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Hospital-acquired conditions after surgery for gynecologic cancer — An analysis of 82,304 patients

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HIGHLIGHTS

- HACs result in patient suffering and increased costs with potential medical legal consequence.
- Older age, Medicaid insured, open surgery were associated with higher HACs among gynecologic cancer patients.
- HACs were associated with higher hospital charges ($89,324 vs. $31,073; $p < 0.001$).

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ABSTRACT

Objective. To evaluate the hospital-acquired condition (HAC) following oophorectomy and/or hysterectomy for gynecologic cancer patients based on clinical outcomes and costs.

Materials and methods. Data were obtained from the Nationwide Inpatient Sample from 2005 to 2011. Chi-squared and Wilcoxon rank sum two-sample tests and multivariate logistic regression model were used for statistical analysis.

Results. Of 82,304 women (median age: 60 years, range: 1–101), 49,386 (60.0%) had endometrial, 23,510 (28.6%) had ovarian, and 9408 (11.4%) had cervical cancers. Of 135 HAC events, these involved catheter-associated urinary tract infections (n = 47), vascular catheter-associated infection (n = 41), foreign object retained after surgery (n = 19), pressure ulcers (n = 16), manifestation of poor glycemic control (n = 10), and air embolism (n = 2). Older patients (≥60 years) experienced more HACs relative to younger (0.23% vs. 0.09%; OR = 2.13, 95% CI: 1.30–3.50; $p = 0.003$), and patients with Medicaid experienced more HACs compared to those with private insurance (0.35% vs. 0.10%; OR = 3.09, 95% CI: 1.70–5.62; $p < 0.001$). Laparoscopic surgeries were associated with less HACs compared to open surgeries (0.05% vs. 0.19%; OR = 0.41, 95% CI: 0.19–0.90; $p = 0.03$). Length of hospitalization and hospital charges were greater for those with HACs, (12 days vs. 3 days; $p < 0.001$; $89,324 vs. $31,107; $p < 0.001$), respectively.

Conclusion. The odds of hospital-acquired conditions were higher in older patients, open surgery, Medicaid insured with higher associated hospital charges.

1. Introduction

The Institute of Medicine report estimated that 98,000 deaths per year are due to medical errors [1]. In addition, medical error is one of the leading causes of hospital deaths costing institutions 17 to 29 billion dollars per year [1]. Recently, medical errors were reported as the third leading cause of death in the U.S. [2]. Adverse events, including hospital acquired condition (HAC), are usually caused by medical errors [1]. Based on the Center for Medicaid and Medicare Services (CMS), HACs are defined as foreign object, air embolism, blood incompatibility, and pressure ulcers, falls and trauma, catheter-associated urinary tract infection, vascular catheter-associated infection, manifestations of poor glycemic control, surgical site infection, and deep vein thrombosis/pulmonary embolism (DVT/PE) [3].

HACs result in patient suffering, increased costs, and may lead to medical legal consequences to the provider and institutions. Furthermore, a previous report has shown that HAC events resulted in

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$50,000 extra cost per patient admission totaling over 470 million dollars to hospitals [4]. Although prior reports on HACs have focused on head and neck, bariatric, bowel, bladder, prostate, and neurosurgery, there are no studies on gynecologic cancer surgeries and associated HACs [4–13].

In bariatric surgery, 2.85% of patients were found to have associated HACs [6]. Older age, higher BMI, increased comorbidities, and open surgeries were associated with increased risk of HACs [6]. In spinal cancer surgery, the HACs rate was 9.0% in those with dependent functional status [7]. However, these studies lacked information on hospital characteristics such as teaching vs. non-teaching and urban vs. rural. Furthermore, there is a lack of information on the cost associated with HACs, length of hospital stays, and patient's insurance in these studies.

In this current report, we have evaluated the incidence of HACs in women after surgery for endometrial, ovarian, and cervical cancers. Furthermore, we performed an economic analysis to investigate the financial impact associated with HACs in gynecologic cancer surgeries.

2. Methods

2.1. Data source

The National Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP) database was used to conduct this cross-sectional analysis. It is the largest all-payer inpatient healthcare database in the U.S., which represents >96% of the population [14]. NIS contains 20% of patient discharge information stratified by the U.S. community hospitals [14]. This include patient demographics, hospital characteristics, methods of payment, total charges, discharge status, length of stay, severity and comorbidity measure, insurance information, and hospital volume. Since the NIS HCUP database contains de-identified information, the study was exempt from IRB approval.

