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Factors Associated With 30-Day Hospital Readmission After Hysterectomy

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Abstract

Objectives—To analyze factors associated with 30-day readmission among women who underwent hysterectomy for uterine cancer and benign indications.

Methods—We used the National Surgical Quality Improvement Project database to perform a cohort study of women who underwent hysterectomy from 2011–2012. Patients were stratified by surgical indication (uterine cancer or benign indications). Multivariable logistic regression models were constructed to determine factors associated with 30-day readmission. Model fit statistics were utilized to evaluate the importance of demographic factors, preoperative comorbidities, and postoperative complications on readmission.

Results—The rate of 30-day readmission was 6.1% among 4,725 women with uterine cancer and 3.4% after hysterectomy for benign gynecologic disease in 36,471 patients. In a series of multivariable models, postoperative complications including wound complications, infections, and pulmonary emboli, and myocardial infarctions were the factors most strongly associated with readmission. Compared to women without a complication, complications increased the readmission rate from 2.5% to 20.3% for women with uterine cancer and from 1.5% to 15.1% for those without cancer. Among women with uterine cancer, postoperative complications explained 34.3% of the variance in readmission compared to 5.9% for demographic factors and 2.2% for

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preoperative comorbidities. For patients with benign diseases, complications accounted for 32.1%, preoperative conditions 1.2% and demographic factors 2.5% of the variance in readmission.

Conclusion—Efforts to reduce readmission should be directed at initiatives to reduce complications and improve the care of women who experience a complication.

Introduction

Hospital readmission has gained increasing recognition as a metric of healthcare quality. Among patients receiving treatment at acute care facilities, hospital readmission is inconvenient, a major driver of hospital cost, and has become an important quality metric.[1–3] In 2004, it was estimated that unplanned readmissions among Medicare beneficiaries were associated with over $17 billion in expenditures.[2] While quality improvement efforts by the Centers for Medicare and Medicaid Services initially focused on rehospitalization for medical conditions, there has now been greater focus on hospital readmission after common surgical procedures.[3]

To date, the understanding of what drives readmission is limited.[4–8] A large analysis of over 230,000 patients who underwent general, gastrointestinal, vascular or thoracic surgery noted an all-cause readmission rate of 7.8%. A variety of factors, including surrogates of preoperative functional status, medical comorbidities, and complications were associated with readmission.[5]

Efforts to describe factors that influence readmission after gynecologic surgery have been limited to date.[9,10] One report of a gynecologic oncology service at a tertiary care hospital noted that 13.2% of patients were readmitted within 30 days of discharge. Unplanned readmissions accounted for a substantial proportion of the readmissions, as well as the cost.[9] Given the importance of readmission after hysterectomy, identification of risk factors for readmission would be of great value. Especially if modifiable risk factors were identified, targeted, pragmatic interventions could be implemented to reduce readmission. The objective of our analysis was to examine potentially modifiable risk as well as unmodifiable factors associated with 30-day readmission among women who underwent hysterectomy.

Materials and Methods

The American College of Surgeons' National Surgical Quality Improvement Program (NSQIP) database was used for analysis.[11] The National Surgical Quality Improvement Program is a nationwide effort that collects data on surgical patients from participating hospitals from across the United States. The database was initially developed for benchmarking and quality improvement, and now collects data on over 150 variables from approximately 400 hospitals and tracks patient for 30 days after surgery. Thirty-day readmission rates are calculated from the day of surgery and not day of discharge after the index procedure. Data is abstracted by trained registrars using a defined sampling schema that collects data from the first 40 cases for a given procedure during 8-day sampling cycles. The 8-day sampling cycles are spaced throughout the year to prevent bias in case selection. Data undergoes regular auditing to ensure quality. The study was considered exempt by the Columbia University Institutional Review Board.

We performed a cohort study to examine factors associated with 30-day readmission in women who underwent hysterectomy. We identified women >18 years of age who underwent hysterectomy (abdominal, laparoscopic or laparoscopically assisted, or vaginal) in 2011 and 2012. Patients who died during the index hospitalization and those who remained hospitalized for >30 days were excluded. Similarly, as patients with a prolonged post-surgical hospitalization may bias the findings, we excluded women with a length of stay of >20 days from the index operation since they would have a minimal time frame in which to be readmitted in the 30-day postoperative period.[12]

Two groups of women were selected, those who underwent hysterectomy for benign indications and those who underwent hysterectomy for endometrial cancer. Among women who underwent surgery for benign gynecologic disease, the following surgical indications were noted: leiomyoma, endometriosis, abnormal bleeding, benign adnexal neoplasms, and pelvic organ prolapse. Patients with other gynecologic malignancies were excluded. The primary outcome of the analysis was hospital readmission. Readmission was defined as return to the hospital within 30 days of the index procedure.

