk score. A generalized linear mixed model (PROC GLIMMIX in SAS/STAT software) was used to estimate and compare LOS and costs between cases and matched controls. LOS was modeled to follow a negative binomial distribution, and costs were modeled to follow a γ distribution. A dichotomous (yes/no) VTE, CAUTI, or PU indicator was the main predictor in 6 separate models, 1 for each main predictor for LOS and cost outcomes. Other covariates included age, gender, race/ethnicity, insurance, year, propensity score (to account for variability across the matched groups), and interactions for each condition by age, gender, race/ethnicity, insurance category, and year. Matching of case and controls was taken into account by introducing a random effect for the matching identifier. Least squares estimates and P values were obtained from the fitted models. A comparative statistical profile of matched and unmatched cases is also presented for propensity risk scores, unadjusted LOS, and costs.

Descriptive analyses included population weights and hospital strata to account for the National Inpatient Study sampling design. All analyses were performed by using SAS Enterprise Guide 6.1 (SAS Institute, Inc, Cary, NC). All statistical tests were evaluated at a 2-sided 5% significance level.

RESULTS

In our study data, we identified 503,890 pediatric inpatient stays at risk for VTE, 132,994 for CAUTI, and 504,094 for PUs. Overall, the incidence rates per 10,000 at-risk patient discharges were 32.4 for VTE, 130.0 for CAUTI, and 2.9 for PU (Table 1). Children 13 to 17 years of age experienced each condition at a higher rate than children of younger age groups. The rate of CAUTI among girls (215.6 per 10,000 discharges) was >3 times higher than boys (61.5 per 10,000 discharges). Medicaid insured (156.0) and those with other insurance (158.0) had CAUTI rates 1.5 times higher than privately insured patients (101.0) per 10,000 discharges. Despite small numbers of identified PUs in our study data, those with Medicaid insurance (4.0) had double the rate per 10,000 discharges compared with those privately insured (2.0).

Tables 2 (LOS) and 3 (costs) reveal that compared with matched controls, cases with VTE had on average, an increased LOS of 8.1 days (95% confidence interval [CI]: 3.9 to 12.3) and excess costs of $27,686 (95% CI: $11,137 to $44,235). Similarly, compared with matched controls, cases with CAUTI had on average, an increased LOS of 2.4 days (95% CI: 1.2 to 3.6) and excess costs of $7200 (95% CI: $2224 to $12,176). We identified a relatively small number of PUs, and despite numerical differences in overall average LOS (4.9 days) and costs ($19,740) between cases and controls, we were not able to conclude statistical significance.

We found estimated average differences in LOS and excess costs by patient age. The estimated average VTE LOS difference between cases and controls for patients in the younger 1 to 4 and 5 to 7 years of age categories was 6.8 (95% CI: 4.3 to
9.2) and 8.0 (95% CI: 4.9 to 11.1) days, respectively. This was associated with identical case-control estimated cost differences of $47 761 with 95% CI of $17 207 to $66 314 and $7302 to $76 220 for these age groups, respectively.

In contrast to VTE, CAUTI estimated average case-control differences in LOS was higher in the older 9 to 12 (2.8 days [95% CI: 1.1 to 4.5]) and 13 to 17 (2.8 days [95% CI: 1.1 to 4.5]) years of age categories. These were associated with estimated excess costs of $9188 (95% CI: $646 to $17 702) and $10 539 (95% CI: $3051 to $18 027) for each age category, respectively.

PU occurring in patients 1 to 4 years of age were associated with an average LOS of 14.1 (95% CI: 0.9 to 27.3) excess days and average excess cost of $85 853 (95% CI: $8701 to $163 004) compared with patients in this age category who did not acquire a PU.

The case-control matching algorithm that we used was successful in matching 2 controls to each individual case for 96% with a VTE, 88% with a CAUTI, and 81% of all children experiencing a PU (Table 4). Across all 3 conditions and on average, the propensity score in unmatched cases was much higher than those successfully matched ($P < .001$). Unmatched VTE cases spent a mean 31.1 days in hospital compared with a mean of 15.3 days for matched cases ($P < .001$).

