# Hysterectomy for benign conditions: Complications relative to surgical approach and other variables that lead to post-operative readmission within 90 days of surgery

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## Abstract

**Objective:** To examine variables associated with hysterectomy-related complications, relative to surgical approach and other variables, that lead to readmission within 90 days of surgery.

**Methods:** We conducted an observational cohort study for which data were extracted from electronic health records. Data were extracted of all patients (n = 3106) who underwent hysterectomies at 10 Kaiser Permanente Southern California medical centers between June 2010 and September 2011. Patients who were pregnant or had a cancer diagnosis were excluded from the study. To identify univariate associations between examined variables and procedure type, chi-square tests for categorical variables and t-tests or analysis of variance for continuous variables were used. Generalized estimating equations methods were used to test associations between independent variables and primary outcomes of interest. Statistical significance was determined using a p-value < .05.

**Results:** Of 3106 patients, 109 experienced 168 post-operative complications. The most common post-operative complications were related to pelvic abscesses, bowel obstruction, or severe ileus, and the vaginal cuff. Pelvic abscesses were most frequent among total laparoscopic hysterectomy and total abdominal hysterectomy cases (p = .002), and vaginal cuff complications were most frequent among total laparoscopic hysterectomy cases (p = .015). Patients who underwent total vaginal hysterectomy (odds ratio = 2.13, confidence interval = 1.15–3.92), laparoscopic supracervical hysterectomy (odds ratio = 3.11, confidence interval = 1.13–8.57), and total laparoscopic hysterectomy (odds ratio = 5.60, confidence interval = 2.90–10.79) experienced increased occurrence of post-operative complications resulting in readmission. Other variables associated with an increased risk for readmission included high estimated blood loss (201–300 mL and 301+ mL, relative to 0–50 mL; odds ratio = 2.28, confidence interval = 1.24–4.18 and odds ratio = 2.63, confidence interval = 1.67–4.14) and long length of stay of 3 days or more (relative to 0 days; odds ratio = 2.93, confidence interval = 1.28–6.69). Pelvic specimen weight in the 151–300 g and 501+ g ranges appeared protective (odds ratio = 0.40, confidence interval = 0.25–0.64 and odds ratio = 0.54, confidence interval = 0.33–0.90). In a sub-analysis of 1294 patients, 74 hospital operative complications directly related to hysterectomy were identified among 59 patients. The most common hospital operative complications were excessive bleeding associated with surgery or injury to nearby structures. Among the sub-sample of 1294 patients, those with hospital operative complications were more likely to experience post-operative complications that lead to readmission (odds ratio = 3.82, confidence interval = 1.55–9.43, p = .004).

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**Conclusion:** The observed increased risk of complications among patients of Black race, who underwent laparoscopic supracervical hysterectomy or total laparoscopic hysterectomy, who experienced more than 300 mL surgical blood loss, who suffered hospital operative complications, and those whose hospitalization was 3 days or greater, offers an opportunity for higher scrutiny and preventive measures during usual hysterectomy care to prevent later readmission.

## Introduction

Patient attributes and case-related risk factors are key components in determining the approach for hysterectomy procedures. Hysterectomy is the second most common gynecological surgery among women of reproductive age and is used to treat various benign conditions.[1,2] Approximately 600,000 women undergo hysterectomies each year in the United States.[3] Patient and case-specific factors influencing surgical approach include size and shape of the pelvis, vagina, and uterus; accessibility to the uterus; extent of extra-uterine disease; the need for adnexal procedures; surgeon training and experience; patient preference; and other factors.[2] Data from the United States reflect a trend toward increasing use of minimally invasive surgical approaches for achieving optimal hysterectomy outcomes. In 2000, 74.5% of cases were abdominal, 22.2% vaginal, and 3.3% laparoscopic; in contrast, in 2010, only 36.6% of cases were abdominal and 17.2% were vaginal, while 43.5% of cases were laparoscopic.[4]

The decreasing reliance on abdominal approaches is not surprising, given the disadvantages with this procedure. These include longer hospital stay and recovery time, greater pain, and greater risk of infection.[5] While minimally invasive approaches are associated with shorter lengths of stay and faster recovery times, they may confer a different set of surgical risks and benefits. While the literature includes some data on the relative risks and benefits of different hysterectomy procedures, the data are often contradictory or inconclusive. The purpose of our study was to determine predictors of optimal hysterectomy care. Specifically, we examined variables from a diverse population associated with hysterectomy-related complications that lead to hospital readmission within 90 days of surgery relative to surgical approach and other variables.

