Gender Differences in Risk of Bloodstream and Surgical Site Infections

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BACKGROUND: Identifying patients most at risk for hospital- and community-associated infections is one essential strategy for preventing infections.

OBJECTIVE: To investigate whether rates of community- and healthcare-associated bloodstream and surgical site infections varied by patient gender in a large cohort after controlling for a wide variety of possible confounders.

DESIGN: Retrospective cohort study.

PARTICIPANTS: All patients discharged from January 1, 2006 through December 31, 2008 (133,756 adult discharges and 66,592 pediatric discharges) from a 650-bed tertiary care hospital, a 220-bed community hospital, and a 280-bed pediatric acute care hospital within a large, academic medical center in New York, NY.

MAIN MEASURES: Data were collected retrospectively from various electronic sources shared by the hospitals and linked using patients' unique medical record numbers. Infections were identified using previously validated computerized algorithms.

KEY RESULTS: Odds of community-associated bloodstream infections, healthcare-associated bloodstream infections, and surgical site infections were significantly lower for women than for men after controlling for present-on-admission patient characteristics and events during the hospital stay [odds ratios (95 % confidence intervals) were 0.85 (0.77–0.93), 0.82 (0.74–0.91), and 0.78 (0.68–0.91), respectively]. Gender differences were greatest for older adolescents (12–17 years) and adults 18–49 years and least for young children (<12 years) and older adults (≥70 years).

CONCLUSIONS: In this cohort, men were at higher risk for bloodstream and surgical site infections, possibly due to differences in propensity for skin colonization or other anatomical differences.

KEY WORDS: surgical site infection; bloodstream infection; healthcare-associated infection; gender.

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INTRODUCTION

Preventing bacterial infections is an increasingly important goal in hospitals and communities as the prevalence of antibiotic-resistant organisms continues to increase in both settings.^{1,2} In addition to implementing systems-level approaches for preventing infections, such as transmission-based isolation precautions, checklists and care bundles for indwelling devices, and education of healthcare personnel and visitors,³ recent studies have also sought to determine which patients are most at risk of developing an infection.⁴ Understanding the individual-level characteristics that put patients at risk for community- and healthcare-associated infections can potentially lead to improvements in infection rates and outcomes through targeted prevention and surveillance strategies, as well as provide important information for standardizing the calculation of infection rates to make comparisons across populations, hospitals, and healthcare providers more meaningful and accurate.^{5–7}

For urinary tract infections (UTI), individual risk factors among hospitalized patients and the general population are well understood, and differences between men and women have been consistently described. Risk of UTI varies according to genetic predisposition, medical conditions, surgical interventions, catheter use, sexual activity, age, and gender, with women having a higher risk of infection than men at all stages of life.⁸ On the contrary, individual-level risk factors for bloodstream infections (BSI) and surgical site infections (SSI) are less clear, particularly with regard to gender differences, where there is little consistency across studies.⁹ As part of a larger study to estimate the costs of infections, a significant difference in risk of BSI and SSI for men versus women was discovered. The purpose of this study was to investigate whether community- and

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healthcare-associated BSI and SSI rates varied by gender in this large cohort after controlling for a wide variety of possible confounders.

METHODS

Sample and Setting

The analyses included all adult patients (≥ 18 years) discharged from a 650-bed tertiary care hospital and a 220-bed community hospital within a large, academically affiliated hospital network in New York, NY, between January 1, 2006 and December 31, 2008. A separate analysis of pediatric patients included all children discharged from a 280-bed pediatric acute care hospital within the same network during the same 3-year period.

Procedure

All study data were collected retrospectively from various electronic sources shared by the hospitals, including a clinical data warehouse containing laboratory culture results, medication administration records, hospital procedures performed, and patient location information; an admission-discharge-transfer database containing International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes; a cost accounting system containing billed charges, revenue codes, and insurance information; and an electronic medical record used for clinical charting. Operating room data were provided by the individual perioperative services departments at each hospital and included information on incision and closure times, type of procedure performed, and type of anesthesia used. The information extracted from these systems was compiled into a single database and linked by patients' unique medical record numbers using a process described in detail elsewhere.¹⁰

Measures

Infections were identified using previously validated computerized algorithms.^{10,11} Incident cases of BSI were patients who had a positive blood culture in the absence of a positive culture for the same organism in another body site within the previous 14 days. BSIs were considered community-associated if they occurred <48 h after hospital admission and healthcare-associated if they occurred ≥ 48 h after admission. Incident cases of SSI were patients who underwent a National Healthcare Safety Network (NHSN) surgical procedure¹² as indicated by an ICD-9-CM procedure code and had a positive wound culture at the surgical site within 30 postoperative days.