Clinical and demographic characteristics including age at diagnosis (<50, 50–59, 60–69, ≥70 years), race (white, black, other, unknown), and body mass index (normal [<25 kg/m^2], overweight [25–29.9 kg/m^2], obese [≥30 kg/m^2], and unknown), were recorded. Covariates associated with performance status including American Society of Anesthesiology (ASA) classification score (1, 2, 3, 4, 5, or unknown), preoperative functional status (independent, partially dependent, totally dependent, and unknown) and preoperative albumin (<3.5 g/dL, 3.5–4 g/dL, and >4 g/dL), were noted. Performance of concurrent procedures, including lymphadenectomy for women with uterine cancer, and anterior or posterior colporrhaphy, or anti-incontinence surgery for women with benign disease, were recorded.

For each patient, the following preoperative conditions were recorded: diabetes mellitus (insulin dependent or non-insulin dependent), tobacco use, chronic obstructive pulmonary disease, congestive heart failure, hypertension, corticosteroid use, weight loss (>10% body weight in 6 months), bleeding disorders, and preoperative transfusion. Postoperative complications that occurred during the index admission that were analyzed included: reoperation (within 30 days), superficial, deep, or organ space surgical site infections, wound dehiscence, pneumonia, pulmonary embolism, deep vein thrombosis, urinary tract infection, transfusion, sepsis, myocardial infarction, and acute renal failure.

Separate statistical analyses were performed for women with uterine cancer and those with benign gynecologic disease. Frequency distributions between categorical variables were compared using χ^2 tests. Multivariable logistic regression models were developed to determine the demographic factors, preoperative conditions, and postoperative complications associated with readmission while controlling for other factors. The results are reported with odds ratios and 95% confidence intervals. A separate descriptive analysis is reported examining readmission rates based on the number of complications experienced by patients.

To determine the strength of association between each group of covariates and readmission, we evaluated a number of model fit statistics. The c-statistic indicates the area under the curve of a receiver operating characteristic (ROC) curve plotted with the true positive rate versus the false positive rate. The c-statistic is related to the overall ability of a model to correctly classify the outcome, in our case hospital readmission. A c-statistic of 0.5 indicates that the model is no better than chance in discriminating an outcome while a c-statistic of 1 suggests the model perfectly predicts the outcome. The pseudo-R^2 is analogous to R^2 in ordinary least squares linear regression, which is an indicator of the total variability explained by the model in predicting the outcome. The Akaike information criterion is a measure of the relative quality of a model. The Akaike information criterion evaluates the goodness of fit of a model in light of the complexity of a given model. When one set of variables is included in a model, a lower Akaike information criterion indicates a higher importance of that set of variables; in contrast, in models including two groups of variables, a higher Akaike information criterion indicates a greater importance of the set of variables omitted from the model. The likelihood ratio test compares the fit of two models, one containing a set of covariates, the other a null model or a full model containing all sets of covariates. When one group of variables is examined, and compared to a null model, a higher likelihood ratio test indicates greater importance of that group of variables, whereas in models containing two groups of variables, a higher LRT compared to the full model indicates a greater importance of the omitted variables.

We assumed that a null model, a model that contains no covariates, is associated with a c-statistic of 0.5, indicating that the model is no better in predicting the outcome of interest than chance alone. For models with one group of variables, we calculated the ability of the given group of variables to predict readmission as: (c-statistic of model with one group of variables)/(c-statistic of null model). For models with two groups of variables, we determined the reduction in the ability to predict readmission as: [(c-full model) − (c-reduced model)] / [(c-full model) − (c-null model)].[12] All analyses were performed with SAS version 9.4 (SAS Institute Inc, Cary, North Carolina). All statistical tests were two-sided. A P-value of <0.05 was considered statistically significant.

Results

A total of 41,196 women were identified. Among the 4,725 women who underwent hysterectomy for uterine cancer, 30-day readmissions were noted in 289 (6.1%) patients, while readmissions were documented in 1221 (3.4%) of the 36,471 patients who underwent hysterectomy for benign indications (Tables 1 and 2).

