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Assessment of risk and economic burden of surgical site infection (SSI) posthysterectomy using a U.S. longitudinal database

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ABSTRACT

Background: Surgical site infection posthysterectomy has significant impact on patient morbidity, mortality, and health care costs. This study evaluates incidence, risk factors, and total payer costs of surgical site infection after hysterectomy in commercial, Medicare, and Medicaid populations using a nationwide claims database.
Methods: IBM MarketScan databases identified women having hysterectomy between 2014 and 2018. Deep-incisional/organ space (DI/OS) and superficial infections were identified over 6 months postoperatively with risk factors and direct infection-associated payments by insurance type over a 24-month postoperative period.
Results: Analysis identified 141,869 women; 7.8% Medicaid, 5.8% Medicare, and 3.9% commercially insured women developed deep-incisional/organ space surgical site infection, whereas 3.9% Medicaid, 3.2% Medicare, and 2.1% commercially insured women developed superficial infection within 6 months of index procedure. Deep-incisional/organ space risk factors were open approach (hazard ratio, 1.6; 95% confidence interval, 1.5–1.8) and payer type (Medicaid versus commercial [hazard ratio, 1.4; 95% confidence interval, 1.3–1.5]); superficial risk factors were payer type (Medicaid versus commercial [hazard ratio, 1.4; 95% confidence interval, 1.3–1.6]) and solid tumor without metastasis (hazard ratio, 1.4; 95% confidence interval, 1.3–1.6). Highest payments occurred with Medicare ($44,436, 95% confidence interval: $33,967–$56,422) followed by commercial ($27,140, 95% confidence interval: $25,990–$28,317) and Medicaid patients ($17,265, 95% confidence interval: $15,247–$19,426) for deep-incisional/organ space infection at 24-month posthysterectomy.
Conclusions: Real-world cost of managing superficial, deep-incisional/organ space infection after hysterectomy was significantly higher than previously reported. Surgical approach, payer type, and comorbid risk factors contributed to increased risk of infection and economic burden. Medicaid patients experienced the highest risk of infection, followed by Medicare patients. The study suggests adoption of a robust evidence-based surgical care bundle to mitigate risk of surgical site infection and economic burden is warranted.

Introduction

After caesarean section, hysterectomy is the second most commonly performed surgical procedure in women of reproductive age in the United States.[1,2] In 2006, the National Hospital Discharge Summary data reported that 569,000 women underwent hysterectomy; this figure rose to 600,000 by 2015.[3–5] Surgical site

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infection (SSI) was the most common reason for unplanned readmission after hysterectomy; SSIs tripled readmission rates and doubled the total cost of care.[2] As a result, SSI rates after abdominal hysterectomy have been used as a metric to rank hospitals and assess financial penalties.[6,7] SSIs, whether superficial incisional, deep incisional, or organ space type, have been reported to occur in 1% to 4% of hysterectomies, resulting in 6,000 to 24,000 SSIs annually in the United States. Hysterectomy SSI rates have been publicly reported since 2013 and, since January 2014, hospitals have been penalized with diminished reimbursement by the Centers for Medicare and Medicaid Services if the hysterectomy rate exceeds an expected value. This represents a considerable cost to the health care systems, also resulting in a significant social and economic burden for patients and their families[8,9] It has been estimated that SSI adds approximately $5,000 to the average cost of hysterectomy.[10]

Evidence-based surgical care bundles have been developed to reduce the risk of postoperative surgical site infection. Components of these evidence-based practices that are classified as moderate to level 1A include pre, intra, and postoperative interventions such as staphylococcal decolonization, weight-based antibiotic prophylaxis, perioperative antisepsis, appropriate hair removal (using single-use clippers), maintenance of normothermia, and glycemic control, all of which are advocated by national and international SSI prevention guidelines.[11–15] Innovative wound closure methods that include use of antimicrobial sutures and novel postoperative dressings, including the use of negative pressure devices, have been documented to reduce the risk of SSI across a spectrum of surgical disciplines.[16–22]

SSI remains a significant source of morbidity after hysterectomy in spite of the introduction of current risk reduction strategies.[5,23,24] Several published gynecological studies have documented the benefit of evidence-based surgical care bundles to reduce the risk of postoperative infection. In 2017, a systematic review and meta-analysis (SR & M) demonstrated that implementation of an evidence-based SSI reduction care bundle resulted in a significant reduction in SSI rates after caesarean section. This involved 14 studies with a SSI relative risk (RR) of 0.33 (95% confidence interval [CI] 0.25–0.43).[25] Another SR & M of interventions in major gynecological surgery demonstrated that an evidence-based SSI reduction care bundle resulted in a reduction in both superficial incisional and deep incisional SSI rates when compared with standard of care. Six studies in the analysis documented an SSI RR of 0.19 (95% CI 0.12–0.32).[26] The analysis, involving a multidisciplinary team, developed an evidence-based SSI reduction care bundle that focused on 4 domains: readiness, recognition, prevention, and response. The SSI reduction care bundle relies heavily on perioperative standardization, with recognition and mitigation of patient risk factors, postoperative care, and postdischarge instructions for both patients and caregivers.

Accurate definitions for SSI require robust validation and intensive postdischarge surveillance.[27] The U.S. Centers for Disease Control and Prevention (CDC) advocates standardized definitions for SSI.[12] In a recent analysis, in general acute care hospitals in California, it was found that SSI rates differed significantly between individual hospitals and failed to identify one-third to one-half of SSIs after colonic and gynecological surgery.[28] This failure to correctly identify SSIs resulted in under-reporting of SSIs in 74% of validated hospitals performing colorectal surgery and 35% of validated hospitals performing abdominal hysterectomy.

The objective of the current analysis using large longitudinal commercial, multistate Medicare and Medicaid databases, was to determine the incidence of SSI, together with comorbid risk factors, and determine the real-world financial burden to payers from SSIs after hysterectomy. This study differs from prior analysis because it relies on patient-level claims data and does not use surrogate data based on hospital episode statistics, which can seriously underestimate the incidence and payments since these data only capture inpatient episodes and hospital-based care.[29–31]

Methods

Data source

IBM MarketScan Commercial Claims and Encounters, Multi-State Medicaid, and Medicare Supplemental databases were used in the current analysis. These databases were composed of patient enrollment information, demographics, and adjudicated inpatient medical, outpatient medical, and outpatient pharmacy claims data. The commercial database includes data collected from more than 300 large, self-insured U.S. employers and more than 25 U.S. health plans. It includes information for 157 million individuals who are under the age of 65 and represents the primary source of health care coverage for a spouse or dependent. It is projectable to the U.S. population covered by employer-sponsored insurance (58% of the U.S. population). The Medicare Supplemental database includes information for 15.3 million individuals who are Medicare-eligible and have a supplemental insurance plan separate from their Medicare benefits. The database is projectable to the U.S. population with Medicare supplemental insurance. The Multi-State Medicaid database includes claims data for 31 million individuals whose Medicaid coverage represents their only insurance coverage. The database includes data from 6 to 13 geographically dispersed states.