2.2. Demographics

We identified 82,304 women who underwent surgical treatment for endometrial, ovarian, or cervical cancers between 2005 and 2011 from the NIS database. These patients' demographics, including age, race, socioeconomic status (High, Upper-Middle, Middle, or Low), and insurance type (private, Medicare, Medicaid, uninsured, or other) were obtained from the NIS database. Socioeconomic status was divided into categories based on the quartiles of median household income provided by the database.

2.3. Hospital characteristics

Hospital geographic region (South, Midwest, Northwest, and West), location (Urban and Rural), teaching status (teaching and non-teaching), and surgery type (open and laparoscopic) were derived from the NIS database.

2.4. International classification of diseases, ninth revision (ICD-9) for hospital acquired conditions

HAC events seen in endometrial, ovarian, or cervical cancer surgeries were examined using the following ICD-9 codes: 998.4 and 998.7 (foreign object); 999.1 (air embolism); 999.60–999.63 and 999.69 (blood incompatibility); 707.23 and 707.24 (pressure ulcers); 800–829, 830–839, 850–854, 925–929, 940–949, 991–994 (falls and trauma); 996.64 (catheter-associated urinary tract infection; 999.31–999.33 (vascular catheter-associated infection); 250.10–250.13, 250.20–250.23, 251.0, 249.10–249.11, 249.20–249.21 (manifestations of poor glycemic control). DVT/PE and surgical site infections were not included as HACs in our analysis since it is not related to gynecologic cancer surgeries as defined by CMS [3].

2.5. Economics-hospital charges

The secondary outcome examined was hospital costs. Using the cost-to-charge ratio provided by the Healthcare Cost and Utilization Project, the hospital charges were converted to costs [14]. This cost variable was used to determine the median costs that are associated for each type of HAC event. The added cost was described as the cost for a single HAC event (i.e. 1 vascular catheter-associated infection). This was calculated by taking the difference between the median cost of each type of HAC event and the median cost for those who have not experienced any of these events, which was considered as the referent group. Thus, the total cost was determined by the multiplication of added cost and frequency number for each HAC type.

2.6. Statistical analyses

Analysis were performed using SAS Enterprise Guide 5.1. The demographic and hospital characteristics were compared using Chi-squared and Wilcoxon rank sum two-sample tests. A multivariable logistic model was used to examine HACs as the binary outcome [15]. The variables were included in the model if they obtained p-value ≤0.05 from the univariate analysis. Furthermore, the Hosmer-Lemeshow test was used to test the model for goodness of fit. The association was considered to be statistically significant if two-sided p-value ≤0.05. Additionally, bar graphs were constructed to examine the role of certain patient characteristics on HACs. Charlson Comorbidity Index Score was also adjusted for in the multivariate anlaysis.

3. Results

3.1. Demographics - age, race, SES, insurance type

Of 82,304 patients, 49,386 (60.0%) were diagnosed with endometrial cancer, 23,510 (28.6%) with ovarian cancer, and 9408 (11.4%) with cervical cancer. The demographics, clinical and hospital characteristics are summarized in Table 1. In brief, the median age was 60 years. The majority (60.3%) were White, 6.8% Black, 7.3% Hispanic, 2.5% Asian, and 2.9% others and 20.2% had missing ethnicity information. Twenty-eight percent of patients were of high socioeconomic status, and 49% had private insurance.

3.2. Clinical-hospital characteristics

Most patients underwent open surgery compared to laparoscopic or robotic surgery (82.1% vs. 17.9%). Nearly 95% were treated at urban hospitals and 35% resided in the Southern part of the U.S. About 70% of women had surgery at a teaching hospital compared to 29.6% at non-teaching institutions.

3.3. Hospital acquired conditions

There were 135 HAC events reported out of 82,304 surgeries with an overall rate of 0.16%. Of these HAC cases, 34.8% (n = 47) were catheter-associated urinary tract infection, 30.4% (n = 41) were vascular catheter-associated infection, 14.1% (n = 19) were foreign object, 11.9% (n = 16) were pressure ulcers, 7.4% (n = 10) were manifestation of poor glycemic control, and 1.4% (n = 2) were air embolisms (see Table 2). No blood incompatibilities or falls and trauma were reported from this data. Older patients (≥60 years) experienced more HAC events relative to younger women (0.23% vs. 0.09%; $p < 0.001$), shown in Fig. 1. Additionally, the figure also illustrates that patients with Medicaid coverage experienced a higher percentage of HACs compared to those with private insurance (0.35% vs. 0.10%; $p < 0.001$). Laparoscopic surgeries were associated with less HACs compared to open surgeries (0.05% vs. 0.19%; $p < 0.001$), shown in Fig. 2. Lengths of hospitalization were greater for those with HACs (12 days vs. 3 days; $p < 0.001$). Furthermore,

Table 1
Patient demographics and hospital characteristics.