Table 1 displays the unadjusted rates of readmission for women with uterine cancer. The readmission rate was 9.9% after abdominal hysterectomy, 4.2% after laparoscopic hysterectomy, and 5.9% after vaginal hysterectomy (P<0.001). In a multivariable model, the readmission rate was 51% lower after laparoscopic, compared to abdominal hysterectomy (OR=0.49; 95% CI, 0.35–0.68) (Table 3). Women with higher ASA scores were more likely to require readmission and the odds ratio for readmission with performance of lymphadenectomy was 1.59 (95% CI, 1.15–2.20). Preoperative comorbidities associated with readmission included insulin dependent diabetes mellitus (10.3%, OR=2.33; 95% CI,

1.36–3.96), congestive heart failure (30.8%, OR=8.05; 95% CI, 1.95–33.17) and significant weight loss (16.7%, OR=3.40; 95% CI, 1.37–8.45). The occurrence of postoperative complications, including superficial (18.3%, OR=3.30; 95% CI, 1.85–5.87), deep (84.6%, OR=28.14; 95% CI, 7.31–108.28), and organ space (85.7%, OR=82.19; 95% CI, 32.23–209.62) surgical site infections, pulmonary embolism (64.3%, OR=28.14; 95% CI, 11.18–70.80), urinary tract infection (22.7%, OR=3.11; 95% CI, 1.62–6.01), sepsis (68.8%, OR=7.02; 95% CI, 2.77–17.84), myocardial infarction (42.9%, OR=6.31; 95% CI, 1.06–37.66), and reoperation (85.1%, OR=128.61; 95% CI, 59.96–290.42), were all associated with readmission in both the univariable and multivariable models.

Within the cohort that underwent hysterectomy for benign gynecologic disease, the readmission rate was 4.5% after abdominal hysterectomy, 3.0% for laparoscopic hysterectomy, and 2.6% for vaginal hysterectomy (P<0.001) (Table 2). In a multivariable model, performance of laparoscopic and vaginal hysterectomy was associated with a lower readmission rate than abdominal hysterectomy (Table 3). Black women (4.7%, OR=1.30; 95% CI, 1.06–1.59), those with higher ASA scores and limited functional status were more likely to require readmission, while women who underwent hysterectomy for leiomyoma (3.0%, OR=0.81; 95% CI, 0.66–0.99) were less likely to be readmitted. Preoperative tobacco use (4.8% OR=1.34; 95% CI, 1.14–1.59), corticosteroid use (6.7%, OR=1.79; 95% CI, 1.11–2.90) and insulin dependent diabetes mellitus (7.8%, OR=1.53; 95% CI, 1.03–2.26) were all associated with 30-day readmission. Similar to hysterectomy for uterine cancer, among women who underwent hysterectomy for benign indications, superficial (15.0%, OR=4.22; 95% CI, 3.03–5.87), deep (50.6%, OR=18.53; 95% CI, 10.86–31.62), and organ space (64.3% OR=41.45; 95% CI, 30.62–56.12) surgical site infections, pneumonia (33.3%, OR=5.64; 95% CI, 2.86–11.14), pulmonary embolism (68.3%, OR=75.48; 95% CI, 44.51–128.00), deep venous thrombosis (54.6%, OR=23.04; 95% CI, 11.36–46.72), urinary tract infection (13.5%, OR=3.11; 95% CI, 1.62–6.01) and reoperation (57.4%, OR=49.58; 95% CI, 39.63–62.01) were all associated with readmission.

Readmission rates were then analyzed based on the number of complications (Table 4). Among women with uterine cancer, the 30-day readmission rate was 2.5% in women who did not experience a complication and rose to 20.3% in those with 1 postoperative complication, 44.1% for women with 2 complications and 62.5% for patients with more than four complications (P<0.001). Similarly, among patients who underwent hysterectomy for benign indications the rate of readmission rose from 1.5% in those without a complication to 15.1% in patients with 1 complication, 42.9% for women with 2 complications and 65.0% for patients who experienced four or more complications (P<0.001).

Model fit statistics were then used to analyze the importance of demographic characteristics, preoperative characteristics, and postoperative complications individually on the risk of 30-day readmission (Table 5). Models for uterine cancer containing one group of variables demonstrated a pseudo-R^2 of 2.2% for preoperative characteristics, 5.9% for demographic factors, and 34.3% for postoperative complications (corresponding c-statistics of 0.58, 0.67, and 0.79, respectively). Compared to chance, this suggests that the ability to distinguish readmission is increased by 15.8% for preoperative characteristics, 34.2% for demographic factors, and 58.4% for postoperative complications. In the models combining various groups

of characteristics, omitting preoperative characteristics reduced the ability of the model to predict readmission by 1.7%, omission of demographic characteristics reduced predictive probability beyond chance by 7.8%, while removal of postoperative complications reduced the discriminatory ability of the model by 48.0%.

