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Potentially Preventable Hospitalizations and the Burden of Healthcare-Associated Infections

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Abstract

Background: An estimated 4% of hospital admissions acquired healthcare-associated infections (HAIs) and accounted for $9.8 (USD) billion in direct cost during 2011. In 2010, nearly 140 000 of the 3.5 million potentially preventable hospitalizations (PPHs) may have acquired an HAI. There is a knowledge gap regarding the co-occurrence of these events.

Aims: To estimate the period occurrences and likelihood of acquiring an HAI for the PPH population.

Methods: Retrospective, cross-sectional study using logistic regression analysis of 2011 Texas Inpatient Discharge Public Use Data File including 2.6 million admissions from 576 acute care hospitals. Agency for Healthcare Research and Quality Prevention Quality Indicator software identified PPH, and existing administrative data identification methodologies were refined for *Clostridium difficile* infection, central line–associated bloodstream infection, catheter-associated urinary tract infection, and ventilator-associated pneumonia. Odds of acquiring HAIs when admitted with PPH were adjusted for demographic, health status, hospital, and community characteristics.

Findings: We identified 272 923 PPH, 14 219 HAI, and 986 admissions with PPH and HAI. Odds of acquiring an HAI for diabetic patients admitted for lower extremity amputation demonstrated significantly increased odds ratio of 2.9 (95% confidence interval: 2.16-3.91) for *Clostridium difficile* infection. Other PPH patients had lower odds of acquiring HAI compared to non-PPH patients, and results were frequently significant.

Conclusions: Clinical implications include increased risk of HAI among diabetic patients admitted for lower extremity amputation. Methodological implications include identification of rare events for inpatient subpopulations and the need for improved codification of HAIs to improve cost and policy analyses regarding allocation of resources toward clinical improvements.

Keywords

healthcare-associated infection, preventable hospitalizations, diabetes, administrative data, comorbidity

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Introduction

More than 3.5 million hospital admissions were identified as potentially preventable during 2010.[1] In addition to potentially misallocated resources, potentially preventable hospitalization (PPH) or any hospital admission carries the risk of acquiring a healthcare-associated infection (HAI). An estimated 1 in 25 US hospital patients acquired an HAI during 2011, translating to $9.8 billion (USD) of additional annual direct medical costs nationwide and an increased risk of death.[2-5]

In our review of the literature, we found little research that examined the patient population with co-occurring PPH and HAI. Since HAIs are known to be both physically and financially costly, reducing exposure to HAI risk by decreasing hospitalizations that are potentially preventable may contribute to improved population health. However, we must first understand the composition and prevalence of individuals with a PPH who acquire an HAI during the same hospitalization. This study begins to address the gap in our knowledge about the PPH population that acquires an HAI.

The primary objectives of the study were to: (1) identify and quantify the prevalence and patient characteristics of individuals who experience co-occurring PPH and HAI and (2) estimate the odds of a PPH patient acquiring an HAI during their hospital admission.

Methods

Data

The 2011 Texas Hospital Discharge Public Use Data File (PUDF) contained over 2.9 million summary abstracts of patient-level information from 1 of 576 Texas hospitals.[6] Institutional review board exempt status approvals were obtained from governing research institutions.

Identification of Patients and Conditions

Identification of PPHs and comorbid conditions. Potentially preventable hospitalizations were identified from the PUDF using SAS 9.3 and program PQSAS1 from the Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicator (PQI), version 4.5.[7] The algorithms identify hospitalizations associated with ambulatory care–sensitive conditions for 1 of 14 adult or 5 pediatric conditions considered potentially preventable through appropriate use of quality preventive care.[2] Thirty comorbid conditions were identified using the comorbidity software from the Health Care Utilization Project.[8,9]

Identification of HAIs. Definitions and methods of identifying HAI from inpatient discharge data were reviewed, combined, and supplemented as described below for use in this study.[10-12] The process used for identifying HAI in the PUDF is represented in Figure 1.