Study population

This retrospective observational cohort analysis included women who were 18 years or older and had a hysterectomy between January 2014 and March 2018. The International Classification of Diseases, 9th and 10th Revision, Clinical Modification (ICD-9-CM and ICD-10-CM) procedure codes and Current Procedural Terminology (CPT) codes were used to identify hysterectomies (index procedures, Supplementary Table S1). The first date of the hysterectomy procedure was defined as the index date. Patients were included only if they had continuous enrollment for at least 12 months before and 6 months after index. Patients were excluded if they had a diagnosis for infection from 30 days pre to 2 days postindex. This criterion was established to ensure that the analysis did not include infections unrelated to the hysterectomy.

Study variables

The patient demographic and surgical characteristics included age, year of surgery (2014 to 2018), site of care (inpatient versus outpatient), admission type (emergency versus nonemergency), and hysterectomy approach (open versus laparoscopic versus unknown) and are shown in Table I. The baseline clinical characteristics includes the Elixhauser comorbidity index, along with 31 individual comorbid risk factors presented in Table II. All baseline comorbidities were evaluated from 12 months pre and up to 1 day postindex surgery. The baseline demographic and clinical characteristics by surgical approach type are presented in Supplementary Table S2 and Supplementary Table S3.

Outcomes

Surgical site infections after hysterectomy were identified from the third to the 180th postoperative day. SSIs were categorized as (1) superficial and (2) deep incisional/

Table I
Demographic, year of surgery, site of care, admission type, and surgical approach type in patients presenting for hysterectomy from January 2014 to March 2018, by payer type

Patient characteristics	All	Commercial	Medicaid	Medicare
N	141,869	114,975	21,667	5,227
Age, mean (SD) in years	46.9 (10.0)	46.4 (8.0)	43.0 (11.4)	72.8 (5.9)
Year of surgery				
2014	25.4%	27.2%	14.5%	31.9%
2015	23.3%	23.2%	23.3%	25.7%
2016	24.6%	23.7%	29.8%	23.2%
2017	21.8%	21.2%	26.2%	15.6%
2018	4.9%	4.7%	6.2%	3.6%
Site of care				
Inpatient	33.1%	32.6%	33.4%	42.4%
Outpatient	66.9%	67.4%	66.6%	57.6%
Admission type				
Nonemergency	99.3%	99.4%	99.0%	99.4%
Emergency	0.7%	0.6%	1.0%	0.6%
Approach type				
Laparoscopic	68.0%	68.9%	63.7%	65.3%
Open	31.4%	30.7%	35.5%	30.9%
Unknown	0.6%	0.4%	0.8%	3.8%

All *P* values by insurance type were <.001.
SD, standard deviation.

Table II
Elixhauser comorbidity index and comorbid conditions in patients presenting for hysterectomy, by payer type

Clinical characteristics	All	Commercial	Medicaid	Medicare
N	141,869	114,975	21,667	5,227
Elixhauser comorbidity index, mean (SD)	2.0 (1.9)	1.7 (1.7)	3.0 (2.4)	3.4 (2.2)
Elixhauser Comorbidity Score				
Score: 0	24.1%	27.1%	12.6%	5.0%
Score: 1–2	44.9%	47.3%	35.5%	32.4%
Score: 3–4	21.3%	19.2%	28.5%	36.1%
Score: 5 and above	9.8%	6.4%	23.5%	26.5%
Hypertension	34.8%	31.2%	44.9%	72.11%
Obesity	20.9%	18.8%	32.3%	19.4%
Depression	18.8%	15.4%	38.3%	12.2%
Hypothyroidism	15.2%	15.2%	13.2%	25.1%
Chronic pulmonary disease	15.0%	11.9%	30.3%	18.2%
Cancer	14.8%	13.2%	13.1%	57.2%
Diabetes	12.0%	9.9%	19.8%	25.6%
Anemia	11.6%	11.6%	13.2%	5.7%
Cardiac arrhythmias	8.5%	7.2%	12.1%	21.5%
Blood loss anemia	6.3%	6.3%	7.4%	1.7%
Fluid and electrolyte disorders	5.7%	4.4%	11.8%	9.7%
Liver disease	5.4%	4.8%	7.9%	8.8%
Rheumatoid arthritis/collagen vascular diseases	4.4%	3.9%	6.4%	6.4%
Valvular disease	4.0%	3.3%	4.9%	14.8%
Other neurological disorders	2.7%	1.8%	7.4%	3.3%
Peripheral vascular disorders	2.2%	1.5%	3.8%	12.2%
Metastatic cancer	2.2%	1.9%	2.1%	8.9%
Drug abuse	2.0%	0.8%	8.9%	0.5%
Coagulopathy	1.9%	1.7%	2.6%	3.2%
Renal failure	1.7%	1.1%	3.6%	7.2%
Congestive heart failure	1.7%	1.0%	4.2%	6.4%
Weight loss	1.7%	1.3%	3.2%	3.7%
Pulmonary circulation disorders	1.2%	0.9%	2.2%	3.0%
Psychoses	1.1%	0.4%	4.9%	0.8%
Alcohol abuse	1.0%	0.6%	3.2%	0.3%
Peptic ulcer disease excluding bleeding	0.7%	0.6%	1.4%	1.2%
Paralysis	0.4%	0.2%	1.4%	0.4%
Lymphoma	0.3%	0.3%	0.4%	1.2%
AIDS/HIV	0.2%	0.1%	0.8%	0.0%

All *P* values by insurance type were <.001.
SD, standard deviation.

organ-space (DI/OS) SSI (Supplementary Table S4). If a patient was identified as having both superficial and DI/OS SSI during the 180-day postindex period, they were categorized as having DI/OS SSI, since this condition resulted in greater cost and a more intensive level of clinical care. All-cause payments (95% CI) were estimated for each payer type (commercial, Medicare Supplemental, and Medicaid) for patients with and without SSI over 6, 12, and 24 months. Incremental payments (95% CI) were then calculated as difference in payments between patients with and without SSI. For payment calculations, patients were required to be continuously enrolled for 24 months postindex.