For women who underwent surgery for benign gynecologic disease, model fit statistics suggested that, compared to chance, preoperative characteristics increased the ability to distinguish readmission by 13.6%, demographic factors 23.0%, and postoperative complications 54.4%. In the models combining various groups of characteristics, omitting preoperative characteristics reduced the ability of the model to predict readmission by 0.9%, omission of demographic characteristics reduced predictive probability by 7.9%, while removal of postoperative complications reduced the discriminatory ability of the model by 61.5%.

Discussion

Our findings provide benchmarking data for the rate of 30-day readmission for women undergoing hysterectomy. While the rate of readmission we noted is lower than that of many higher risk general surgical procedures, it remains appreciable. The occurrence of postoperative complications is by far the most important factor associated with readmission, while demographic characteristics and preoperative conditions are only modestly predictive.

The majority of prior studies have reported readmission rates after hysterectomy of <10%; however, few studies have specifically examined factors associated with readmission.[13–15] A recent single institutional report noted a readmission rate of 4.5% after abdominal hysterectomy, 4.3% after vaginal hysterectomy, and 3.5% after laparoscopic hysterectomy.[13] In our analysis we noted that in addition to route of hysterectomy, ASA class, some preoperative comorbidities, and performance of lymphadenectomy in cancer patients were all associated with readmission; however, the occurrence of a perioperative complication was the strongest factor associated with readmission.

The occurrence of perioperative complications has been shown to be an important risk factor for readmission for a number of surgical procedures.[4,5,7,8,12,16–19] An analysis of over 12,000 patients who underwent colectomy noted that postoperative complications were the strongest factor associated with readmission; the 30-day readmission rate was 9% in patients without a complication compared to 30% in patients who experienced a complication.[12] Our analysis noted similar findings, for hysterectomy for uterine cancer and for benign gynecologic disease the occurrence of a perioperative complication was by far the strongest risk factor for readmission. Each individual complication was relatively rare and accounted for a small number of readmissions. However, as an aggregate perioperative complications were associated with a substantial portion of hospital readmissions.

Given the association between complications and post-hysterectomy readmission, our data suggests that readmission reduction initiatives should focus on complications. First, greater efforts can be directed toward reducing complications. Adherence to quality metrics, such as use of perioperative antibiotics and venous thromboembolism prophylaxis, may help reduce

complications, although studies have shown that compliance for gynecologic surgery is highly variable.[20,21] A nationwide study demonstrated only a modest association between adherence to surgical process measures and reduced readmission rates but noted a significant association between higher procedural volume and lower readmission rates.[22] While surgical volume is associated with outcomes for gynecologic surgery, the magnitude of the effect is more modest than for other, higher risk procedures.[15,23,24]

Second, initiatives can be developed to optimize the management of patients who experience a complication. For surgical disciplines, there is growing recognition that the management of perioperative complications has a stronger influence on outcomes than the actual occurrence of the complication itself, so called failure to rescue.[25,26] Prompt recognition and appropriate treatment of complications may help lower readmission rates. Trends to reduce length of stay postoperatively must be balanced against the possible increased risk of readmission for patients who experience a perioperative complication.[27]

Despite the inclusion of a large sample of women, we recognize a number of important limitations. While NSQIP employs a standardized methodology for data collection and has been utilized in a number of studies examining readmission, we cannot exclude the possibility that a small number of readmissions were not captured.[4,5,8,12] Second, the majority of complications captured by NSQIP are major perioperative complications. Less severe complications as well as complications specific to gynecologic surgery are not captured and may have influenced findings. Third, missing data on some important variables including race and albumin limit the ability to interpret some findings from the study. Finally, the hospitals captured in NSQIP may not be generalizable to hospitals from throughout the United States.

A number of national efforts are now underway to help reduce readmission rates after surgical procedures. In 2012, under the Hospital Readmission Reduction Program, CMS began penalizing hospitals with excessive rates of readmission for common medical conditions.[28] Surgical procedures may be added to this initiative as early as 2015.[1,12] Similarly, readmission rates for common medical conditions are now publically reported on the Hospital Compare website and such reporting could be extended to surgical procedures.[29] Encouragingly, population-based data from general surgery have suggested that readmission rates have declined, although modestly, over the last decade.[30] For gynecologic surgery, while further efforts are needed to validate readmission rates as a quality metric, efforts to decrease perioperative readmission should focus on reducing complications or improving the care of women with complications. Aside from the reductions of complications, we found few modifiable factors that could be used to drive strategies to reduce hospital readmission after hysterectomy.