Catheter-associated urinary tract infection. For catheter-associated urinary tract infection (CAUTI), we used International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 996.64—complications related to infection from an indwelling catheter in any diagnosis field. Since code 996.64 is associated with underreporting of CAUTI, we used 17 ICD-9-CM codes (Supplemental Materials) to identify urinary tract infection not present on admission.[11,13,14] We identified catheterization using ICD-9-CM procedure codes 57.94, 97.62, and 97.64 along with procedure dates to estimate the duration of catheterization. We combined urinary tract infection not present on admission with evidence of catheterization lasting more than 2 days to assign CAUTI.

Ventilator-associated pneumonia. To assign ventilator-associated pneumonia (VAP), 4 things were evaluated. First, diagnoses fields were examined for the diagnosis code 997.31—VAP. Since 997.31 historically underreports VAP, we looked for mechanical ventilation or intubation codes and 1 of 29 pneumonia infection codes (Supplemental Materials) not present on admission.[11,12,15] Finally, an admission was assigned as VAP when (1) a diagnosis code of 997.31 was present in the record or (2) evidence of mechanical ventilation greater than 4 days with a pneumonia infection code not present on admission.[16]

Central line–associated bloodstream infections. In the AHRQ Quality Indicator modules, Patient Safety Indicator 7, Pediatric Quality Indicator 12, and Neonate Quality Indicator 3 identify central line–associated bloodstream infection (CLABSI) rates for the adult, pediatric, and neonate hospitalizations, respectively, and prior to availability of electronic health record data, all were endorsed measures of CLABSI by the National Quality Forum.[17,18]

Clostridium difficile infection. *Clostridium difficile* infection (CDI) was identified by using an *ICD-9-CM* diagnosis of 008.45. Since CDI can also be acquired in a community setting and requires 2 days of incubation before symptoms manifest, a CDI diagnosis was considered an HAI if not present on admission and hospital length of stay was greater than 2 days.

Exclusion Criteria

Discharge records were excluded when evaluation variables were missing or invalid. Patients with a length of stay greater than 180 days were excluded as extreme outliers. Hospitalizations identified by the PQI for perforated appendix were excluded as there is no ambulatory care–sensitive condition that precedes appendicitis, and hospitalization is required for treatment. Evaluation of the PQI for low birth weight babies was also excluded as the preventive care associated with it is prenatal care for the mother, and there was no means to appropriately link a low birth weight infant with its mother.

Finally, when regression models were applied to examine each PPH, non-PPH patient records were excluded if patient characteristics did not match the epidemiologic denominator