## Materials and methods

Kaiser Permanente Southern California (KPSC) is an integrated healthcare system that delivers services through its own medical offices and hospitals situated throughout Southern California, spanning from Bakersfield to San Diego. KPSC offers insurance coverage through employer-based plans, individual plans, and government-subsidized healthcare for the indigent. All plans are capitated (pre-paid) or are capped expenditures associated with deductibles or co-payments; there is no fee-for-service product. At the time of the study, it was very rare for patients to have significant co-payments or deductibles. As of July 2010, KPSC provided healthcare to more than 3.3 million individuals (approximately 40% females aged 18 years or older), with a demographic composition representative of the region.[6] In this observational cohort study, data were extracted from the electronic health records of all patients who underwent hysterectomies at 10 KPSC medical centers between June 2010 and September 2011. Patients who were pregnant or had a cancer diagnosis were excluded from the study.

We examined patient-related and surgery-related factors to test for associations with complications. Patient variables examined were age, race/ethnicity, and body mass index (BMI). Surgery variables examined included surgical approach, pelvic specimen weight, estimated blood loss (EBL), surgery duration, coincident procedure incidence, and length of stay. Hysterectomy surgical approaches were identified using the International Classification of Diseases, 9th Revision (ICD-9) codes. The approaches compared were laparoscopic-assisted vaginal hysterectomy (LAVH, 68.51), laparoscopic supracervical hysterectomy (LSH, 68.31), supracervical abdominal hysterectomy (SAH, 68.39), total abdominal hysterectomy (TAH, 68.49), total laparoscopic hysterectomy (TLH, 68.41), and total vaginal hysterectomy (TVH, 68.59). The SAH cases are described, but omitted from statistical analyses due to small sample size. The choice of hysterectomy route was selected and conducted under usual-care practices. As in standard clinical care, route selection was primarily based on surgeon preference, and patient characteristics such as indication, uterine size, and BMI. ICD-9 codes were used to medically document the surgery that was actually performed.

Pelvic specimen weight, not sole "uterus weight," is the weight recorded in the laboratory's pathology reports of the entire extracted preserved surgical specimen; depending on the case, this may or may not have included adnexal structures. EBL was derived from the operating room logs. Surgery duration was estimated from operating room logs that documented the time from incision to closure and

includes time needed for coincident pelvic surgeries. Coincident surgeries were categorized as adnexal, pelvic floor reconstruction, or stress urinary incontinence procedure. Length of stay is defined as the number of 24-h periods the patient spent occupying a hospital bed.

Post-operative complications were identified through health record review of study participants who were readmitted for hospitalization within 90 days of hysterectomy surgery. The indication for hospital readmission was assessed by the study investigator (N.M.L.) who was deemed to have the required medical expertise to determine whether the readmission was likely related to the hysterectomy surgery or whether the readmission was independent of the surgery (i.e. related to a surgery of another organ system or to an unrelated medical indication). Each complication was categorized as either surgical (wound, infection, bowel function disorder, perforated viscus, bleeding, hematoma, cuff/vaginal disruption or abnormality, pain management, ureteral injury/obstruction, vesicovaginal fistula) or non-hysterectomy related (medical complication(s) such as pneumonia or deep vein thrombosis, or other, which included later, unrelated surgeries).

Approximately one-third of all hysterectomies were performed in the outpatient setting, which reduced the opportunity for in-hospital management of near-term complications. We therefore conducted an analysis of a subsample of patients (n = 1294) with easily accessible data on intra-hospital complications. The sub-sample data were made available through a KPSC pilot project (implemented prior to the study period) testing the feasibility of standardizing the collection of data routinely documented during hysterectomy surgery-related encounters, and thus facilitating data extraction, not requiring the application of natural language processing. Data collection for this pilot project was conducted using a registry tool (constructed by surgical experts, information technologists, and research scientists) incorporated into the existing electronic health record system. Data entry was done by surgeons after hysterectomy surgery. Use of the registry tool by surgeons was not mandated, but highly encouraged by the chiefs of service and its utility compared with standard medical documentation will be the subject of another manuscript. Due to its ease of use, we also used the registry tool to abstract pre-operative indication and post-operative surgical diagnosis data: acute or chronic uterine bleeding, acute or chronic pain, endometriosis, uterine fibroids, or adnexal mass, including benign or borderline ovarian neoplasm, or cases associated with symptomatic pelvic relaxation. We decided that post-operative findings dominate regarding accuracy when both pre-operative indication and post-operative surgical diagnosis data are available and were used regarding our analyses. Data were used to observe associations with hysterectomy route selection and both intra-hospital and post-operative complications. This was meant to serve as a preliminary analysis to help inform the topic of this article (another manuscript will be submitted separately).