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Table 1

Factors associated with readmission among women with uterine cancer.

	No readmission		Readmission		
	n	**(%)**	**N**	**(%)**	***P-value***
	4436	(93.9)	289	(6.1)	
Route of hysterectomy					<0.001
Abdominal	1395	(90.1)	153	(9.9)	
Laparoscopic	2961	(95.8)	131	(4.2)	
Vaginal	80	(94.1)	5	(5.9)	
Year of procedure					0.39
2011	1866	(93.5)	129	(6.5)	
2012	2570	(94.1)	160	(5.9)	
Age					0.54
<50	491	(94.2)	30	(5.8)	
50–59	1188	(93.8)	79	(6.2)	
60–69	1604	(94.4)	95	(5.6)	
≥70	1153	(93.1)	85	(6.9)	
Race					0.12
White	3518	(94.1)	220	(5.9)	
Black	310	(92.0)	27	(8.0)	
Other	156	(90.7)	16	(9.3)	
Unknown	452	(94.6)	26	(5.4)	
BMI					0.06
Normal	769	(94.2)	47	(5.8)	
Overweight	941	(95.5)	44	(4.5)	
Obese	2699	(93.2)	197	(6.8)	
Unknown	27	(96.4)	1	(3.6)	
ASA Class					<0.001
1	115	(99.1)	1	(0.9)	
2	2135	(95.4)	104	(4.6)	
3	2056	(92.4)	170	(7.6)	

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	No readmission		Readmission		
	n	(%)	N	(%)	*P-value*
4	125	(89.9)	14	(10.1)	
5	1	(100)	0	-	
Unknown	4	(100)	0	-	
Functional status					0.84
Independent	4344	(93.9)	281	(6.1)	
Partially dependent	74	(92.5)	6	(7.5)	
Totally dependent	10	(90.9)	1	(9.1)	
Unknown	8	(88.9)	1	(11.1)	
Preoperative albumin					0.20
<3.5	205	(91.5)	19	(8.5)	
3.5–4	875	(93.0)	66	(7.0)	
>4	1434	(94.0)	91	(6.0)	
Unknown	1922	(94.5)	113	(5.6)	
Concurrent procedures					
Lymphadenectomy	2574	(93.2)	188	(6.8)	0.02
Preoperative conditions					
Non insulin dependent diabetes mellitus	1510	(93.7)	45	(6.3)	0.01
Insulin dependent diabetes mellitus	226	(89.7)	26	(10.3)	0.01
Tobacco use	408	(92.7)	32	(7.3)	0.29)
Chronic obstructive pulmonary disease	112	(91.1)	11	(8.9)	0.19
Congestive heart failure	9	(69.2)	4	(30.8)	<0.001
Hypertension	2432	(93.0)	184	(7.0)	0.003
Metastatic cancer	111	(85.4)	19	(14.6)	<0.001
Corticosteroid use	49	(84.5)	9	(15.5)	0.003
Weight loss	40	(83.3)	8	(16.7)	0.002
Bleeding disorder	85	(88.5)	11	(11.5)	0.03
Preoperative transfusion	31	(88.6)	4	(11.4)	0.19
Postoperative conditions					
Reoperation	10	(14.9)	57	(85.1)	<0.001
Superficial surgical site infection	98	(81.7)	22	(18.3)	<0.001

	No readmission		Readmission		
	n	(%)	N	(%)	*P-value*
Deep surgical site infection	4	(15.4)	22	(84.6)	<0.001
Organ space surgical site infection	7	(14.3)	42	(85.7)	<0.001
Dehiscence	18	(56.3)	14	(43.8)	<0.001
Pneumonia	22	(73.3)	8	(26.7)	<0.001
Pulmonary embolism	10	(35.7)	18	(64.3)	<0.001
Deep vein thrombosis	15	(48.3)	15	(51.7)	<0.001
Urinary tract infection	85	(77.3)	25	(22.7)	<0.001
Transfusion	306	(87.4)	44	(12.6)	<0.001
Sepsis	15	(31.3)	33	(68.8)	<0.001
Myocardial infarction	4	(57.1)	3	(42.9)	<0.001
Acute renal failure	3	(75.0)	1	(25.0)	0.11

P-values represent global χ^2 tests p-values for each covariate.