Factors	Overall (N = 82,304)	No HAC (N = 82,169)	HAC (N = 135)	p value
Age (years)				
Median (range)	60 (1−101)	60 (1–101)	67 (33–90)	
<60 years	48.2	48.2	27.4	<0.001
≥60 years	51.8	51.8	72.6	
Race				
White	60.3	60.3	62.2	0.31
Black	6.8	6.8	10.4	
Hispanic	7.3	7.3	8.9	
Asian	2.5	2.5	2.2	
Other	2.9	2.9	1.5	
Missing	20.2	20.2	14.8	
Socioeconomic Status				
High	27.8	27.8	24.4	0.69
Upper-Middle	25.0	25.0	27.4	
Middle	23.2	23.2	25.2	
Low	22.0	22.0	22.2	
Missing	2.1	2.1	0.7	
Insurance Type				
Private	49.2	49.2	29.6	<0.001
Medicare	36.3	36.3	51.1	
Medicaid	7.3	7.3	15.6	
Uninsured	3.3	3.4	1.5	
Other	3.7	3.7	2.2	
Missing	0.1	0.1	0.0	
Geographic Region				
South	34.8	34.8	36.3	0.50
Midwest	22.1	22.1	25.9	
Northeast	20.8	20.8	16.3	
West	22.3	22.3	21.5	
Hospital Location				
Urban	94.7	94.7	92.6	0.10
Rural	4.7	4.7	5.2	
Missing	0.7	0.7	0.5	
Hospital Teaching Status				
Teaching	69.7	69.8	65.2	0.07
Non-teaching	29.6	29.6	32.6	
Missing	0.7	0.7	0.5	
Surgery Type				
Open	82.1	82.0	94.1	<0.001
Laparoscopic	17.9	18.0	5.9	
Cancer Type				
Uterine	60.0	60.0	51.9	<0.001
Ovarian	28.6	28.5	43.0	
Cervical	11.4	11.4	5.2	
Length of Hospitalization (days)[a]				
Median (range)	3 (0−203)	3 (0–203)	12 (1–69)	<0.001
Hospital Charges[a]				
Median	$31,107	$31,073	$89,324	<0.001

Data are % unless otherwise specified.
Note: percentages may not add up to 100 due to rounding.
[a] *t*-Test used to calculate *p*-values for the mean differences of length of hospitalization and hospital charges between no HAC and HAC.

HACs resulted in significantly higher charges at $89,324 per case compared to only $31,107 in those without HACs ($p < 0.001$). Overall, HAC events were associated with an additional charge of $58,000 per patient (see Table 3). In sum, additional reported HACs over the 7-year study period resulted in total charges of $11,900,868 with an approximately extra charge of $1,700,124 per year related to HACs.

3.4. Factors associated with HACs

To examine the potential factors contributing to HAC events, we performed a multivariable logistic regression analysis (see Table 4). We found that older (≥60 years) compared to younger (OR: 2.13, 95%CI: 1.30–3.50, $p = 0.003$) and Medicaid vs. privately insured (OR: 3.09, 95%CI: 1.70–5.62, $p < 0.001$) patients were associated with a higher risk for HACs. Furthermore, HAC events were less common for those undergoing laparoscopic compared to open surgery (OR: 0.41, 95%CI: 0.19–0.90, $p = 0.03$). Furthermore, ovarian cancer patients also had a higher risk of experiencing HAC events compared to uterine cancer patients after adjusting for all other covariates (OR: 1.75, 95%CI: 1.18–2.60, $p = 0.005$). However, race, socioeconomic status, hospital geographic region, hospital location, hospital teaching status were not associated with the risk of HACs.

Table 2
International classification of diseases, ninth revision, for hospital acquired conditions.