Similarly, for VTE, the actual mean inpatient cost for unmatched cases was $162 155, much higher ($P < .001$) than the mean cost of matched cases ($55 846$). We observed similar differences for unmatched and matched cases with CAUTI. Unmatched CAUTI cases had a LOS of 19.2 days and a mean inpatient cost of $58 535 and compared with 8.8

### Table 1: Hospital-Acquired Condition Rates, Overall and by Patient Discharge Characteristics, 2009–2011

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Category</th>
<th>VTE Rate</th>
<th>CAUTI Rate</th>
<th>PU Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 1–4</td>
<td>169 978 (33.7)</td>
<td>374 (22.0)</td>
<td>48 894 (36.8)</td>
<td>633 (129.5)</td>
</tr>
<tr>
<td>5–8</td>
<td>20 031 (17.9)</td>
<td>227 (25.2)</td>
<td>27 000 (20.3)</td>
<td>364 (134.8)</td>
</tr>
<tr>
<td>9–12</td>
<td>85 886 (17.1)</td>
<td>281 (32.7)</td>
<td>23 295 (17.5)</td>
<td>251 (107.7)</td>
</tr>
<tr>
<td>15–17</td>
<td>503 890 (100)</td>
<td>1634 (32.4)</td>
<td>132 994 (100)</td>
<td>1729 (130.0)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boy</td>
<td>265 403 (52.7)</td>
<td>889 (33.5)</td>
<td>73 863 (55.5)</td>
<td>454 (61.5)</td>
</tr>
<tr>
<td>Girl</td>
<td>238 487 (47.4)</td>
<td>745 (31.2)</td>
<td>59 131 (44.5)</td>
<td>1275 (215.6)</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>224 031 (44.5)</td>
<td>747 (33.3)</td>
<td>58 050 (43.7)</td>
<td>709 (122.1)</td>
</tr>
<tr>
<td>African American</td>
<td>77 832 (15.6)</td>
<td>233 (29.9)</td>
<td>17 294 (13.1)</td>
<td>258 (149.2)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>96 007 (19.1)</td>
<td>346 (36.0)</td>
<td>29 157 (22.0)</td>
<td>426 (146.1)</td>
</tr>
<tr>
<td>Other</td>
<td>106 020 (20.8)</td>
<td>308 (29.1)</td>
<td>28 493 (21.2)</td>
<td>336 (117.9)</td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>217 625 (43.2)</td>
<td>711 (32.7)</td>
<td>59 731 (44.8)</td>
<td>43 (2.0)</td>
</tr>
<tr>
<td>Medicaid</td>
<td>245 402 (48.8)</td>
<td>77 (31.2)</td>
<td>62 312 (47.0)</td>
<td>43 (2.0)</td>
</tr>
<tr>
<td>Other</td>
<td>15 104 (3.1)</td>
<td>42 (27.8)</td>
<td>4304 (3.3)</td>
<td>43 (2.0)</td>
</tr>
</tbody>
</table>

### Table 2: Hospital-Acquired Condition Case and Control Estimated LOS (in Days) With Actual and Relative Differences (95% CIs), by Age and Overall

<table>
<thead>
<tr>
<th>Hospital-Acquired Condition</th>
<th>Case, n</th>
<th>Estimated LOS</th>
<th>Difference (95% CI)</th>
<th>Relative Difference Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTE</td>
<td>1–4</td>
<td>398</td>
<td>16.1</td>
<td>6.8 (4.3 to 9.2)</td>
</tr>
<tr>
<td>5–8</td>
<td>219</td>
<td>17.6</td>
<td>9.6</td>
<td>8.0 (4.9 to 11.1)</td>
</tr>
<tr>
<td>9–12</td>
<td>255</td>
<td>14.9</td>
<td>9.7</td>
<td>5.2 (2.5 to 7.8)</td>
</tr>
<tr>
<td>15–17</td>
<td>721</td>
<td>12.6</td>
<td>8.9</td>
<td>3.6 (1.8 to 5.4)</td>
</tr>
<tr>
<td>Overall</td>
<td>1563</td>
<td>15.2</td>
<td>9.4</td>
<td>8.1 (5.9 to 12.3)</td>
</tr>
<tr>
<td>CAUTI</td>
<td>1–4</td>
<td>566</td>
<td>8.1</td>
<td>2.0 (0.6 to 3.6)</td>
</tr>
<tr>
<td>5–8</td>
<td>318</td>
<td>7.6</td>
<td>5.6</td>
<td>2.0 (0.5 to 3.5)</td>
</tr>
<tr>
<td>9–12</td>
<td>209</td>
<td>9.2</td>
<td>8.3</td>
<td>2.9 (0.9 to 4.9)</td>
</tr>
<tr>
<td>15–17</td>
<td>420</td>
<td>9.6</td>
<td>6.8</td>
<td>2.8 (1.1 to 4.5)</td>
</tr>
<tr>
<td>Overall</td>
<td>1513</td>
<td>8.6</td>
<td>6.2</td>
<td>2.4 (1.2 to 3.6)</td>
</tr>
<tr>
<td>PU</td>
<td>1–4</td>
<td>11</td>
<td>20.1</td>
<td>14.1 (9.9 to 27.3)</td>
</tr>
<tr>
<td>5–8</td>
<td>11</td>
<td>11.2</td>
<td>5.3</td>
<td>6.6 (4.4 to 14.8)</td>
</tr>
<tr>
<td>9–12</td>
<td>20</td>
<td>8.7</td>
<td>9.9</td>
<td>12 (8.8 to 6.4)</td>
</tr>
<tr>
<td>15–17</td>
<td>78</td>
<td>9.3</td>
<td>7.2</td>
<td>2.1 (3.0 to 7.2)</td>
</tr>
<tr>
<td>Overall</td>
<td>120</td>
<td>11.8</td>
<td>6.9</td>
<td>4.9 (1.0 to 10.8)</td>
</tr>
</tbody>
</table>
Our study also demonstrates that estimated pediatric LOS and excess costs associated with the conditions under study differ across age groups. For VTE, we found higher LOS and excess costs in younger pediatric patients. This is consistent with a previous finding for pediatric CLABSI.9 Interestingly, for CAUTI we note that older patients incur higher LOS and excess costs, although not substantially higher than for younger patients. Although our data do not speak directly to how age modifies the effect of hospital-acquired condition on LOS and cost, there are potential mechanisms that are worthy