For community-associated infections, the following data were identified: gender, age, hospital admitted to (community vs. tertiary care), previous admission (ever) within the hospital network, admission from a skilled nursing facility as identified through admission codes or home address of a known skilled nursing facility, diagnosis of diabetes mellitus, malignancies, renal failure, chronic dermatitis, trauma, burns, wounds, and history of solid organ transplant identified based on primary or secondary ICD-9-CM codes flagged as present-on-admission, and weighted Charlson comorbidity index constructed from present-on-admission ICD-9-CM codes.¹³ For healthcare-associated infections, the following hospitalization events and the day on which they first occurred were identified through a combination of discharge ICD-9-CM codes and clinical charting in the electronic medical record: dialysis, intensive care unit (ICU) stay, mechanical ventilation/intubation, feeding tube placement, biopsy, operating room procedure, urinary catheter placement, central venous catheter placement, administration of chemotherapeutic, immunosuppressive, and anti-inflammatory medications, and length of stay in days. For patients who developed BSI or SSI, these risk factors were considered present if they occurred ≥ 48 h before the diagnosing culture was taken. For patients who did not develop an infection, these risk factors were considered present if they occurred ≥ 48 h before discharge. Data on height and weight were also collected from patients' electronic medical records and used to calculate body mass index (BMI) according to the Centers for Disease Control and Prevention guidelines.¹⁴

Statistical Analysis

All analyses were performed in SAS version 9.2 (SAS Institute, Cary, NC). For the adult cohort, descriptive statistics (means and standard deviations for continuous variables and frequencies and percents for categorical variables) for all patient characteristics were calculated separately for men and women, and gender differences were tested using bivariate methods (two-sample t-tests for independent samples and chi-square test of independence for categorical variables). Continuous variables were determined to follow a normal distribution. Bivariate associations between each patient characteristic and each infection type were modeled with logistic regression. Multivariable logistic regression models were created for each infection outcome using all patient characteristics significantly associated with infection in the bivariate analyses. Backward selection was used to determine the final models. A separate bivariate analysis of the association between gender and healthcare-associated BSI was conducted excluding all patients who had positive blood and urine cultures with the same organism, regardless of the order in which these cultures were taken. Finally, we reported

adjusted and unadjusted age-specific odds ratios for the association between gender and infection for six age strata: <12, 12–17, 18–49, 50–59, 60–69, and ≥70 years.

RESULTS

A total of 133,756 adult discharges occurred during the study period, representing 82,225 unique patients. Identified infections included 2,485 community-associated BSIs (18.6 per 1,000 discharges), 1,671 healthcare-associated BSIs (12.5 per 1,000 discharges), and 779 SSIs (5.8 per 1,000 discharges). The organisms causing BSI and SSI have been described previously.¹⁰ Table 1 compares the infection rates and prevalence of known infection risk factors between men and women. Prior in-network hospitalizations, diabetes, malignancies, chronic dermatitis, renal failure, history of solid organ transplant, wounds, trauma, burns, ICU stay, intubation/mechanical ventilation, feeding tube insertion, dialysis, biopsy, operating room procedures, central venous catheters, and solid organ transplant during the hospital stay were all slightly but significantly more common among men. The men were also significantly older, had more comorbidities, and longer length of stay than the women, although these differences were also small in magnitude. Women had slightly but significantly higher BMI compared to men, and they were significantly more likely than men to receive urinary catheters, be admitted from a skilled nursing facility, and be admitted to the community hospital.

For community-associated BSI, the odds of infection were significantly lower for women in the unadjusted model (OR=0.75, 95 % CI=0.70–0.82; Table 2), and this difference remained significant, although attenuated, after adjusting for all present-on-admission patient characteristics (OR=0.85, 95 % CI=0.77–0.93; Table 2). The findings were similar for healthcare-associated BSI and SSI, where the unadjusted odds of infection were significantly lower for women (OR=0.64, 95 % CI=0.58–0.70 and OR=0.60, 95 % CI=0.52–0.69 for BSI and SSI, respectively; Table 3) and remained significantly lower after adjusting for present-on-admission and hospitalization characteristics (OR=0.82, 95 % CI=0.74–0.91 and OR=0.78, 95 % CI=0.68–0.91 for BSI and SSI, respectively; Table 3). Data on height and weight were available for 51,200 (38 %) of patient discharges. Among these patients, BMI was not associated with incidence of community-associated BSI (OR=0.977, 95 % CI=0.970–0.984), healthcare-associated BSI (OR=0.995, 95 % CI=0.988–1.003), or SSI (OR=1.005, 95 % CI=0.997–1.014) and therefore did not confound the association between gender and infection. Seventy-four patients with a positive blood culture also had a positive urine culture with the same organism during their hospital stay. Excluding these patients from the analysis did not change the association between gender and BSI (OR=0.636, 95 % CI=0.577–0.701 including these