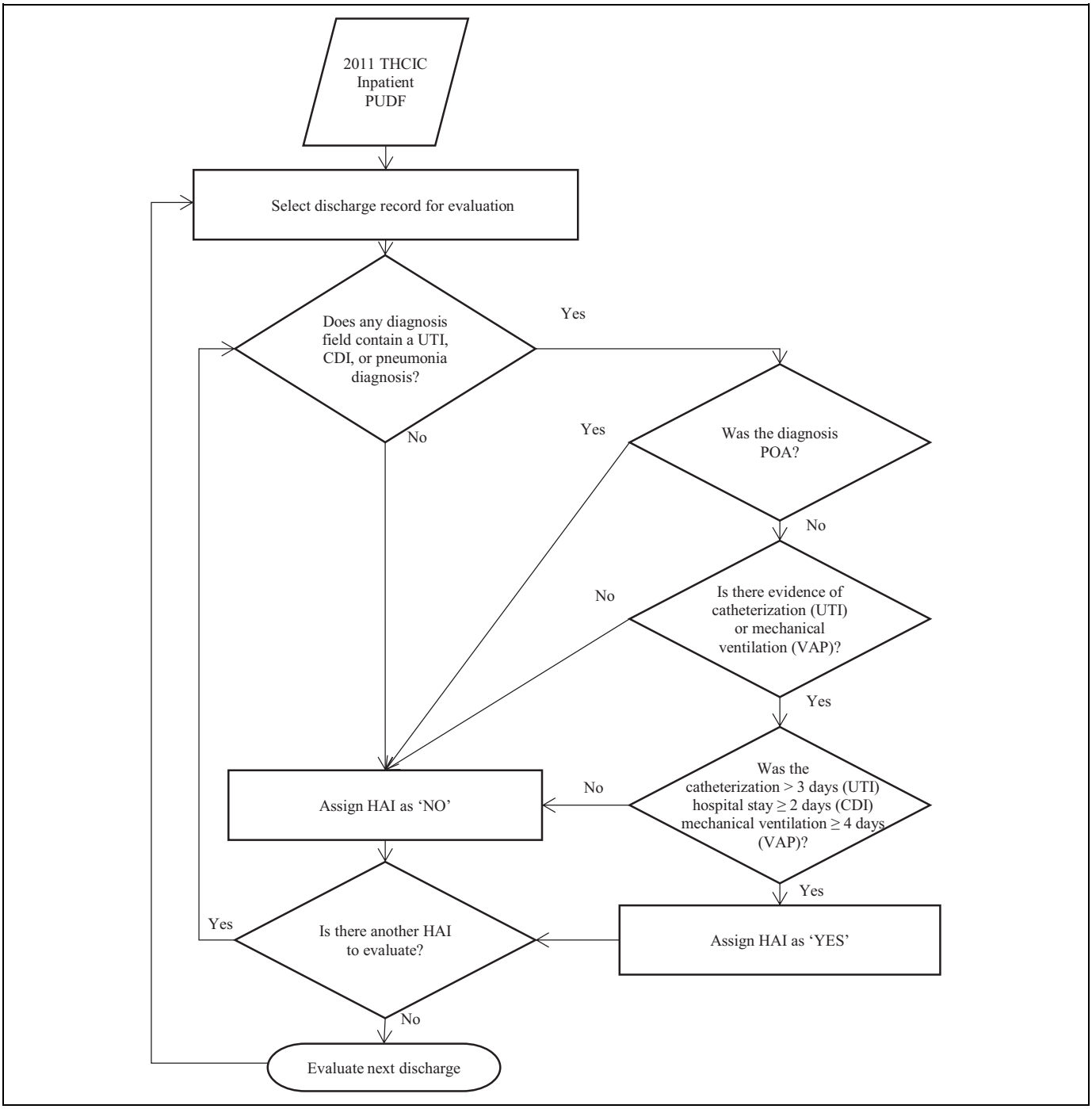

Figure 1. Identification of CAUTI, CDI, and VAP from administrative inpatient data. CAUTI indicates catheter-associated urinary tract infection; CDI, *Clostridium difficile* infection; HAI, healthcare-associated infection; POA, present on admission; PUDF, public use data file; THCIC, Texas Health Care Information Collection; UTI, urinary tract infection; VAP, ventilator-associated pneumonia.

population, or patient at-risk population specifications, of the PQI. For example, patients under 18 would not be included when evaluating the adult asthma PPH. Additionally, each PPH associated with less than 10 HAIs were excluded from PPH-specific analyses due to the inability to make meaningful inferences from statistical analyses. This eliminated all pediatric PPH and adult PPH for hypertension, angina without procedure, uncontrolled diabetes, and asthma in younger adults. However, these subpopulations were included when all PPH were evaluated collectively for an HAI.

Analyses

Period occurrences and odds ratios of PPH with HAI. A correlation matrix that included variables for PPH, HAI, and other independent characteristics was examined for confounding

relationships. Period occurrences were tabulated and reported by evaluation variables. Odds ratios were calculated using 45 logistic regression models. The logistic regression equations modeled the probability of an HAI. The primary independent variable was PPH hospital admission. For example, the presence of CAUTI, VAP CLABSI, CDI, or any HAI was set as the dependent variable in the regression equations. The primary independent variable was 1 of the 8 PPH admission types or all PPH. Hospital admission records were excluded from the denominator population for 3 reasons: (1) if the patient age was less than 18 years, (2) the admission record was identified with an HAI not being evaluated, or (3) the admission record was identified with a PPH not being evaluated.

Other independent variables used to adjust the logistic regression models included age, gender, race, hospital characteristics, community characteristics, and health status as measured by the presence of comorbid conditions. For the 30 comorbid conditions, conditions were excluded from the regression models when the PPH under evaluation was associated with or similar to the comorbid condition. For example, the variable reflecting comorbid diabetes was excluded from regression models when evaluating the PPHs for short-term complications due to diabetes, long-term complications due to diabetes, and diabetes-related lower extremity amputation.