days ($P < .001$) and $26,207 (P < .001)$ for matched cases.

DISCUSSION

Hospitalized children with VTE had on average 8.1 excess hospital days and $27,686 (2011 dollars) in excess costs compared with matched controls. Similar documented excess costs in adults were $17,848.21 For CAUTI, where good evidence exists on preventing the hospital-acquired-condition,22,23 excess cost between pediatric and adult patients was similar. We found hospitalized children with CAUTI have, on average, 2.4 excess hospital days and $7,200 in excess cost compared with matched controls. Recent estimates for adult Medicare patients revealed CAUTI excess costs of $1479 for non-ICU and $8548 for inpatient stays that included an ICU setting.24 Comparisons between populations should be made with caution, because demographic differences within study populations, study methodologies (most have no controls), and the variation in the estimation of excess costs make direct comparisons between pediatric and adult (and across studies in general) for many conditions problematic.25

TABLE 4  Propensity Score, Average Cost, and LOS Difference Between Matched and Unmatched Hospital-Acquired Condition Cases, by Hospital-Acquired Condition

<table>
<thead>
<tr>
<th>Propensity score</th>
<th>Matched</th>
<th>Unmatched</th>
<th>Matched</th>
<th>Unmatched</th>
<th>Matched</th>
<th>Unmatched</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (% )</td>
<td>1563 (96)</td>
<td>71 (4)</td>
<td>1513 (88)</td>
<td>216 (12)</td>
<td>120 (81)</td>
<td>28 (19)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>0.057 (0.102)</td>
<td>0.650 (0.210)</td>
<td>0.073 (0.100)</td>
<td>0.573 (0.213)</td>
<td>0.041 (0.074)</td>
<td>0.479 (0.259)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>0.012 (0.004–0.043)</td>
<td>0.637 (0.404–0.764)</td>
<td>0.023 (0.009–0.115)</td>
<td>0.534 (0.392–0.754)</td>
<td>0.009 (0.002–0.049)</td>
<td>0.504 (0.227–0.618)</td>
</tr>
<tr>
<td>$P$</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>$P$</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>LOS (days)</td>
<td>15.3 (20.0)</td>
<td>31.3 (26.8)</td>
<td>8.8 (15.2)</td>
<td>19.2 (27.8)</td>
<td>11.8 (15.6)</td>
<td>20.6 (21.5)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>9 (4–18)</td>
<td>23 (14–43)</td>
<td>4 (2–8)</td>
<td>8 (4–21)</td>
<td>6 (4–13)</td>
<td>8 (6–34)</td>
</tr>
<tr>
<td>$P$</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.051</td>
</tr>
</tbody>
</table>

Costs and LOS are unadjusted and represent actual values from the data. $P$ value represents an unadjusted statistical test of matched versus unmatched mean difference. Source: Nationwide Inpatient Sample, 2009–2011.10 IQR, interquartile range.
of further study. First, it may be that clinicians are comfortable doing shorter courses of antibiotic therapy and/or oral fluoroquinolones for older children with CAUTI; this therapy may not substantially add to hospital LOS or costs. Alternatively, our requirement for major surgery during the hospitalization for CAUTI may have resulted in more precise matching because surgical procedures are likely a large driver of LOS and costs and may be incompletely captured by ICD-9-CM codes alone. For VTE and CAUTI, excess LOS is likely driving most of the higher costs because these conditions do not add a lot in terms of therapy costs. For PU, we are limited by numbers to concluding that among the very young patients (1–4 years of age) the excess LOS and cost due to the condition is high.