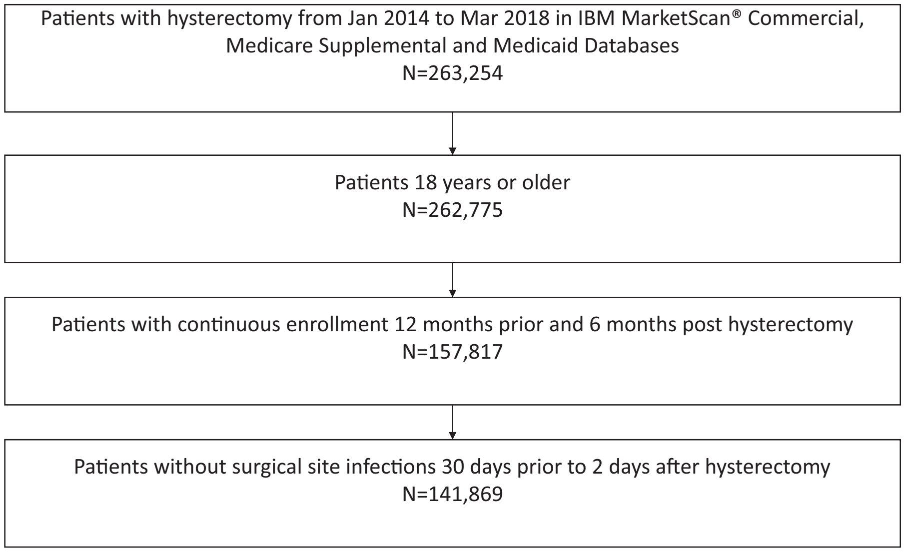

Figure 1. Cohort selection for patients presenting for hysterectomy in IBM MarketScan Commercial, Medicare Supplemental and Medicaid Databases.

Statistical analysis

Descriptive statistics were used to describe demographic, surgical, and clinical characteristics of patients for each payer type (commercial, Medicare Supplemental, and Medicaid). Crude and adjusted rates of SSI were calculated by payer type and surgical approach. Poisson regression models were developed to calculate the adjusted incidence of SSI by payer type and surgical approach adjusting for age, year of surgery, comorbidities, admission type, and site of care. Kaplan-Meier curves were plotted to determine the risk of infection over time and stratified by type of database and surgical approach. Log rank tests were used to test statistically significant differences between databases and surgical approach. Patients were right censored if they did not have either DI/OS SSI or superficial SSI by the end of 6 months. Two Cox proportional hazards models were used to assess the risk factors for DI/OS SSI and superficial SSI. The risk factors evaluated for both models included age, approach type, year of surgery, 31 individual comorbidities, payer type, and site of care. Backward selection method was used to identify statistically significant variables. For models evaluating risk factors and payments, patients admitted through emergency room and those with unknown surgical approach were excluded because of low sample sizes. Generalized linear models with gamma distribution and log link function were used to determine payments for patients with and without SSI. Incremental payments calculated as difference in payments between patients with and without infections were reported along with 95% CI. The incremental payments were assumed to be attributable to SSI. The factors adjusted in the generalized linear models included age, year of surgery, comorbidities, approach type, admission type, and site of care. Different models were run for each payer type. For estimates of payment, only patients having index payments >0 were included. The total payment data were trimmed at the first and 99th percentile to remove extreme values because these were considered outliers. Only patients with continuous enrollment over 24 months postindex were included. For calculating the 12- and 24-month payments associated with infection, the infections were tracked beyond the initial 180-day postindex, over 24 months postindex. All payments were adjusted to 2020 medical consumer price index.[32] SAS version 9.4 was used to conduct statistical analysis.

Results

The study included 141,869 women undergoing hysterectomy between January 2014 and March 2018 (Figure 1). Table I depicts patient demographics, year of surgery, site of care, admission type, and surgical approach at index surgery by payer type. The mean (standard deviation, ±SD) age of the cohort was 46.9 (±10.0) years in the overall group, 46.4 (±8.0) years in commercially insured patients, 43.0 (±11.4) years in Medicaid patients, and 72.8 (±5.9) years in the Medicare population. Almost all surgeries were elective, ranging from 99.0% in Medicaid to 99.4% in both commercial and Medicare patients. Patients with commercial (67.4%) and Medicaid (66.6%) insurance had more outpatient surgeries than patients with Medicare (57.6%) insurance ($P < .0001$). Most of the surgeries were performed laparoscopically, ranging from 63.7% in Medicaid to 68.9% in commercial patients.

Table II reports the clinical presentation of the study population by payer type. The top 8 comorbid preoperative conditions within the overall cohort groups were hypertension (34.8%, of which 2.2% were complicated), obesity (20.9%), depression (18.8%), hypothyroidism (15.2%), chronic pulmonary disease (15.0%), cancer (14.8%), diabetes (12.0%), and anemia (11.6%). A total of 27.1% patients with commercial insurance had an Elixhauser comorbidity score of 0, whereas 12.6% of Medicaid patients and 5.0% of Medicare had an Elixhauser comorbidity score of 0. This is compared to 6.4% of commercial patients, who had an Elixhauser comorbidity index ≥5, whereas 23.5% and 26.5% of Medicaid and Medicare, respectively, had a score ≥5. Hypertension was prominent in both Medicaid and Medicare patients, with hypertension noted in 72.1% of Medicare patients. More women in the Medicaid and Medicare insurance populations exhibited comorbid risk factors than the commercial payer group. Obesity, depression, and chronic pulmonary disease were prominent risk factors present in >30% of Medicaid women having a hysterectomy, whereas hypothyroidism, diabetes, and cardiac arrhythmias were prominent comorbid risk factors in the Medicare patient population.

Overall, the crude incidence of DI/OS SSI at 6 months post-hysterectomy was 4.6%: 7.8% in Medicaid, 5.8% in Medicare, and 3.9% in the commercial population. The overall incidence of superficial SSI was 2.4%: 3.9% in Medicaid, 3.2% in Medicare, and 2.1% in the commercial patient population (Figure 2, *A*). The adjusted