Table 2

Factors associated with readmission among women undergoing hysterectomy for benign gynecologic disease.

	No Readmission		Readmission		
	n	**(%)**	**n**	**(%)**	***P-value***
	35,250	(96.7)	1221	(3.4)	
Route of hysterectomy					<0.001
Abdominal	9819	(95.5)	461	(4.5)	
Laparoscopic	18,719	(97.0)	579	(3.0)	
Vaginal	6712	(97.4)	181	(2.6)	
Year of procedure					0.68
2011	14,861	(96.6)	522	(3.4)	
2012	20,389	(96.7)	699	(3.3)	
Age					0.02
<50	22,150	(96.5)	805	(3.5)	
50–59	7830	(97.1)	236	(2.9)	
60–69	3456	(97.1)	105	(3.0)	
≥70	1814	(96.0)	75	(4.0)	
Race					<0.001
White	24,991	(96.8)	826	(3.2)	
Black	4337	(95.3)	213	(4.7)	
Other	1445	(97.4)	39	(2.6)	
Unknown	4477	(96.9)	143	(3.1)	
BMI					0.04
Normal	9643	(96.9)	313	(3.1)	
Overweight	10,438	(96.9)	332	(3.1)	
Obese	14,991	(96.3)	569	(3.7)	
Unknown	178	(96.2)	7	(3.8)	
ASA Class					<0.001
1	5127	(98.0)	107	(2.0)	
2	23,582	(96.8)	779	(3.2)	
3	6303	(95.3)	312	(4.7)	

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	No Readmission		Readmission		
	n	(%)	n	(%)	*P-value*
4	214	(90.7)	22	(9.3)	
5	4	(100)	0	-	
Unknown	20	(95.2)	1	(4.8)	
Functional status					0.003
Independent	35,040	(96.7)	1209	(3.3)	
Partially dependent	117	(91.4)	11	(8.6)	
Totally dependent	16	(94.1)	1	(5.9)	
Unknown	77	(100)	0	-	
Preoperative albumin					<0.001
<3.5	809	(93.3)	58	(6.7)	
3.5–4	4334	(95.4)	209	(4.6)	
>4	6429	(96.5)	235	(3.5)	
Unknown	23,678	(97.1)	719	(3.0)	
Indication for surgery					
Leiomyoma	10,976	(97.0)	340	(3.0)	0.01
Endometriosis	2265	(96.2)	90	(3.8)	0.19
Abnormal bleeding	7788	(96.4)	294	(3.6)	0.10
Benign neoplasm	1595	(95.5)	75	(4.5)	0.008
Pelvic organ prolapse	4896	(97.7)	116	(2.3)	<0.001
Other	7730	(96.2)	306	(3.8)	0.009
Concomitant procedures					
Anterior colporrhaphy	3026	(97.8)	67	(2.2)	<0.001
Posterior colporrhaphy	2600	(98.0)	52	(2.0)	<0.001
Incontinence repair	2802	(97.6)	70	(2.4)	0.005
Preoperative conditions					
Non insulin dependent diabetes mellitus	1887	(96.1)	76	(3.9)	<0.001
Insulin dependent diabetes mellitus	591	(92.2)	50	(7.8)	<0.001
Tobacco use	6256	(95.3)	312	(4.8)	<0.001
Chronic obstructive pulmonary disease	361	(94.5)	21	(5.5)	0.02
Congestive heart failure	20	(95.2)	1	(4.8)	0.72

	No Readmission		Readmission		
	n	(%)	n	(%)	*P-value*
Hypertension	9359	(96.2)	367	(3.8)	0.006
Metastatic cancer	179	(89.1)	22	(11.)	<0.001
Corticosteroid use	376	(93.3)	27	(6.7)	0.0002
Weight loss	82	(93.2)	6	(6.8)	0.07
Bleeding disorder	333	(92.8)	26	(7.2)	<0.001
Preoperative transfusion	303	(94.4)	18	(5.6)	0.02
Postoperative conditions					
Reoperation	236	(42.6)	318	(57.4)	<0.001
Superficial surgical site infection	414	(85.0)	73	(15.0)	<0.001
Deep surgical site infection	44	(49.4)	45	(50.6)	<0.001
Organ space surgical site infection	110	(35.7)	198	(64.3)	<0.001
Dehiscence	72	(72.0)	28	(28.0)	<0.001
Pneumonia	46	(66.7)	23	(33.3)	<0.001
Pulmonary embolism	26	(31.7)	56	(68.3)	<0.001
Deep vein thrombosis	25	(45.5)	30	(54.6)	<0.001
Urinary tract infection	793	(86.5)	124	(13.5)	<0.001
Transfusion	1284	(91.5)	120	(8.6)	<0.001
Sepsis	56	(29.2)	136	(70.8)	<0.001
Myocardial infarction	9	(75.0)	3	(25.0)	<0.001
Acute renal failure	4	(57.1)	3	(42.9)	<0.001