There are limitations of using administrative data for our study. The hospital-acquired conditions may not have been precisely identifiable given the limitations of using administrative data ICD-9-CM codes. This may be especially true when defining these conditions by using a combination of ICD-9-CM codes. However, given the relatively low prevalence rates of the conditions under study, large administrative data were required to obtain the numbers of patients needed to study the excess LOS and costs associated with the conditions. We implemented hospital-acquired condition definitions by using ICD-9-CM based algorithms with the greatest PPV published in the literature. The published algorithms to identify the hospital-acquired conditions in this study ranged from moderate to good in the validity of identifying those with the conditions. Some of these algorithms were developed and validated in adult patients. Although PPV will indicate the extent of those listed with hospital-acquired conditions actually have them, the overall impact of hospital-acquired conditions may be difficult to ascertain because of incomplete coding. This is especially important in the case of VTE where some patients may have VTEs that are not identified during hospitalization when ultrasound testing is not performed.

We consider one of the strengths of this study was using a high density propensity score case-control matching strategy. Propensity scores are particularly well suited when the outcome of study is rare, which limits the use of traditional multivariable regression to control for several variables. Matching on propensity score avoids the complexity of matching on multiple covariates. Matching within a properly sized matching range, or caliper, addresses this issue because subjects with extreme ranges will not have eligible matches from the other group and are thus excluded from subsequent analyses. There were several patients in the PU group who we could not match for this reason; their propensity score was too high to find a suitable match. These patients represent extreme observations, presumably extremely sick patients with PUs, which would bias estimates of cost if attempting to match to a less sick patient without a PU.

This study provides essential attributable cost data to inform hospital administrators and safety departments who are planning interventions to reduce harm associated with pediatric VTE, CAUTI, or PU. The study also adds to the body of literature supporting the business case for quality improvement work. Although our analysis did not include the costs of quality improvement initiatives or interventions to reduce these conditions, it is important to note that there are several evidence-based interventions to reduce these conditions with modest additional cost (eg, early ambulation for VTE, early removal of Foley catheters for CAUTI, and turning a patient every 2 hours to reduce PUs).

Hospitals seeking to develop programs targeting pediatric VTE and CAUTI may wish to consider the number of bed-days made available by each HAC prevented. When designing targeted VTE interventions, hospitals should also consider the impact on LOS and cost is greatest in the youngest children. The significantly extended LOS attributed to VTE and CAUTI highlight the substantial morbidity associated with these potentially preventable events.

ACKNOWLEDGMENT

We thank the Children’s Hospitals’ Solutions for Patient Safety Network for their support of this work.

ABBREVIATIONS

CAUTI: catheter-associated urinary tract infection
Cl: confidence interval
CLABSI: central line-associated bloodstream infection
ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification
LOS: length of stay
PPV: positive prediction value
PU: pressure ulcer
UTI: urinary tract infection
VTE: venous thromboembolism

REFERENCES


## APPENDIX Administrative Data Identification of Hospital-Acquired Condition

<table>
<thead>
<tr>
<th>Hospital-Acquired Condition</th>
<th>Administrative Data Identification of Condition ICD-9-CM Code, Secondary Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTE</td>
<td>415.×, 451.×, and 453.×</td>
</tr>
<tr>
<td>CAUTI</td>
<td>996.64, 112.2, 590.10, 590.11, 590.2, 590.80, 590.81, 590.9, 595.0, 595.3, 595.4, 595.89, 595.9, 597.0, 597.80, 599.0</td>
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<tr>
<td>PU</td>
<td>707.23, 707.24, 707.25</td>
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Costs of Venous Thromboembolism, Catheter-Associated Urinary Tract Infection, and Pressure Ulcer
Anthony Goudie, Linda Dynan, Patrick W. Brady, Evan Fieldston, Richard J. Brilli and Kathleen E. Walsh
Pediatrics; originally published online August 10, 2015;
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