Table 1. Description of Adult Study Cohort and Infection Rates by Patient Gender

	Women	Men	<i>p</i> [*]
Study sample and infection outcomes			
Total discharges	53.1 (71,044)	46.9 (62,712)	
Unique patients	54.8 (45,035)	45.2 (37,190)	
Community-associated BSI per 1,000 admissions (N)	16.2 (1,148)	21.3 (1,337)	<0.001
Hospital-associated BSI per 1,000 admissions (N)	9.9 (702)	15.7 (969)	<0.001
SSI per 1,000 admissions (N)	4.4 (315)	7.4 (464)	<0.001
Patient characteristics upon admission			
Age in years	57.5 (20.9)	58.6 (17.1)	<0.001
Body mass index	27.5 (9.0)	26.7 (7.6)	<0.001
Charlson comorbidity index	1.4 (2.0)	1.7 (2.2)	<0.001
Prior SNF stay	3.9 (2,769)	3.2 (2,032)	<0.001
Prior in-network hospitalization	37.2 (26,455)	40.8 (25,594)	<0.001
Diabetes	22.6 (16,049)	26.1 (16,363)	<0.001
Malignancies	9.9 (7,061)	13.9 (8,733)	<0.001
Chronic dermatitis	4.7 (3,305)	6.2 (3,907)	<0.001
Renal failure	14.4 (10,211)	21.4 (13,413)	<0.001
History of solid organ transplant	1.6 (1,139)	2.7 (1,673)	<0.001
Wounds	0.4 (290)	0.7 (458)	<0.001
Trauma	0.08 (56)	0.2 (139)	<0.001
Burns	0.03 (23)	0.06 (35)	0.039
Characteristics of hospitalization			
Length of stay in days	5.9 (9.1)	6.7 (10.8)	<0.001
Admitted to community hospital	30.3 (21,494)	18.5 (11,598)	<0.001
Admitted to ICU	8.7 (6,205)	11.8 (7,406)	<0.001
Intubation/mechanical ventilation	2.7 (1,928)	3.4 (2,149)	<0.001
Feeding tube	0.9 (645)	1.3 (797)	<0.001
Dialysis	2.6 (1,864)	3.7 (2,289)	<0.001
Biopsy	1.6 (1,120)	2.4 (1,523)	<0.001
Operating room procedure	23.8 (16,886)	25.7 (16,105)	<0.001
Urinary catheter	38.4 (27,258)	36.5 (22,867)	<0.001
Central venous catheter	6.1 (4,362)	8.9 (5,594)	<0.001
High-risk medication [†]	18.1 (12,890)	18.4 (11,525)	0.266
Solid organ transplant	0.7 (525)	1.4 (905)	<0.001

Data are % (N) for categorical variables and mean (standard deviation) for continuous variables unless otherwise indicated

BSI bloodstream infections, SSI surgical site infections, SNF skilled nursing facility, ICU intensive care unit

^{*}Results of chi-square test for independence for categorical variables and two-sample t-test for independent samples

[†]Chemotherapeutic, immunosuppressive, or antiinflammatory medications

patients vs. OR=0.635, 95 % CI=0.575–0.700 excluding these patients).

Among children less than 18 years old (66,592 discharges), there were 699 community-associated BSIs, 637 healthcare-associated BSIs, and 183 SSIs detected during the study period. There was no significant association between gender and infection for pediatric patients overall (OR=0.94, 95 % CI=0.81–1.09 for community-associated BSI, OR=0.97, 95 % CI=0.83–1.13 for healthcare-associated BSI, and OR=0.87, 95 % CI=0.65–1.16 for SSI). Results of age-stratified models comparing females to males are presented in Table 4.