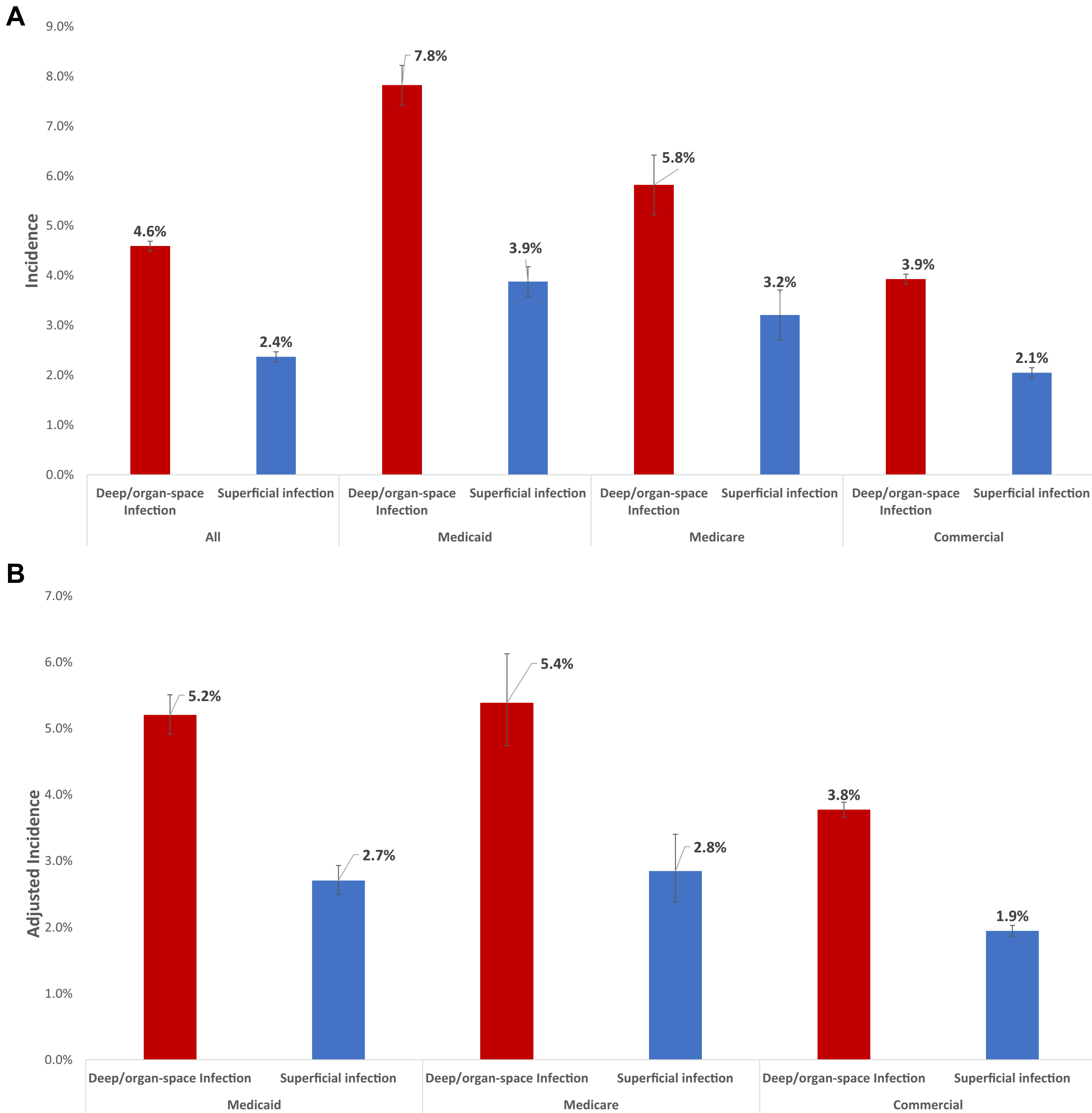

Figure 2. (a) Unadjusted incidence for SSI over 180 days after hysterectomy by payer type. Bars represent 95% confidence intervals of the incidence; (b) Adjusted incidence for SSI over 180 days after hysterectomy by payer type. Bars represent 95% confidence intervals of the incidence.

incidence of DI/OS SSI ranged from 3.8% for commercial to 5.4% for the Medicare population, whereas for superficial infection, the adjusted incidence ranged from 1.9% for commercial to 2.8% for the Medicare population (Figure 2, *B*). The unadjusted as well as adjusted incidence of SSI differed by surgical approach. After adjusting for demographic and clinical characteristics, the laparoscopic approach had a significantly lower DI/OS (3.4% vs 5.8%) and superficial (1.8% vs 2.9%) SSI rate than an open surgical approach ($P < .001$) (Figure 3, *A*–*B*).

Time to DI/OS SSI and superficial infection significantly differed by databases and by surgical approach ($P < .001$; Figure 4 and Figure 5). A multivariable Cox proportional hazards model identified that the top 5 significant risk factors associated with DI/OS SSI were open approach for the surgery versus laparoscopic approach (HR, 1.6; 95% CI, 1.5–1.8, $P < .001$), Medicaid versus commercial payer (HR, 1.4; 95% CI, 1.3–1.5, $P < .001$), metastatic cancer (HR, 1.3; 95% CI, 1.2–1.5, $P < .001$), Medicare versus commercial payer (HR, 1.3; 95% CI, 1.0–1.7, $P = .03$), and alcohol abuse (HR, 1.3; 95% CI, 1.1–1.5, $P < .001$), (Figure 6, *A*). For superficial SSI, the top 5 statistically significant risk factors reported were Medicaid versus commercial payer (HR, 1.4; 95% CI, 1.3–1.6, $P <.001$), solid tumor without metastasis (HR, 1.4; 95% CI, 1.3–1.6, $P < .001$), open versus laparoscopic approach (HR, 1.4; 95% CI, 1.3–1.6, $P < .001$), diabetes (HR, 1.3; 95% CI, 1.2–1.5, $P < .001$), and inpatient