Results

Demographic and Independent Variables

Of the 2 937 134 discharges in the 2011 Texas inpatient data, 294 453 (10.0%) were excluded due to missing or invalid data. Nearly 6.5% of total discharges were excluded for missing gender and were attributed to the suppression of gender to protect the identification of individuals with a diagnosis of substance abuse or HIV. Among the remaining 2 642 681 discharges, 272 923 (10.3%) were identified as PPH, 14 219 (0.5%) included evidence of a potential HAI, and 986 (0.36% of PPH discharges) demonstrated evidence of co-occurring PPH and HAI. Compared to the general inpatient population, individuals with a PPH were older and more likely to have Medicare identified as their primary insurer (Table 1).

Odds Ratios

When examined in aggregate, odds of acquiring an HAI in the PPH population were significantly lower than the remaining inpatient population, with odds ratios ranging from 0.335 (95% confidence interval [CI]: 0.295-0.381) for VAP to 0.729 (95% CI: 0.609-0.874) for CLABSI (Table 2). Of the significant differences, men, white individuals, and individuals with congestive heart failure, paralysis, weight loss, and renal failure had higher odds of acquiring an HAI, except for the renal failure with CLABSI group. Conversely, individuals with hypertension had significantly lower odds of acquiring any form of HAI.

When we estimated the odds ratios for each HAI for the different types of PPH, we found the reduced odds of acquiring an HAI did not hold for patients admitted with a diabetes-related lower extremity amputation (Table 3). For the diabetes-related lower extremity amputation group, significantly higher odds of acquiring an HAI were reported for CDI (OR: 2.9; 95% CI: 2.16-3.91). However, despite increased odds of acquiring VAP (OR: 1.4; 95% CI: 0.95-2.18), CLABSI (OR: 1.7; 95% CI: 0.68-4.03), or CAUTI (OR: 2.2; 95% CI: 0.90-5.32) among this same group, the results were not significant, despite the substantial effect sizes.

Discussion

The reduced odds uncovered through our quantitative evaluation are consistent with PPH individuals potentially requiring less intensive acute care that translates into a decreased risk of acquiring an HAI. When considered from this perspective, comorbid conditions including congestive heart failure, valvular disease, renal failure, pulmonary circulation disorders, weight loss, and paralysis may be important HAI risk factors for PPH individuals. Regarding the reduced odds of acquiring an HAI for diabetes-related comorbidities, in addition to not requiring the invasive and antibiotic therapies, it is possible that the consciousness of providers regarding the heightened risks associated with infections and corresponding best practice treatment protocols for diabetic patients may also play a role in the reduced odds of HAIs.

Aside from lower extremity amputation among diabetic patients, individuals admitted with a PPH had odds approximately half those of the general inpatient population for acquiring an HAI. Thus, while population-based healthcare initiatives may encourage patients to use quality preventive care and chronic disease management to reduce preventable hospitalizations, it seems unlikely the reduced hospitalizations will translate to reduced HAI events.

For individuals with diabetes-related lower extremity amputation, their increased odds of acquiring any HAI are concerning. With significant odds of acquiring CDI at 2.9 times the adjusted non-PPH inpatient population, individuals admitted for diabetes-related lower extremity amputation may benefit from additional specialized care directed toward reducing contact with pathogens or the invasive procedures that increase the risk of acquiring the HAIs identified in this study.

Although administrative discharge data are not preferred or recommended for surveillance of HAI, it remains a valuable resource for policy and cost assessment. One limitation of using administrative data was the potential underidentification of HAI. Even with the enhanced methods for the identification of CAUTI and other forms of HAI, only 0.5% of discharges were identified with a potential HAI. Although our study did not attempt to identify all forms of HAI such as surgical site infection, administrative data continue to underidentify HAI according to the Centers for Disease Control and Prevention's (CDC) estimate of 4% of discharges. This may be attributed to the inability during secondary data analysis to link infection

Table 1. Distributions of Inpatients Across Demographic and Select Evaluation Variables by Type of Admission, 2011.[a]