Table 2. Differences in Odds of Community-Associated Bloodstream Infection by Gender and Patient Characteristics at Admission

Patient characteristic	Odds ratio (95 % confidence interval)
Unadjusted model	
Gender (female vs. male)	0.75 (0.70–0.82)
Adjusted model*	
Gender (female vs. male)	0.85 (0.77–0.93)
Hospital (community vs. tertiary care)	1.23 (1.11–1.35)
Age (1-year increase)	1.006 (1.003–1.008)
Prior stay in skilled nursing facility	2.34 (2.04–2.68)
Prior hospitalization in network	1.43 (1.31–1.55)
Charlson weighted comorbidity index (1-unit increase)	1.07 (1.05–1.09)
Diabetes mellitus†	0.90 (0.82–0.99)
Malignancies†	1.16 (1.01–1.33)
Renal failure†	2.92 (2.66–3.21)
Chronic dermatitis†	2.11 (1.87–2.39)
Solid organ transplant†	1.39 (1.11–1.74)

*Trauma, burns, and wounds at admission were not significantly associated with incidence of community-associated bloodstream infections and were not included in the final adjusted model

†Conditions present vs. absent on admission

For community-associated BSI, the strongest effects of male gender in the adjusted models were observed for children 12–17 years, followed by adults 18–49 years; there was no effect of gender among young children (<12 years) and older adults (≥60 years). For healthcare-associated BSI, significant effects of male gender in the adjusted models were observed for adults 18–49 years but for no other age group. No significant gender differences were observed in the adjusted age-stratified models; in the unadjusted models, the effect of male gender was strongest in adults 18–49, and significant gender differences persisted for all older adults.

DISCUSSION

The results of this study indicate that despite controlling for a wide range of possible confounders, the odds of community-associated and hospital-associated BSI, as well as SSI, were significantly higher for men than for women. The results for BSI are surprising, as previous findings suggest that 25–43 % of all BSIs originate from UTIs, which are more common in women than in men.^{15–17} One possible explanation could stem from detection bias for UTIs, which might go undetected more often in men because they are thought to be less common (and thus looked for with less vigilance) and because men are less likely to have urinary

catheters and thus urine cultures.¹⁸ If UTIs are more likely to go undiagnosed and untreated in men, this could potentially lead to higher rates of BSI. However, our data suggest that this scenario is unlikely, since after removing all patients who had a positive urinary culture either before or after having a positive blood culture with the same organism, the results remained unchanged. Furthermore, rates of urinary catheterization were very similar for women and men in this cohort (38 % and 36 %, respectively).

Another possible reason for gender differences in both BSI and SSI incidence may be biological differences between men and women's skin. Several studies have found that bacterial colonization of the skin surrounding a central venous catheter at the insertion site is greater on men than on women, even when controlling for baseline colonization.^{19–22} In addition, it has been suggested that hair growth and shaving interfere with wound dressing adherence, which could lead to a higher risk of infection among men who have thicker, coarser hair.²² The fact that our study revealed no gender differences in infection rates among young children supports this theory, since gender differences in skin quality and hair growth are not pronounced in childhood. Moreover, we found that among adolescents, in whom skin differentiation might begin to resemble that of adults, girls had significantly lower odds of community-associated BSI and lower odds of SSI, although this was not significant. The protective effect of gender also diminished among older women who had likely undergone menopause.

We performed a search of the PubMed database for all English language entries available prior to March 2012 that contained the keywords “bloodstream,” “infection,” and “gender” or “surgical,” “site,” “infection,” and “gender.” The search revealed nine publications that reported differences between men and women with respect to incidence of BSI (Table 5, available online).^{23–31} Controlling for a variety of covariates, three of the articles reported that men had significantly higher infection rates than women, and six reported no significant gender differences. Although the majority found no significant gender differences, the fact that all studies reporting significant differences found that males were at higher risk suggests a possible association. Thirty-nine articles reporting gender differences in SSI were identified; some controlled for characteristics of the patients and surgery, while others reported only bivariate comparisons (Table 6, available online).^{32–68} Twelve studies reported that men had significantly higher infection rates, 18 reported no significant gender differences, and 9 reported that women had significantly higher infection rates. Notably, more than half of these were studies of patients undergoing cardiac surgeries.^{61,64,65,67,68} Previous authors have posited that women may be at higher risk for SSI after cardiac surgery because they have smaller arteries that put them at higher risk for surgical complications,⁶⁹ they are more likely to have emergency versus elective cardiac surgery,⁶¹ or their pendulous breasts place added tension on chest incisions, which raises the risk of infection.⁶⁷

Table 3. Differences In Odds Of Healthcare-associated Bloodstream Infection And Surgical Site Infection By Gender, Patient Characteristics At Admission, And Hospital Events