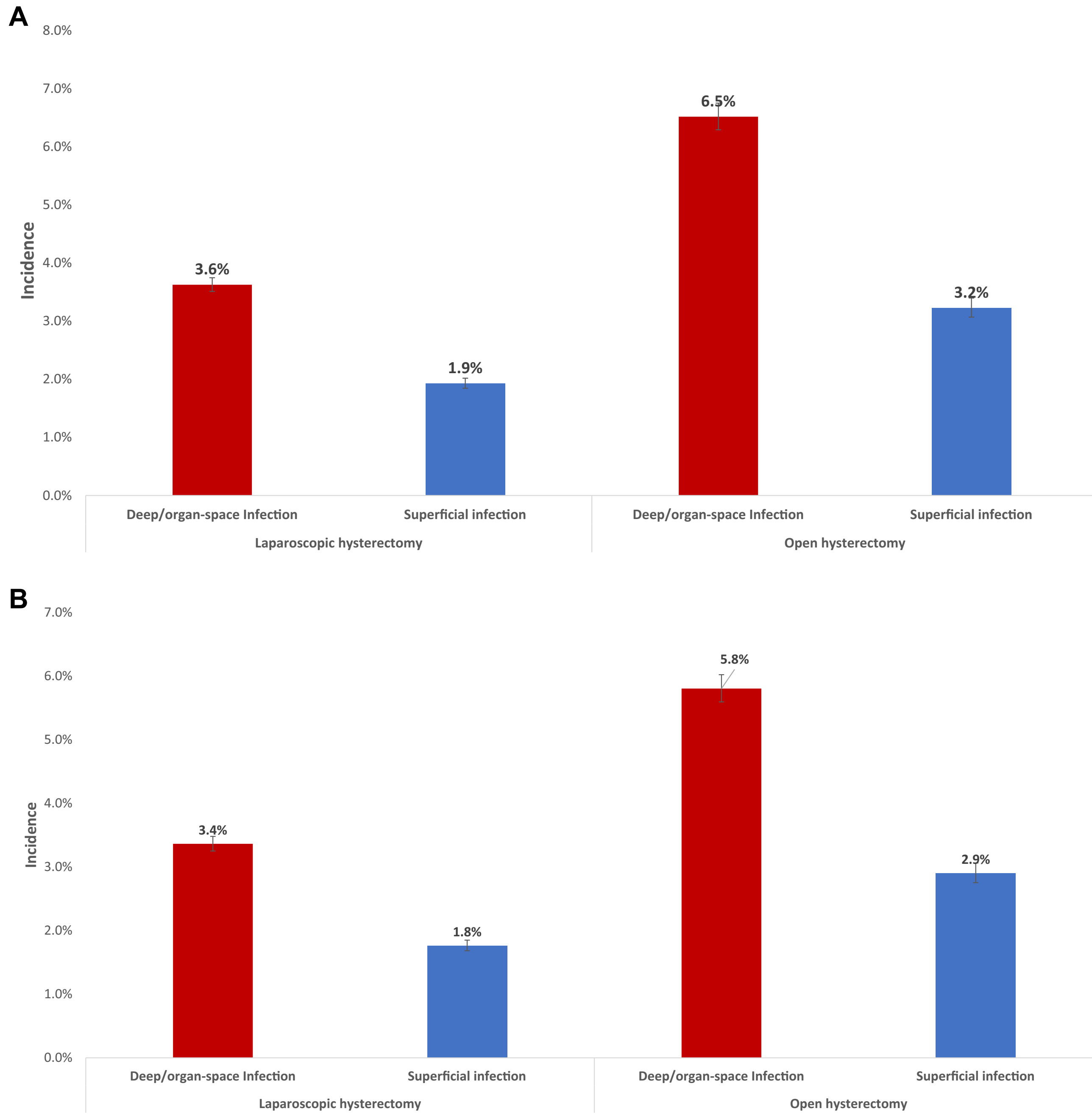

Figure 3. (a) Unadjusted incidence for SSI over 180 days after hysterectomy by surgical approach. Bars represent 95% confidence intervals of the incidence; (b) Adjusted incidence for SSI over 180 days after hysterectomy by surgical approach. Bars represent 95% confidence intervals of the incidence.

versus outpatient site of care (HR, 1.3; 95% CI, 1.1–1.4, $P < .001$), (Figure 6, *B*). The common significant risk factors between the 2 models were surgical approach, payer type, site of care, age, solid tumor without metastasis, metastatic cancer, obesity, chronic pulmonary disease, diabetes, cardiac arrhythmia, and fluid electrolyte balance.

Incremental commercial payments for management of DI/OS SSI ranged from $18,467 over 6 months to $27,168 over 24 months postindex. The adjusted incremental payments for superficial infections ranged from $6,842 over 6 months to $12,672 over 24 months. Medicare adjusted incremental payments for DI/OS SSI management ranged from $26,680 over 6 months to $43,605 over 24 months. The adjusted incremental payments for superficial infections ranged from $14,567 over 6 months to $25,631 over 24 months. Incremental Medicaid payments were the lowest with $17,476 for DI/OS SSI and $8,188 for superficial SSI over 24 months postindex (Table III).

Discussion

The data for the current analysis were derived from the IBM MarketScan Commercial, Multi-State Medicaid, and Medicare Supplemental database, which is a nationwide representative claims database that captures the continuum of care, including physician office visits, hospital stays, outpatient and inpatient procedures and payment, and their corresponding diagnoses. The

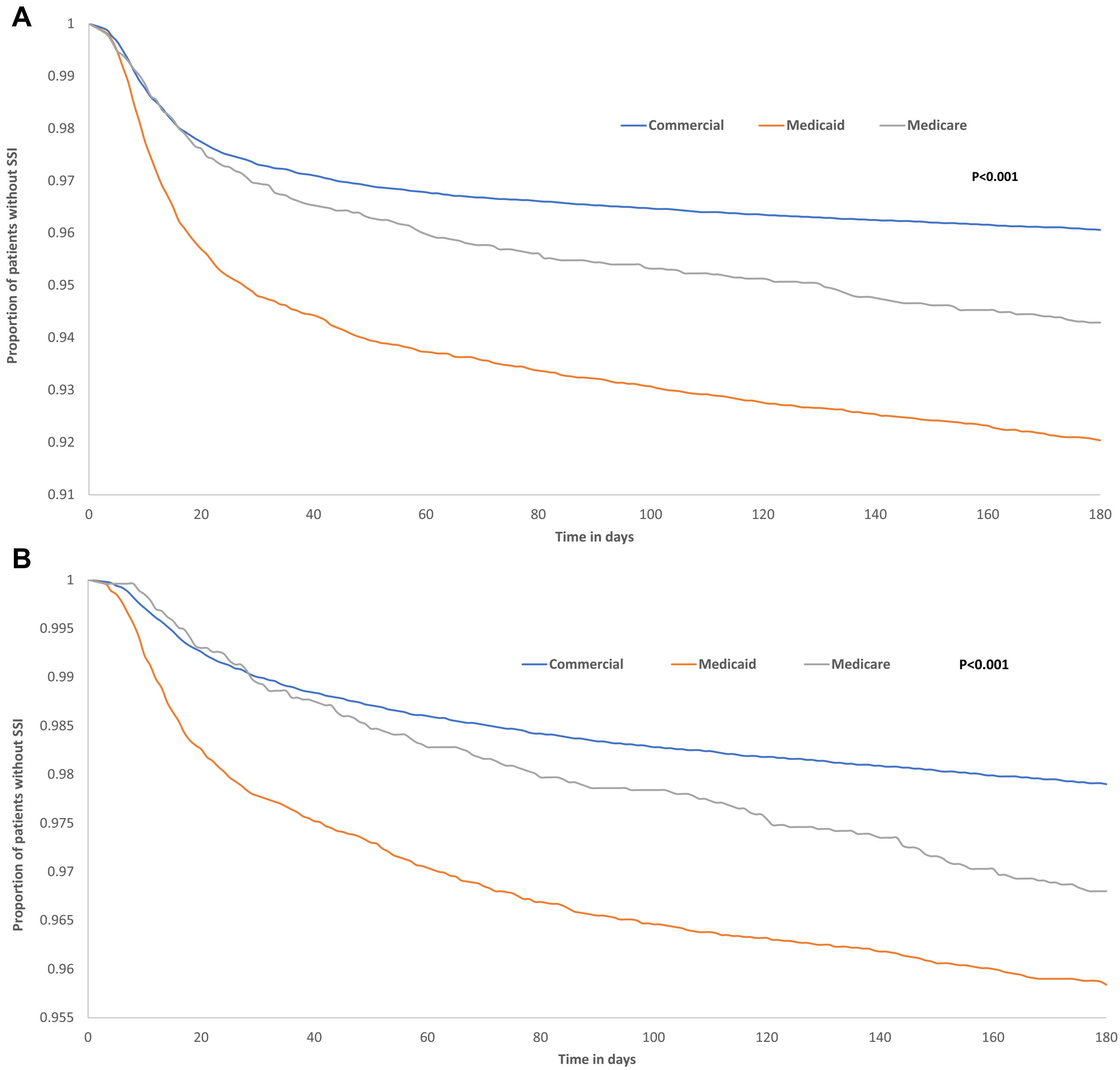

Figure 4. (a) Kaplan Meier curves for time to deep incisional/organ-space SSI over 180 days after hysterectomy stratified by payer type; (b) Kaplan Meier curves for time to superficial SSI over 180 days after hysterectomy stratified by payer type.