	PPH[b]		HAI[c]		With Both[d]		Total Discharges	
	N = 272 923		N = 14 219		N = 986		N = 2 642 681	
Variable categories	n	% of PPH discharges	n	% of HAI discharges	n	% of both discharges	n	% of total discharges
Gender								
Male	116 172	43%	6898	49%	421	43%	1 030 128	39%
Female	156 751	57%	7321	51%	565	57%	1 612 553	61%
Age group								
Under 1 year	20 178	7%	435	3%	39	4%	401 863	15%
1-17 years	14 700	5%	363	3%	9	1%	151 462	6%
18-24 years	5992	2%	238	2%	6	1%	190 732	7%
25-44 years	27 135	10%	1165	8%	69	7%	513 224	19%
45-64 years	72 441	27%	4082	29%	299	30%	576 503	22%
65-74 years	47 211	17%	3315	23%	214	22%	334 456	13%
75-84 years	50 633	19%	3097	22%	214	22%	302 540	11%
85+ years	34 633	13%	1524	11%	136	14%	171 901	6%
Race								
White	143 653	53%	7813	55%	550	56%	1 323 466	50%
Black	43 745	16%	1880	13%	139	14%	339 738	13%
Hispanic	69 764	26%	3080	22%	243	25%	773 549	29%
Asian/Pacific Islander	2720	1%	197	1%	10	1%	45 762	2%
American Indian./Eskimo/Aleut	2052	1%	56	0%	5	1%	18 334	1%
Other	10 989	4%	1193	8%	39	4%	141 832	5%
Primary payer								
Private payer	55 996	21%	2819	20%	146	15%	842 482	32%
Medicare	146 944	54%	8842	62%	646	66%	909 285	34%
Medicaid	36 971	13%	1419	10%	111	11%	583 356	22%
Other government	5867	2%	326	2%	16	2%	77 403	3%
Self-pay or charity	27 145	10%	813	6%	67	7%	230 155	9%
Comorbid conditions								
Congestive heart failure	31 194	11%	1 938	14%	177	18%	151 997	6%
Pulmonary circulation disorders	3455	1%	485	3%	36	4%	28 883	1%
Hypertension	137 217	50%	5498	39%	502	51%	888 641	34%
Paralysis	2809	1%	510	4%	21	2%	27 770	1%
Diabetes without chronic complications	56 673	21%	2195	15%	202	20%	366 177	14%
Renal failure	43 243	16%	2401	17%	265	27%	216 262	8%
Obesity	31 030	11%	1411	10%	155	16%	205 673	8%
Weight loss	9880	4%	1853	13%	116	12%	82 433	3%

Abbreviations: HAI, healthcare-associated infection; PPH, potentially preventable hospitalizations.

[a]Texas Health Care Information Collection Inpatient Public Use Data File, 2011.

[b]All variable distributions were significantly different than the general inpatient population at $p < .0001$, except for the comorbid condition of paralysis that was not significantly different from the general inpatient population.

[c]All variable distributions were significantly different than the general inpatient population at $p < .0001$, except for the comorbid condition of depression and measures of rurality that were not significantly different from the general inpatient population.

[d]All variable distributions were significantly different than the general inpatient population at $p < .05$, except for hospital ownership, measures of rurality, public health benefits and the comorbid conditions lymphoma, blood loss anemia, and psychoses that were not significantly different from the general inpatient population.

codes to the cause using the current coding system. Also, since there are *ICD-9-CM* codes for CAUTI, and the CDC's estimate of CAUTI in the hospitalized population is much higher than identified, it is probable that the data abstraction and coding processes are systemically misaligned with reporting HAI due to the disconnected billing and payment process.

However, we were able to identify a sufficient sample to evaluate the population affected. Although bias may exist toward individuals with more severe disease, we anticipate with the transition to *ICD-10* more accurate reporting of CAUTI as there are at least 4 codes that specify the source of urinary tract infection as secondary to the indwelling catheter. Additionally, we were able to identify a sufficient sample size of HAI to identify significant relationships adjusting for numerous demographic and environmental factors. Therefore, this method should translate to other hospital subpopulations for examining the odds of acquiring an HAI or other rare event.