Patient characteristic	Healthcare-associated bloodstream infections		Surgical site infections	
	Bivariable OR (95 % CI)	Multivariable OR (95 % CI)	Bivariable OR (95 % CI)	Multivariable OR (95 % CI)
Gender (female vs. male)	0.64 (0.58–0.70)	0.82 (0.74–0.91)	0.60 (0.52–0.69)	0.78 (0.68–0.91)
Hospital (community vs. tertiary care)	0.48 (0.42–0.55)	0.67 (0.58–0.78)	0.33 (0.26–0.42)	0.42 (0.33–0.53)
Age (1-year increase)	1.008 (1.006–1.011)	0.996 (0.993–0.999)	1.005 (1.001–1.009)	–
Prior stay in skilled nursing facility*	1.99 (1.64–2.41)	1.45 (1.17–1.79)	1.23 (0.87–1.73)	–
Prior hospitalization in network*	1.33 (1.21–1.47)	–	2.45 (2.12–2.82)	2.17 (1.87–2.53)
Charlson weighted comorbidity index (1-unit increase)	1.21 (1.19–1.23)	1.05 (1.02–1.07)	1.10 (1.07–1.13)	0.93 (0.89–0.97)
Diabetes mellitus*	1.27 (1.14–1.41)	–	1.90 (1.65–2.20)	1.41 (1.20–1.66)
Malignancies*	2.14 (1.91–2.41)	1.63 (1.41–1.90)	1.23 (1.01–1.51)	1.40 (1.09–1.80)
History of renal failure* and/or dialysis during hospitalization†	5.06 (4.59–5.57)	2.56 (2.27–2.88)	2.92 (2.53–3.38)	1.54 (1.29–1.84)
Chronic dermatitis*	2.30 (1.97–2.68)	1.75 (1.48–2.05)	5.62 (4.76–6.64)	4.59 (3.85–5.48)
Trauma*	2.09 (0.86–5.07)	–	3.41 (1.27–9.17)	4.01 (1.44–11.13)
Burns*	1.39 (0.19–10.02)	–	6.13 (1.50–25.11)	–
Wounds*	1.29 (0.73–2.29)	–	0.45 (0.11–1.81)	–
Solid organ transplant†	2.48 (2.06–2.99)	–	4.60 (3.71–5.69)	2.66 (2.05–3.46)
Length of stay (1-day increase)†	1.04 (1.037–1.042)	1.016 (1.013–1.018)	1.025 (1.022–1.027)	1.013 (1.010–1.016)
Stay in intensive care unit†	6.64 (6.01–7.34)	1.70 (1.45–2.00)	3.95 (3.38–4.62)	1.62 (1.28–2.06)
Mechanical ventilation and/or intubation†	9.78 (8.67–11.02)	1.52 (1.28–1.80)	5.01 (4.07–6.16)	–
Feeding tube†	8.32 (6.78–10.20)	1.35 (1.06–1.71)	5.85 (4.24–8.09)	1.69 (1.16–2.45)
Biopsy†	3.92 (3.18–4.83)	–	3.74 (2.76–5.07)	–
Operating room procedure†	1.76 (1.59–1.95)	0.74 (0.65–0.84)	NA	NA
Urinary catheter†	2.87 (2.60–3.16)	1.38 (1.22–1.57)	1.77 (1.54–2.04)	0.75 (0.62–0.91)
Central venous line†	7.73 (6.98–8.57)	1.99 (1.71–2.32)	5.27 (4.50–6.17)	1.95 (1.54–2.47)
High-risk medications†	3.20 (2.89–3.54)	1.28 (1.14–1.44)	1.88 (1.60–2.21)	0.65 (0.53–0.81)

OR odds ratio, CI confidence interval, NA not applicable

*Based on ICD-9-CM codes present on admission

†Occurred during hospitalization at least 2 days prior to diagnosis of infection for cases or prior to 2 days before discharge for non-cases

Compared with the studies identified in our literature review, our analysis benefited from a large sample size, a diverse case mix representative of hospitalized adults in general medical and surgical units, the inclusion of all organisms, the inclusion of all types of surgery for SSI, and an investigation of both community-acquired and healthcare-acquired infections. However, like many retrospective studies that make use of electronic administrative and

medical records, the data used for this study have some weaknesses. First, our ability to detect significant differences by gender in the age-stratified model may be due to insufficient power. Second, admission and discharge codes are used primarily for billing purposes and thus may lack sensitivity for identifying certain procedures and conditions.⁷⁰ To remedy this, our study made use of data charted by clinicians in electronic