P-values represent global χ^2 tests p-values for each covariate.

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Table 3

Multivariable models of predictors of 30-day readmission.

	Benign gynecologic disease	Uterine cancer
Route of hysterectomy		
Abdominal	Referent	Referent
Laparoscopic	**0.82 (0.70–0.96)***	**0.49 (0.35–0.68)***
Vaginal	**0.62 (0.49–0.79)***	0.79 (0.24–2.68)
Year of diagnosis		
2011	Referent	
2012	0.98 (0.86–1.13)	
Age		
<50	Referent	Referent
50–59	0.95 (0.79–1.14)	1.13 (0.65–1.96)
60–69	0.99 (0.76–1.30)	1.13 (0.65–1.96)
≥70	1.35 (0.97–1.87)	1.07 (0.59–1.92)
Race		
White	Referent	Referent
Black	**1.30 (1.06–1.59)***	1.01 (0.58–1.76)
Other	1.12 (0.78–1.62)	1.86 (0.93–3.73)
Unknown	0.99 (0.79–1.23)	1.25 (0.76–2.08)
BMI		
Normal	Referent	Referent
Overweight	0.93 (0.77–1.12)	0.77 (0.46–1.28)
Obese	0.93 (0.77–1.11)	1.03 (0.66–1.59)
Unknown	0.66 (0.25–1.75)	0.97 (0.12–8.01)
ASA Class		
1	Referent	Referent
2	**1.51 (1.18–1.93)***	8.64 (0.73–102.94)
3	**1.86 (1.38–2.50)***	**12.05 (1.01–144.49)***
4	**3.58 (1.96–6.52)***	**13.63 (1.02–182.62)***
5	-	-
Unknown	2.21 (0.24–20.73)	-
Functional status		
Independent	Referent	Referent
Partially dependent	**2.01 (0.96–4.26)***	0.91 (0.29–2.84)
Totally dependent	**0.05 (0.002–0.93)***	0.66 (0.03–12.97)
Unknown	-	1.43 (0.14–15.23)
Preoperative albumin		
<3.5	Referent	Referent
3.5–4	0.97 (0.66–1.43)	1.64 (0.79–3.43)
>4	0.95 (0.64–1.39)	2.08 (1.00–4.33)

	Benign gynecologic disease	Uterine cancer
Unknown	0.72 (0.50–1.04)	1.64 (0.80–3.37)
Indications for surgery		
Leiomyoma	**0.81 (0.66–0.99)***	-
Endometriosis	1.03 (0.77–1.38)	-
Abnormal bleeding	1.06 (0.87–1.30)	-
Benign neoplasm	1.12 (0.82–1.52)	-
Pelvic organ prolapse	0.80 (0.60–1.06)	-
Concurrent procedures		
Lymphadenectomy	-	**1.59 (1.15–2.20)***
Preoperative conditions		
Non insulin dependent diabetes mellitus	0.86 (0.63–1.16)	0.93 (0.60–1.44)
Insulin dependent diabetes mellitus	**1.53 (1.03–2.26)***	**2.33 (1.36–3.96)***
Tobacco use	**1.34 (1.14–1.59)***	1.11 (0.67–1.84)
Chronic obstructive pulmonary disease	0.91 (0.52–1.59)	0.80 (0.33–1.93)
Congestive heart failure	0.39 (0.04–4.24)	**8.05 (1.95–33.17)***
Hypertension	1.01 (0.85–1.21)	0.93 (0.66–1.32)
Corticosteroid use	**1.79 (1.11–2.90)***	1.78 (0.64–4.97)
Weight loss	1.06 (0.37–3.07)	**3.40 (1.37–8.45)***
Bleeding disorder	1.11 (0.65–1.87)	1.63 (0.70–3.80)
Preoperative transfusion	0.88 (0.47–1.66)	0.72 (0.16–3.27)
Postoperative conditions		
Reoperation	**49.58 (39.63–62.01)***	**128.61 (59.96–290.42)***
Superficial surgical site infection	**4.22 (3.03–5.87)***	**3.30 (1.85–5.87)***
Deep surgical site infection	**18.53 (10.86–31.62)***	**28.14 (7.31–108.28)***
Organ space surgical site infection	**41.45 (30.62–56.12)***	**82.19 (32.23–209.62)***
Dehiscence	1.16 (0.62–2.19)	0.67 (0.17–2.70)
Pneumonia	**5.64 (2.86–11.14)***	1.56 (0.51–4.83)
Pulmonary embolism	**75.48 (44.51–128.00)***	**28.14 (11.18–70.80)***
Deep vein thrombosis	**23.04 (11.36–46.72)***	3.54 (0.97–12.90)
Urinary tract infection	**4.32 (3.34–5.57)***	**3.11 (1.62–6.01)***
Transfusion	0.81 (0.61–1.08)	0.84 (0.50–1.41)
Sepsis	**13.27 (8.54–20.62)***	**7.02 (2.77–17.84)***
Myocardial infarction	**5.70 (1.08–30.21)***	**6.31 (1.06–37.66)***
Acute renal failure	4.18 (0.61–28.51)	0.06 (0.003–1.40)