Table 2. Odds of Acquiring HAI[a] for All PPHs,[b] 2011.[c,d]

	All HAI			CDI			CLABSI			CAUTI			VAP		
	n = 14 219			n = 6617			n = 1532			n = 1139			n = 5012		
Variable Categories	Odds Ratio	LCL	UCL	Odds Ratio	LCL	UCL	Odds Ratio	LCL	UCL	Odds Ratio	LCL	UCL	Odds Ratio	LCL	UCL
PPH admission	**0.478**	0.447	0.510	**0.541**	0.494	0.592	**0.729**	0.609	0.874	**0.561**	0.455	0.693	**0.335**	0.295	0.381
Gender															
Male	**1.261**	1.219	1.306	**1.071**	1.018	1.127	**1.315**	1.184	1.461	0.989	0.875	1.117	**1.582**	1.492	1.677
Age group															
85+ years	Referent			Referent			Referent			Referent			Referent		
Under 1 year	**0.112**	0.099	0.127	**0.026**	0.020	0.035	0.970	0.690	1.363	**0.006**	0.002	0.016	**0.274**	0.223	0.336
1-17 years	**0.266**	0.234	0.303	**0.231**	0.190	0.281	**2.130**	1.524	2.979	**0.034**	0.016	0.072	**0.203**	0.153	0.269
18-24 years	**0.148**	0.128	0.172	**0.107**	0.084	0.137	**0.638**	0.427	0.954	**0.055**	0.031	0.095	**0.256**	0.200	0.328
25-44 years	**0.287**	0.262	0.315	**0.232**	0.203	0.265	0.941	0.689	1.285	**0.130**	0.095	0.177	**0.477**	0.405	0.563
45-64 years	0.972	0.907	1.043	**0.791**	0.718	0.870	**2.059**	1.569	2.703	**0.434**	0.345	0.545	**1.624**	1.422	1.856
65-74 years	**1.180**	1.108	1.256	0.963	0.885	1.047	**1.992**	1.536	2.584	**0.641**	0.528	0.777	**1.926**	1.703	2.180
75-84 years	**1.185**	1.114	1.261	1.082	0.997	1.174	**1.461**	1.116	1.911	0.877	0.732	1.051	**1.608**	1.419	1.823
Race															
White	Referent			Referent			Referent			Referent			Referent		
Black	**0.567**	0.533	0.604	**0.478**	0.439	0.520	**0.583**	0.483	0.704	**0.700**	0.555	0.883	**0.695**	0.619	0.780
Hispanic	**0.618**	0.574	0.666	**0.512**	0.460	0.569	**0.727**	0.585	0.902	0.862	0.654	1.135	**0.755**	0.661	0.863
Asian/Pacific Islander	**0.570**	0.531	0.612	**0.496**	0.449	0.548	**0.519**	0.421	0.639	**0.632**	0.485	0.823	**0.734**	0.647	0.833
American Indian./Eskimo/Aleut	**0.651**	0.559	0.758	**0.540**	0.430	0.678	**0.638**	0.412	0.989	0.583	0.302	1.128	0.925	0.727	1.177
Other	**0.317**	0.242	0.416	**0.196**	0.124	0.310	**0.283**	0.116	0.694	0.488	0.197	1.208	**0.470**	0.310	0.713
Primary payer															
Medicare	Referent			Referent			Referent			Referent			Referent		
Self-pay or charity	**0.698**	0.643	0.758	**0.463**	0.403	0.533	**0.742**	0.583	0.945	0.807	0.597	1.091	0.996	0.881	1.127
Medicaid	**0.850**	0.787	0.917	**0.582**	0.513	0.661	1.163	0.953	1.418	0.892	0.663	1.200	1.111	0.986	1.252
Other government	**0.766**	0.682	0.861	**0.526**	0.430	0.643	0.892	0.643	1.238	0.721	0.458	1.135	1.062	0.894	1.262
Private insurance	**0.664**	0.628	0.702	**0.561**	0.516	0.609	**0.734**	0.618	0.872	**0.671**	0.547	0.824	**0.766**	0.699	0.839
Comorbid conditions[e]															
Congestive heart failure	**1.432**	1.357	1.510	**1.369**	1.266	1.480	**1.258**	1.041	1.521	**1.223**	1.009	1.482	**1.781**	1.636	1.938
Pulmonary circulation disorders	**1.686**	1.531	1.857	**1.461**	1.255	1.701	**1.983**	1.466	2.682	1.409	0.971	2.045	**1.944**	1.687	2.239
Hypertension	**0.538**	0.517	0.559	**0.480**	0.454	0.508	**0.602**	0.529	0.684	**0.529**	0.464	0.603	**0.577**	0.541	0.616
Paralysis	**2.598**	2.370	2.847	**2.123**	1.834	2.457	**3.551**	2.833	4.450	**3.223**	2.371	4.380	**2.899**	2.514	3.342
Diabetes without chronic complications	**0.726**	0.691	0.762	**0.725**	0.674	0.780	0.906	0.777	1.057	**0.603**	0.503	0.723	**0.699**	0.645	0.758
Renal failure	**1.517**	1.442	1.596	**1.481**	1.376	1.595	**0.808**	0.664	0.983	**1.218**	1.011	1.466	**1.904**	1.755	2.065
Obesity	**1.304**	1.231	1.382	0.978	0.888	1.076	**1.556**	1.316	1.840	**1.624**	1.337	1.971	**1.431**	1.306	1.567
Weight loss	**2.627**	2.492	2.770	**2.635**	2.446	2.839	**2.696**	2.264	3.211	**1.586**	1.279	1.968	**2.892**	2.652	3.153