Table 4. Age-specific Gender Differences In Odds Of Bloodstream And Surgical Site Infection

Age	Community-associated BSI		Healthcare-associated BSI		SSI	
	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
<12						
12–17	1.06 (0.91–1.24)	1.16 (0.99–1.37)	0.96 (0.82–1.14)	0.81–1.17	0.89 (0.64–1.24)	1.00 (0.71–1.40)
18–49	0.38 (0.24–0.60)	0.43 (0.27–0.70)	1.02 (0.64–1.62)	1.02 (0.61–1.71)	0.70 (0.381–1.31)	0.72 (0.37–1.39)
50–59	0.54 (0.46–0.64)	0.77 (0.64–0.91)	0.51 (0.42–0.62)	0.76 (0.62–0.93)	0.54 (0.40–0.71)	0.86 (0.64–1.16)
60–69	0.68 (0.55–0.83)	0.78 (0.64–0.96)	0.70 (0.56–0.89)	0.80 (0.63–1.02)	0.69 (0.50–0.94)	0.84 (0.61–1.15)
≥70	0.80 (0.66–0.96)	0.86 (0.73–1.07)	0.74 (0.59–0.90)	0.86 (0.69–1.07)	0.64 (0.47–0.88)	0.76 (0.56–1.01)
	0.92 (0.81–1.04)	0.95 (0.84–1.08)	0.70 (0.59–0.82)	0.89 (0.75–1.06)	0.66 (0.51–0.85)	0.80 (0.61–1.05)

Odds ratios compare females to males. BSI bloodstream infection, SSI surgical site infection, OR odds ratio, CI confidence interval. Adjusted models for community-associated BSI include hospital (for adults ≥18 years), age, prior stay in a skilled nursing facility, prior hospitalization in network, Charlson weighted comorbidity index, diabetes mellitus, malignancies, renal failure, chronic dermatitis, and solid organ transplant. Adjusted models for healthcare-associated BSI and SSI include age, hospital (for adults ≥18 years), prior stay in a skilled nursing facility, prior hospitalization in network, Charlson weighted comorbidity index, diabetes mellitus, malignancies, history of renal failure and/or dialysis during hospitalization, chronic dermatitis, trauma, burns, wounds, solid organ transplant, length of stay, stay in intensive care unit, mechanical ventilation and/or intubation, feeding tube, biopsy, operating room procedure (for BSI only), urinary catheter, central venous line, and high-risk medications

health records to supplement ICD-9 codes where possible. Although the electronic algorithms used to identify infections were developed based on the “gold standard” NHSN definitions, they do not incorporate all of the NHSN criteria for SSI.¹² Additionally, the data available for this study were limited to patient encounters that occurred within the two study sites and the other two inpatient facilities that comprise the hospital network. As a result, we had access to data regarding prior hospitalizations and previously documented conditions that occurred at the study institution. This is particularly important for identifying SSI, since these infections sometimes occur after patients are discharged postoperatively,⁷¹ and patients may receive diagnoses and treatment for SSI at other facilities. Nevertheless, while the true incidence of SSI might be higher than that represented in the study data, this phenomenon is not likely to affect this study’s overall conclusions unless women were less likely than men to return to the study institution for diagnosis and treatment of an SSI. Finally, information on patients’ smoking status, use of alcohol and other drugs, and HIV infection was not available. These factors are generally associated with higher infection risk and are more common among men, which may partially account for the higher infection risk observed for men in this study.^{72–75} In addition to data limitations, the research question was generated after exploratory analyses and not based on an *a priori* hypothesis about the effects of male gender on infection risk.

In conclusion, although the retrospective design of this study precludes making causal inferences, we found a significant association between gender and the development of community- and healthcare-associated BSI and SSI, which was robust to our tests for confounding by a variety of factors, including patient comorbidities, activities during the hospital stay, and demographic characteristics. The precise mechanisms by which gender might influence infection risk are unclear, but could possibly be related to differences in skin colonization or unknown anatomical differences between men and women. The findings with regard to BSI are consistent across the literature; to our knowledge, no studies have found significantly higher rates of infection among women. For SSI, it is possible that the impact of gender varies according to the type of surgery and incision site. The results of this study underscore the importance of enhancing infection risk profiles for the purpose of targeted, efficient surveillance. It may also be prudent to explore interventions to prevent infections in men, such as specialized preoperative skin decontamination procedures and postoperative wound care.

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