current IBM MarketScan database comprised nearly 50% of the U.S. population. The present study included 141,869 women undergoing hysterectomy. The incidence of SSI in women undergoing a hysterectomy was 7.0%; 2.4% for superficial SSI, while 4.6% represented deep/organ space infections. However, infection rates as defined by payer type were highly variable: (1) in the commercial group, there were 2.1% superficial SSI and 3.9% DI/OS SSI; (2) in the Medicare population, there were 3.2% superficial SSI and 5.8% DI/OS SSI; (3) and in the Medicaid patient population, there were 3.9% superficial SSI and 7.8% DI/OS SSI.

The incidence of SSI in women treated laparoscopically was 5.2%, among whom 3.4% developed a DI/OS SSI, whereas 1.8% developed a superficial incisional SSI. In patients undergoing an open approach, the infection rate was 8.7%; 5.8% experienced a DI/OS SSI, whereas 2.9% experienced a superficial SSI. The overall rate of infection, especially after an open procedure, was found to be higher than reported previously, which may be because the database includes both inpatient and outpatient cases, whereas prior analyses focused on infections as captured during inpatient care and readmission records.[8–10,29–31] As expected, superficial incisional SSI rates (mostly port-site infections) were found to be lower after a minimally invasive approach (1.8%) versus an open surgical procedure (2.9%). DI/OS SSI rates were also lower after laparoscopy (3.4%) compared to an open procedure (5.8%). The rate of superficial incisional infection (1.8%) after a laparoscopic approach was similar to an earlier report and SR & M.[33] The subcohort analysis documented a higher rate of infection, especially DI/OS SSI relative to previous published studies.[6–9,34]

In the current analysis, DI/OS SSI were found to be associated with admission type, surgical approach, payer type, and patient comorbidities. The risk factors for the development of SSI after hysterectomy were as diverse as those found in other studies. In a multicenter retrospective case-control study of 820 hysterectomy patients, BMI >35 kg/m^2 and intra or postoperative blood

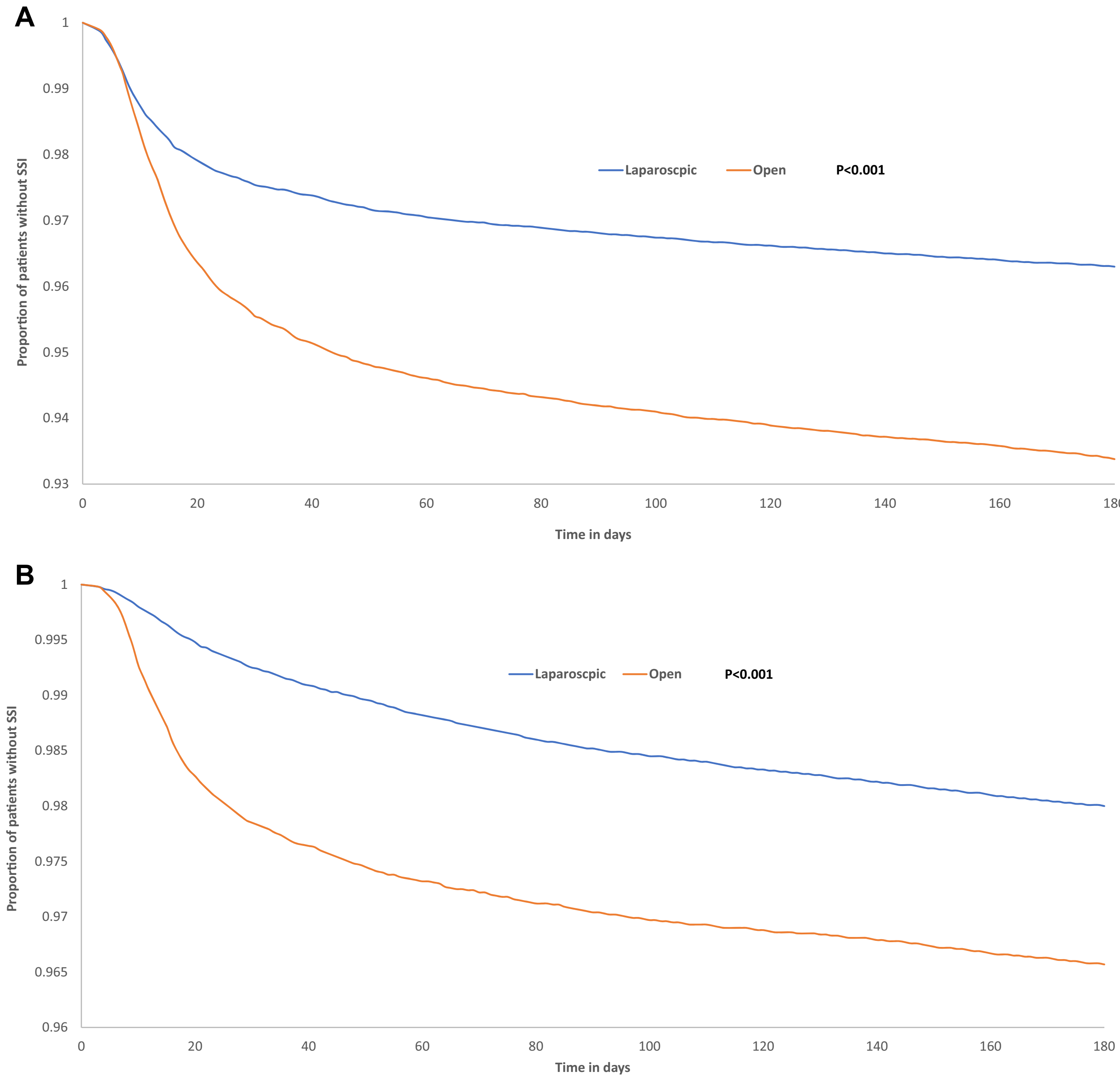

Figure 5. (a) Kaplan Meier curves for time to deep incisional/organ-space SSI over 180 days after hysterectomy stratified by surgical approach; (b) Kaplan Meier curves for time to superficial SSI over 180 days after hysterectomy stratified by surgical approach.