* P<0.05. Adjusted odds ratio (95% confidence interval).

Results are displayed as adjusted odd ratios.

Boldface type indicates statistically significant values.

Table 4

Association between postoperative complications and readmission*

	No readmission	Readmission	*P-value*
Uterine cancer			<0.001
No complications (n=4038)	97.5%	2.5%	
1 complication (n=531)	79.7%	20.3%	
2 complications (n=102)	55.9%	44.1%	
3 complications (n=46)	37.0%	63.0%	
≥4 complications (n=8)	37.5%	62.5%	
Benign Gynecologic Disease			<0.001
No complications (n=32,945)	98.6%	1.5%	
1 complication (n=2923)	85.0%	15.1%	
2 complications (n=466)	57.1%	42.9%	
3 complications (n=117)	23.9%	76.1%	
≥4 complications (n=20)	35.0%	65.0%	

* χ^2 tests for overall covariate.

Table 5

Association between demographic factors, preoperative conditions, and postoperative complications and readmission for uterine cancer and benign gynecologic disease.

	C-statistic	Increase in ability to distinguish readmission	Reduction in ability to distinguish readmission	Pseudo-R^2	Likelihood ratio test
Uterine Cancer					
Individual variables					
Demographic factors	0.67	34.2%	-	5.9%	103.99
Preoperative conditions	0.58	15.8%	-	2.2%	38.22
Postoperative complications	0.79	58.4%	-	34.3%	639.67
Combinations of variables					
Demographic factors and preoperative conditions (postoperative complications omitted)	0.68	-	48.0%	7.1%	596.45
Demographic factors and postoperative complications (preoperative conditions omitted)	0.84	-	1.7%	37.2%	24.27
Preoperative conditions and postoperative complications (demographics omitted)	0.82	-	7.8%	35.8%	53.40
Full model	0.85	-	-	38.4%	721.70
Benign Gynecologic Disease					
Individual variables					
Demographic factors	0.62	23.0%	-	2.5%	232.26
Preoperative conditions	0.57	13.6%	-	1.2%	106.84
Postoperative complications	0.77	54.4%	-	32.1%	3104.11
Combinations of variables					
Demographic factors and preoperative conditions (postoperative complications omitted)	0.63	-	61.5%	3.2%	3004.50
Demographic factors and postoperative complications (preoperative conditions omitted)	0.83	-	0.9%	33.7%	23.26
Preoperative conditions and postoperative complications (demographics omitted)	0.80	-	7.9%	32.6%	129.58
Full model	0.83	-	-	33.8%	3284.33

Clinical variables included route of hysterectomy, age, race, BMI, ASA class, preoperative functional status, preoperative albumin, and year of surgery. Preoperative variables include comorbidities listed in Table 3, while postoperative variables include complications listed in Table 3.

In models containing one group of variables a higher likelihood ratio test indicates a higher importance of those variables, whereas in a models containing a combination of variables, a higher likelihood ratio test indicates a greater importance of the omitted variables. In models containing one set of variables, a lower Akaike information criterion indicates a higher importance of that set of variables, in contrast, in models including two groups of variables, a higher Akaike information criterion indicates a greater importance of the set of variables omitted from the mode.