HAC[a]	ICD-9 Code	Total N (%)
Foreign object	998.4, 998.7	19 (0.02)
Air embolism	999.1	(0.00)[b]
Blood incompatibility	99.60, 999.61, 999.62, 999.63, 999.69	0
Pressure ulcers	707.23, 707.24	16 (0.02)
Falls and trauma	800–829, 830–839, 850–854, 925–929, 940–949, 991–994	0
Catheter-associated urinary tract infection	996.64	47 (0.06)
Vascular catheter-associated infection	999.31, 999.32, 999.33	41 (0.05)
Manifestations of poor glycemic control	250.10–13, 250.20–23, 251.0, 249.10–11, 249.20–21	(0.01)[b]
Total HAC events		135 (0.16)

[a] Hospital acquired-conditions were identified from Centers for Medicare and Medicaid Services.
[b] According to NIS reporting guidelines, number of cases were deleted for events occurring ≤10, but numbers are included in total HAC events.

4. Discussion

Hospital acquired condition (HAC) results in patient suffering and increased costs with potential medical legal consequences to the provider and institutions. This current study pertains to gynecologic cancer patients undergoing oophorectomy and/or hysterectomy surgeries who may encounter HAC events. From a sample size of 82,304 gynecologic cancer patients who underwent surgery and hospitalization, our study showed that older age, Medicaid insurance, open surgery, and ovarian cancer were associated with HACs.

4.1. Age

Our analysis suggests that HACs were more common in older age compared to younger patients. Similarly, a study on bariatric surgery patients showed that those older than 64 years had an associated HAC of 3.66% compared to only 2.53% and 3.38% in patients younger than 50 years and 50–64 years, respectively [6]. In another study on knee

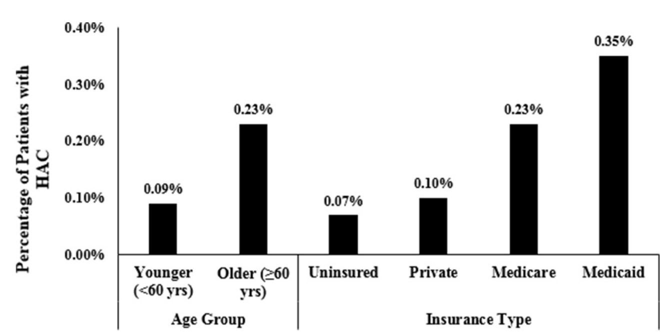

Fig. 1. Hospital acquired conditions based on age and insurance type.

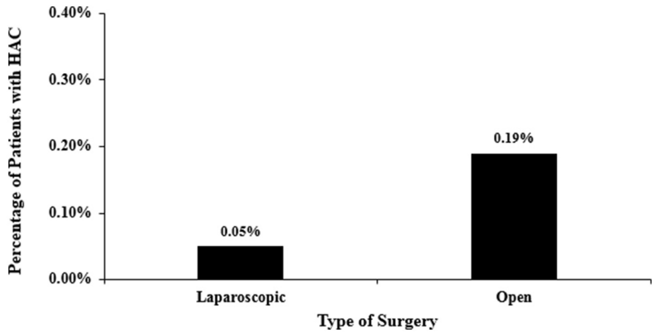

Fig. 2. Hospital acquired conditions based on type of surgery.

and hip arthroplasties, increasing age was found to be one of the predictors for the risk of HACs [16]. Furthermore, a study on bowel surgery showed that patients older than 80 years had a higher incidence of catheter-related urinary tract (35% vs. 12%) and vascular catheter infections (15% vs. 4%) compared to 65–79 years, using the Greenville Hospital System (GHS) database [8]. A previous NIS study found that brain cancer patients who are older were more likely to experience HACs (OR: 1.15, $p < 0.01$) [4]. On the other hand, another study did not find age to be an independent risk factor for HACs among spinal cord cancer patients using the ACS NSQIP database [7]. In this current report of 82,304 gynecologic cancer patients, our data showed that older age was an independent predictor for increased risk of HACs. Increased comorbidities in the older patients may explain the higher risk in complications [9, 12, 17, 18]. Nevertheless, after adjusting for comorbidities, older age remained as an independent risk factor for HACs. However, other factors not reported by the NIS can influence age as a risk factor for HACs, such as the surgeon characteristics, complexity of the procedure, and operative time.