transfusion were found to be major risk factors.[35] A single institutional chart review found that obesity (BMI ≥30 kg/m^2) and blood transfusion (given pre, intra, or postoperatively) were associated with SSIs.[36] A further study reported an association between DI/OS SSI and the American Society of Anesthesiologists (ASA) class (>3), smoking, a history of cerebrovascular accident with neurologic deficit, preoperative anaemia, and morbid obesity.[8]

The present investigation represents the largest study to date of the risk of infection after hysterectomy. Subgroup analysis clearly documented a higher risk of infection (superficial and DI/OS) in the Medicaid patient populations compared to the commercially insured patients. These findings are consistent with published reports from other surgical services. A study from the Division of Healthcare Quality Promotion of the Centers for Disease Control and Prevention found that women with Medicaid coverage were 40% more likely to develop an SSI after Caesarean delivery than women with private insurance.[37] The authors suggested that the reason for these findings are likely multifactorial. A published study in the spinal literature found that Medicaid payer status conferred a 2-fold higher risk of postoperative infection when controlled for surgical severity over Medicare or other commercially insured patients.[38] A study of 53,000 hysterectomy patients published in 1993 found that women who were more likely to be insured through Medicaid had a 2-fold higher rate of postoperative complications requiring prolonged hospitalization than women who were privately insured or covered through a health maintenance organization.[39] The overall risk of superficial SSI in both the Medicare (3.2%) and Medicaid population (5.8%) was greater than reported in previous published studies.[6–8,29–31,33]

The real-world cost for managing a superficial SSI over 24 months after hysterectomy to the U.S. public payers was found to range from $8,188 (Medicaid) to $25,631 (Medicare), while the cost for managing a DI/OS ranged from $17,476 (Medicaid) to $43,605

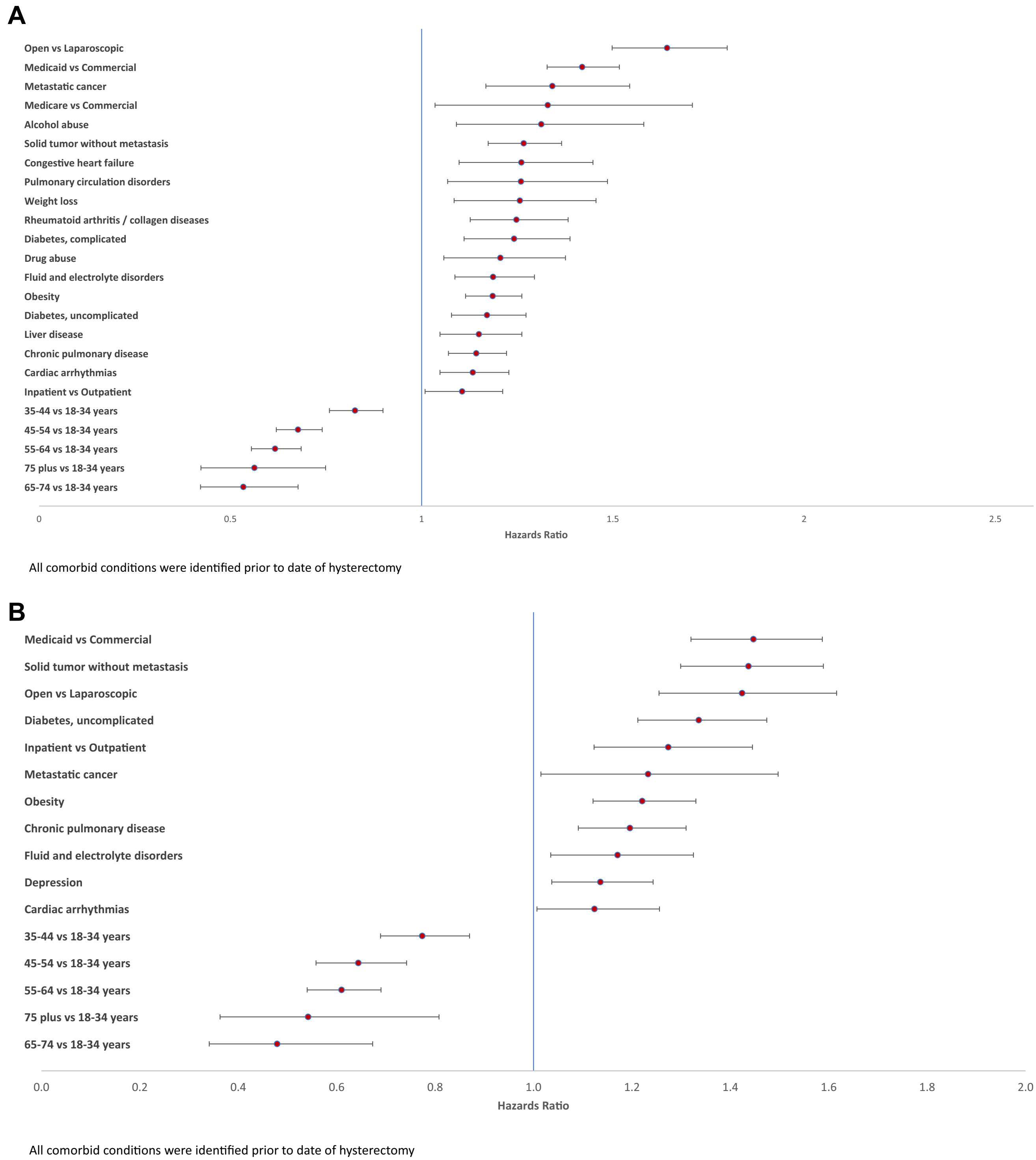

Figure 6. (a) Hazard ratio and 95% confidence interval for significant risk factors associated with deep incisional/organ-space SSI over 180 days post hysterectomy; (b) hazard ratios and 95% confidence intervals for significant risk factors associated with superficial SSI over 180 days post hysterectomy.