Abbreviations: CAUTI, catheter-associated urinary tract infection; CDI, *Clostridium difficile* infection; CLABSI, central line–associated bloodstream infection; HAI, healthcare-associated infections; LCL, lower confidence limit; PPH, potentially preventable hospitalization; UCL, upper confidence limit; VAP, ventilator-associated pneumonia.

[a]The denominator or at-risk population, n = 2 642 681.

[b]The PPH population, n = 272 923.

[c]Texas Health Care Information Collection Inpatient Public Use Data File, 2011.

[d]Odds ratios in bold are significant at $p < .0001$.

[e]Referent group for comorbid conditions consist of individuals without the comorbid condition.

Table 3. Adjusted Odds of Acquiring an HAI by HAI and AHRQ Prevention Quality Indicator, 2011.[a,b]

Type of PPH	PPH Denominator Population[c]	PPH Population	HAI Population	PPH with HAI	Odds Ratio	LCL	UCL
			Any HAI				
All PPH	2 642 681	272 923	14 219	986	**0.335**	0.295	0.381
PQI01 diabetes short-term complications	1 862 070	10 759	12 514	31	**0.660**	0.463	0.941
PQI03 diabetes long-term complications	1 872 221	20 910	12 590	112	**0.629**	0.519	0.762
PQI05 COPD or asthma in older adults	1 891 645	40 334	12 617	139	**0.372**	0.313	0.442
PQI08 heart failure	1 899 828	48 517	12 740	270	**0.592**	0.522	0.672
PQI10 dehydration	1 870 759	19 448	12 542	60	**0.419**	0.324	0.542
PQI11 bacterial pneumonia	1 893 646	42 335	12 626	144	**0.382**	0.324	0.452
PQI12 urinary tract infection	1 885 483	34 172	12 598	135	**0.377**	0.314	0.454
PQI16 LEA among diabetes patients	1 854 910	3599	12 560	77	**2.067**	1.640	2.606
			CDI				
All PPH	2 642 681	272 551	6617	530	**0.541**	0.494	0.592
PQI01 diabetes short-term complications	1 862 070	10 749	5919	21	1.123	0.729	1.728
PQI03 diabetes long-term complications	1 872 221	20 875	5970	76	0.966	0.763	1.222
PQI05 COPD or asthma in older adults	1 891 645	40 241	5939	42	**0.242**	0.178	0.330
PQI08 heart failure	1 899 828	48 358	5997	104	**0.500**	0.409	0.611
PQI10 dehydration	1 870 759	19 423	5933	36	**0.501**	0.359	0.699
PQI11 bacterial pneumonia	1 893 646	42 288	5994	97	**0.567**	0.463	0.695
PQI12 urinary tract infection	1 885 483	34 151	5992	96	**0.605**	0.492	0.743
PQI16 LEA among diabetes patients	1 854 910	3568	5945	46	**2.904**	2.159	3.906
			CLABSI				
All PPH	2 642 681	272 068	1532	133	**0.729**	0.609	0.874
PQI01 diabetes short-term complications	1 862 070	10 732	1120	4	0.683	0.255	1.830
PQI03 diabetes long-term complications	1 872 221	20 812	1125	10	0.618	0.320	1.196
PQI05 COPD or asthma in older adults	1 891 645	40 210	1127	10	**0.387**	0.213	0.703
PQI08 heart failure	1 899 828	48 284	1141	24	0.847	0.566	1.267
PQI10 dehydration	1 870 759	19 393	1120	4	**0.366**	0.137	0.977
PQI11 bacterial pneumonia	1 893 646	42 218	1142	26	0.889	0.600	1.317
PQI12 urinary tract infection	1 885 483	34 070	1129	14	**0.514**	0.296	0.892
PQI16 LEA among diabetes patients	1 854 910	3526	1121	4	1.654	0.679	4.031
			CAUTI				
All PPH	2 642 681	272 029	1139	94	**0.677**	0.556	0.826
PQI01 diabetes short-term complications	1 862 070	10 730	1032	2	0.638	0.159	2.565
PQI03 diabetes long-term complications	1 872 221	20 807	1035	4	0.420	0.174	1.015