4.2. Surgery type

In a prior study of 98,553 patients undergoing bariatric surgery, laparoscopic gastric banding was associated with a 1.3% rate of HACs compared to 8.0% in the open surgeries [6]. Similarly, our findings showed that laparoscopic surgery patients experienced less HACs compared to open procedures. In contrast, a study on pediatric surgery did not find a significant difference of HACs based on the type of surgery [19]. Furthermore, a prior study from our research group found that the robotic and laparoscopic approach was associated with less hospitalization and less surgical complication compared to open surgery among endometrial cancer patients [20]. It is possible that those who undergo laparoscopic surgery may have less comorbidities, and lower BMI, earlier staged cancers, and may have undergone less extensive surgeries [21–24]. Prior studies have reported that teaching status or resident surgeons may influence the risk of HACs in surgery type [25–28]. However, our multivariate analysis suggests that after adjusting for teaching status, gynecologic patients undergoing minimally invasive surgeries were associated with a decreased risk of HACs.

Table 3
Median hospital charges for hospital-acquired conditions.

Event	Median Cost[a]	Added Cost	Frequency	Total Cost
No HAC (referent)	$31,073	–	82,169	–
Vascular catheter–associated infection	$213,892	$182,819	41	$7,495,579
Pressure ulcers	$124,905	$93,832	16	$1,501,312
Catheter-associated urinary tract infection	$81,876	$50,803	47	$2,387,741
Manifestations of poor glycemic control	$58,888	$27,815	[b]	$278,150
Foreign objects	$43,195	$12,122	19	$230,318
Air embolism	$34,957	$3,884	[b]	$7,768
All HAC events	$89,324	$58,251	135	$11,900,868

[a] Median costs of HAC events after gynecologic oncology surgeries.
[b] According to NIS reporting guidelines, number of cases were deleted for events occurring ≤10, but numbers are included in total HAC events.

Table 4
Multivariate Analysis of Factors Associated with Hospital-Acquired Conditions.

Factors	OR (95% Confidence Interval)[a]	*p* value
Age (years)		
Younger (<60)	1.0	
Older (≥60)	2.13 (1.30–3.50)	0.003
Race[b]		
White	1.0	
Black	1.22 (0.66–2.26)	0.42
Hispanic	1.14 (0.59–2.22)	0.58
Asian	1.15 (0.35–3.75)	0.71
Other	0.50 (0.12–2.04)	0.27
Socioeconomic Status[b,c]		
High	1.0	
Upper-middle	1.03 (0.61–1.76)	0.82
Middle	1.06 (0.62–1.82)	0.71
Low	0.90 (0.51–1.60)	0.57
Insurance Type[b]		
Private	1.0	
Medicare	0.89 (0.55–1.45)	0.48
Medicaid	3.09 (1.70–5.62)	<0.001
Uninsured	0.75 (0.18–3.14)	0.54
Other	0.69 (0.17–2.91)	0.46
Geographic Region		
South	1.0	
Midwest	1.13 (0.66–1.92)	0.31
Northeast	0.81 (0.47–1.39)	0.44
West	0.83 (0.49–1.40)	0.54
Hospital Location[b]		
Urban	1.0	
Rural	1.21 (0.51–2.86)	0.67
Hospital Teaching Status[b]		
Teaching	1.0	
Non-teaching	1.24 (0.83–1.86)	0.30
Surgery Type		
Open	1.0	
Laparoscopic	0.41 (0.19–0.90)	0.03
Cancer Type		
Uterine	1.0	
Ovarian	1.75 (1.18–2.60)	0.005
Cervical	0.63 (0.25–1.60)	0.11
Charlson Comorbidity Index Score	1.46 (1.32–1.60)	<0.001

[a] Odds ratios generated using multivariable logistic regression model, additionally controlling for fixed effects displayed in the table as well as year of diagnosis and hospital size.
[b] Missing data for the covariates race and income level were imputed with multiple imputation using chained equations.
[c] Quartiles determined by the NIS.

4.3. Hospital charges

In neurologic oncology surgeries, HACs were associated with prolonged length of hospitalization and increased hospital cost, totaling about $470,000,000 over 8 years [5]. Another study on bladder cancer also showed a correlation between HACs and hospitalization costs, which totals to about $440,000,000 over the 8-year span [10]. Similarly, our study showed that HACs in gynecologic cancer surgery resulted in additional chargers of >11 million dollars over 7 years. The costliest HAC events reported in our study was vascular catheter-associated infections with the most frequent being catheter-associated urinary tract infections. In a recent report on head and neck cancer surgery using the NIS database, the mean cost of treatment after experiencing HACs was $53,000 compared with no HACs [5]. In contrast, a non-cancer study on Crohn's disease patients have reported mean hospital charges of $62,000 for patients experiencing at least one HAC event [29]. In comparison to these previous studies, our economic analysis for treatments in gynecologic cancer patients have a higher charge of

$89,773 related to HACs. Previous reports on prostate cancer and otolaryngology suggest that HACs was also associated with increased length of stay [11, 12]. Furthermore, hospital charges have been known to be associated with lengths of hospitalization in previous findings [5, 29]. After a patient experiences an HAC event, subsequent treatments to correct these complications require longer hospitalization resulting in higher charges [30].