(Medicare). The results from this study suggest that an opportunity exists for implementation of evidence-based risk reduction strategies to improve surgical outcomes, reducing the fiscal burden to the health care system, especially within the Medicare and Medicaid patient populations. The findings of the current study emphasize the need for further research and implementation of selective targeted surgical care bundles for the most vulnerable hysterectomy patient populations.[40,41] In a study published in 2018, the posthysterectomy infection rate at an academic medical center was 5.4%. To mitigate this risk, an SSI reduction care bundle was introduced.[42] The agreed-upon evidence-based bundled components included use of chlorhexidine-impregnated preoperative wipes, standardized aseptic surgical preparation, standardized prophylactic-weight-based antibiotic dosing, maintenance of perioperative normothermia, and surgical wound dressings, with structured feedback to surgical team members when procedural deviations were noted. The bundle was implemented in a stepwise fashion over a period of 18 months, and outcomes were measured

Table III
Mean adjusted payer payments and incremental payments along with 95% confidence intervals for SSI after hysterectomy, by payer type, SSI type, and postindex time point

Commercial $N = 66{,}829$	0–6 Mo			0–12 Mo			0–24 Mo		
	Mean	95% CI		Mean	95% CI		Mean	95% CI	
DI/OS	$42,230	$41,209	$43,276	$49,352	$48,236	$50,493	$63,520	$62,184	$64,883
Superficial	$30,642	$29,637	$31,682	$37,265	$36,173	$38,391	$49,196	$47,882	$50,547
No infection	$23,721	$23,608	$23,834	$27,983	$27,847	$28,119	$36,380	$36,194	$36,566
Incremental DI/OS	$18,509	$17,601	$19,442	$21,369	$20,389	$22,374	$27,140	$25,990	$28,317
Incremental superficial	$6,921	$6,029	$7,848	$9,282	$8,326	$10,272	$12,816	$11,688	$13,981
Medicare $N = 2{,}367$	0–6 Mo			0–12 Mo			0–24 Mo		
	Mean	LCL		Mean	95% CI		Mean	95% CI	
DI/OS	$74,964	$64,003	$87,802	$92,078	$80,111	$105,832	$121,440	$108,192	$136,309
Superficial	$60,233	$49,929	$72,664	$72,347	$60,987	$85,823	$103,721	$89,114	$120,722
No infection	$45,895	$44,239	$47,614	$57,001	$54,950	$59,128	$77,004	$74,225	$79,887
Incremental DI/OS	$29,069	$19,764	$40,188	$35,077	$25,161	$46,704	$44,436	$33,967	$56,422
Incremental superficial	$14,338	$5,690	$25,050	$15,346	$6,037	$26,695	$26,717	$14,889	$40,835
Medicaid $N = 8{,}449$	0–6 months			0–12 months			0–24 months		
	Mean	95% CI		Mean	95% CI		Mean	95% CI	
DI/OS	$23,269	$21,651	$25,008	$31,780	$29,784	$33,910	$48,080	$45,390	$50,929
Superficial	$18,959	$17,236	$20,855	$24,884	$22,861	$27,088	$38,756	$35,880	$41,862
No infection	$14,649	$14,349	$14,955	$20,423	$19,996	$20,859	$30,815	$30,143	$31,503
Incremental DI/OS	$8,620	$7,302	$10,053	$11,357	$9,788	$13,051	$17,265	$15,247	$19,426
Incremental superficial	$4,310	$2,887	$5,900	$4,461	$2,865	$6,229	$7,941	$5,737	$10,359

All payments were adjusted to 2020 Medical CPI.
CI, confidence interval; *SD*, standard deviation.

12 months after full implementation. A total of 2,099 hysterectomies were studied. The authors found that 61 SSIs occurred in the preimplementation bundle period, and 14 SSIs were observed after full implementation of the surgical care bundle. The overall SSI rate was 1.9% (adjusted odds of infection after full implementation, 0.46); the superficial SSI rate decreased from 2.1% to 0.8%, whereas the rate of DI/OS SSI fell from 3.0% to 1.2%. A crucial component of any successful evidence-based migration strategy is enhanced compliance to all elements of the surgical care bundle.[43]

Several key findings of this study are worthy of consideration. First, treatment of an SSI after hysterectomy is expensive. Second, the study clearly documents that the fiscal burden to payers is not limited to the first 30 days posthysterectomy but rather continues to increase over a 24-month postoperative period for commercial, Medicare Supplemental, and Medicaid insurance plans. Third, as the Centers for Medicare and Medicaid Services (CMS) continues to implement value-based payment programs that reward or penalize hospitals based on their quality of care, preventable SSIs within the public payer domain can readily tip the balance toward diminished reimbursement for selective surgical procedures such as hysterectomy. Fourth, this study represents the first robust real-world analysis of the cost associated with superficial and DI/OS SSI in both laparoscopic and open procedures after hysterectomy. Finally, this study expands the scope of discovery for postoperative infection after hysterectomy from 30 to 90 days.

A major strength of the current study is that the data from 4 consecutive years were analyzed, providing an opportunity for a long-term follow-up of a large cohort of women. The 3 databases capture integrated data from a large sample of individuals covered under commercial, Medicare Supplemental, and Medicaid plans nationwide. Potential confounders were controlled by the multivariable analyses. A possible limitation of the study may involve the potential bias or accuracy of the clinical (administrative) documentation within the database. No prior hysterectomy records were checked for exclusion. However, this criterion would mainly affect the patients with hysterectomy in 2014 (25%), as the index date was defined as the first date of the hysterectomy procedure over 2014 through 2018. For the cohort from 2015 to 2018 (75%), this was the first date of hysterectomy with no 1-year prior hysterectomy records. The occurrence of SSIs was identified based on ICD-9-CM and ICD-10-CM diagnosis codes, without the availability of laboratory confirmation, although the diagnosis of an SSI is most often a clinical decision. The study did not consider other concomitant surgical procedures such as salpingectomy or oophorectomy, which may have implications on SSI risk and/or downstream payments. The current codes used to identify a minimally invasive approach do not allow for differentiation between robotic or traditional laparoscopic surgery. Although, in general, robotic surgery as a minimally invasive procedure may have a higher index cost, the risk of postoperative SSI is likely mitigated compared to a traditional open abdominal hysterectomy. Furthermore, going forward, future investigations should carefully consider the impact of site of care (inpatient versus outpatient) on both the postoperative infection rate and concomitant cost.

In conclusion, the findings of this study, which are based on real-world rather than surrogate data, suggest that SSI rates after hysterectomy and the fiscal burden associated with commercial, Medicare, and Medicaid patient populations are considerably higher than previously reported.[6–8,29–31,33] Furthermore, the analysis demonstrates the value of using claims-based databases to evaluate SSIs after hysterectomy, especially over a prolonged postdischarge period. The investigation has also identified the comorbidity risk factors for DI/OS SSI and superficial SSI after hysterectomy as well as the continued increased costs when a 24-month follow-up is undertaken. The value of evidence-based innovative care bundles to reduce the incidence and cost of SSIs warrants further exploration in gynecological surgery. The current analysis identifies both Medicare and Medicaid patient populations as most vulnerable for postoperative infection, suggesting that an enhanced effort should be given to these 2 patient populations when developing an effective evidence-based mitigation strategy. For example, use of antimicrobial wound closure as part of an evidence-based surgical care bundle has been documented to reduce the risk of infection and cost-effectiveness across a multitude of surgical disciplines and therefore warrants further consideration as an effective mitigation strategy in patients undergoing abdominal hysterectomy.

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Conflicts of interest/Disclosure

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Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.surg.2021.11.034.

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