PQI05 COPD or asthma in older adults	1 891 645	40 211	1042	11	**0.387**	0.219	0.686
PQI08 heart failure	1 899 828	48 303	1075	45	1.257	0.925	1.708
PQI10 dehydration	1 870 759	19 401	1042	12	0.922	0.521	1.632
PQI11 bacterial pneumonia	1 893 646	42 205	1043	13	**0.415**	0.239	0.719
PQI16 LEA among diabetes patients	1 854 910	3526	1035	4	2.185	0.897	5.322
			VAP				
All PPH	2 642 681	272 860	5012	258	**0.335**	0.295	0.381
PQI01 diabetes short-term complications	1 862 070	10 732	4492	4	**0.197**	0.074	0.525
PQI03 diabetes long-term complications	1 872 221	20 824	4509	21	**0.310**	0.201	0.476
PQI05 COPD or asthma in older adults	1 891 645	40 272	4560	76	**0.564**	0.446	0.714
PQI08 heart failure	1 899 828	48 352	4580	98	**0.563**	0.457	0.695
PQI10 dehydration	1 870 759	19 398	4497	9	**0.193**	0.100	0.371
PQI11 bacterial pneumonia	1 893 646	42 200	4496	8	**0.056**	0.028	0.113
PQI12 urinary tract infection	1 885 483	34 065	4496	8	**0.083**	0.041	0.166
PQI16 LEA among diabetes patients	1 854 910	3545	4511	23	1.440	0.949	2.184

Abbreviations: COPD, Chronic obstructive pulmonary disease; HAI, healthcare-associated infections; LCL, lower confidence limit; LEA, lower extremity amputation; PPH, potentially preventable hospitalization; PQI, Prevention Quality Indicator; UCL, upper confidence limit.

[a]Texas Health Care Information Collection Inpatient Public Use Data File, 2011.

[b]Odds ratios in bold are significant at $p < .0001$. Odds ratios are adjusted for age, gender, race, hospital characteristics, community characteristics, and comorbid conditions.

[c]The denominator population for the logistic regression included all inpatient records that were not identified as potentially preventable and those records identified as the PQI identified with the PPH being evaluated.

Conclusions

The increased odds of acquiring all forms of HAI by the diabetes population with lower extremity amputation are of particular interest. Although studies of amputee care during hospitalization should inform best practices related to hospital care, patient education and comparison of preventive care utilization between diabetic amputees and diabetic nonamputees could inform policy makers about key services that may reduce the occurrence of amputations and, by extension, eliminate the risk of HAI.

Although the number of individuals identified with co-occurring PPH and HAI was consistent with broad probability calculations, the potential for substantial underidentification of HAIs, especially CAUTI, suggests there is more to learn about identifying this population through administrative data. Additionally, the potential underidentification limits our ability to accurately estimate direct medical costs attributable to co-occurring PPH and HAI. However, identification may not be an issue for other rare events, making this method one to consider when exploring the period occurrence of rare events particularly in hospital subpopulations.

Declaration of Conflicting Interests

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Supplemental Material

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