4.4. Strengths/limitations

The results of this current report need to be interpreted with caution and may not be generalizable to all patients. We do not have data on the type of surgeon who conducted the surgery, stage of disease, grade, prior cancer treatment, or the survival outcome of the cancer. Since the NIS database is only limited to 30 days after surgery, the postoperative complications may not have been thoroughly captured and lead to under-reporting of HAC events which may not be reflective of the true frequency. Additionally, the database is comprised of disproportionate percentage of teaching vs. non-teaching and Southern vs. Northwestern vs. Midwestern vs. Western hospitals. Therefore, it may not accurately reflect the distribution of hospitals in the U.S.

These HACs were only captured by the NIS during the patient's current admission. Any complications that occurred after discharge were not reported to the NIS. This may account in part to the small number of HAC events in our study. The low rates of the HAC reported in our study may reflect that they are based on International Classification of Diseases coded claims, and not directly on clinical data. Therefore, the administrative claim data may be less accurate and reflect differences in completeness of coding for each of the HAC and for different conditions/procedures studied. The issue of validity of HAC conditions have been reported in a recent systemic review and meta-analysis [31]. After assessing sensitivity, specificity, positive predictive value, and negative predictive value of HACs using a prospective and retrospective chart review data as a referenced standard, these investigators found that for any of the HACs there were insufficient studies for validity determination. These results showed that coding errors were reported as the most common reason for the discrepancies between medical record review and administrative databases [31]. Nevertheless, the HAC rate in our study is similar with other reports using the NIS database, including those for head and neck cancer surgeries (with <1% HAC events) and prostate cancer surgeries (with 0.08% HAC events) [5, 11]. Additionally, ICD-9 codes were used to identify HAC events which may not provide comprehensive information with missing charges on minor complications. With a more accurate reporting there may be a higher number of HAC events and consequently the associated costs would be higher.

Other HAC events not included into this study were deep vein thrombosis/pulmonary embolism (DVT/PE) and surgical site infections. Although these complications are serious, they were not defined as HACs for cancer surgeries by CMS. According to the CMS site, DVT/PE is only recognized as a HAC within orthopedic procedures [3]. Similarly, surgical site infection is recognized as a HAC within bariatric, orthopedic, and cardiac surgery [3]. Although it is important to look at DVT/PE and surgical site infections, this current study aimed to only evaluate the rate of HAC as defined by CMS and their economic associations in gynecological cancer patients.

Other factors not evaluated in this study that may increase the risk of HACs include the experience of surgeons, the complexity of the surgery, and volume of surgery cases for surgeon and hospital. Since this study follows a cross-sectional design, the temporal association or the causality between the risk factors and HAC events are difficult to validate [32]. Nevertheless, this is the first reported study analyzing HACs in gynecologic cancer surgeries with 82,304 patients including endometrial, ovarian, and cervical cancers from the NIS database capturing up to 96% of the U.S. population. Furthermore, this study examines the associated factors that contribute to HACs and provides economic analyses related to these events.

Older patients, patients who underwent open vs. minimally-invasive surgery, and Medicaid insured patients were associated with a higher risk of HACs. These complications resulted in a median of $58,251 extra hospitalization charge per patient. In consideration of these risk factors, hospitals should implement preventable measures to reduce HAC events and additional hospital charges. A 2016 report from the U.S. Department of Health and Human Services has found a 9% decrease in HACs over their two-year study period. To further improve prevention of these events and promote quality of care, further research is on-going to implement checklist after complex surgeries and to increase awareness of HAC events by the hospital staff [33, 34].

Conflict of interest statement

The authors declare no conflicts of interest.

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Author contribution

	Study conception design	Acquisition of data	Analysis and interpretation of data	Drafting of manuscript	Critical revision
John K. Chan MD	x	x	x	x	x
Austin B. Gardner BA	x	x	x	x	x
Amandeep K. Mann MPH	x	x	x	x	x
Daniel S. Kapp MD PhD	x			x	x

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