We examined variables for all study patients, stratified by procedure type. To identify univariate associations between examined variables and procedure type, we used chi-square tests for categorical variables and t-tests or analysis of variance (ANOVA) for continuous variables. In order to account for the correlation within the same medical center, we used generalized estimating equations (GEE) methods to test associations between independent variables and primary outcomes of interest. Statistical significance was determined using a p-value < .05. Using the same regression approaches, we adjusted for potential confounders, examining whether pre-operative characteristics modified associations between procedure type and post-operative outcomes. All computations were done with SAS System, version 9.3 (SAS, Institute, Cary, NC). The study protocol was reviewed and approved by the KPSC Institutional Review Board (#5710). Informed consent was waived as the study only involved review of electronic health records and posed minimal risk to patients.

## Results

A total of 3490 patients underwent hysterectomy at 1 of 10 KPSC medical centers during the study period. Hysterectomies were performed by a total of 368 primary and assistant surgeons. In total, 25 cases were excluded due to pregnancy and an additional 359 were excluded due to a cancer diagnosis. This resulted in a final analytic sample of n = 3106. Participants' demographic characteristics are listed in Table 1, by procedure type and for the group as a whole. Statistically significant differences by procedure type were documented for every variable examined. The distribution of procedures from most to least common was as follows: LAVH (23.8%, n = 740), followed by TLH (22.7%, n = 706), TVH (18.9%, n = 587), LSH (15.9%, n = 494), TAH (15.7%, n = 489), and SAH (2.9%, n = 90). Patient age varied significantly by surgery type, with those in the TVH group older than all others (mean age = 53 years versus 46–49 years). The racial and ethnic background of the sample was highly diverse, but groups differed significantly in this regard. While Black women made up 18.6% of the full sample, only 6.6% of women who underwent TVH were Black, while a much higher proportion of women in the LSH and SAH groups were Black (35.4% and 27.8%, respectively). White women comprised just over one-third of the full sample, but they were relatively under-represented among women receiving LSH and SAH procedures (21.9% and 20.0%, respectively). Average BMI was 30.1, with women undergoing SAH higher on average (32.8) and those undergoing TVH lower (28.8).

While roughly one-third to one-quarter of the women in the other groups had small pelvic specimens (150 g or less), the proportion among women in the TVH group was almost

**Table 1.** Patient characteristics by hysterectomy route.

Hysterectomy route

| | LAVH (N=740) | LSH (N=494) | SAH (N=90) | TAH (N=489) | TLH (N=706) | TVH (N=587) | Total (N=3106) | p-value |
|---|---|---|---|---|---|---|---|---|
| Age (years) | | | | | | | | <.001 |
| Mean (SD) | 47.6 (9.7) | 46.0 (6.7) | 45.7 (5.7) | 48.9 (9.8) | 48.0 (8.9) | 53.0 (12.1) | 48.6 (9.8) | |
| Age (years) | | | | | | | | <.001 |
| 25–39 | 118 (15.9%) | 62 (12.6%) | 9 (10.0%) | 63 (12.9%) | 93 (13.2%) | 76 (12.9%) | 421 (13.6%) | |
| 40–49 | 378 (51.1%) | 317 (64.2%) | 64 (71.1%) | 245 (50.1%) | 365 (51.7%) | 179 (30.5%) | 1548 (49.8%) | |
| 50–59 | 156 (21.1%) | 93 (18.8%) | 16 (17.8%) | 119 (24.3%) | 168 (23.8%) | 154 (26.2%) | 706 (22.7%) | |
| 60–69 | 63 (8.5%) | 18 (3.6%) | 1 (1.1%) | 42 (8.6%) | 55 (7.8%) | 114 (19.4%) | 293 (9.4%) | |
| 70+ | 25 (3.4%) | 4 (0.8%) | 0 (0%) | 20 (4.1%) | 25 (3.5%) | 64 (10.9%) | 138 (4.4%) | |
| Race/ethnicity | | | | | | | | <.001 |
| White | 286 (38.6%) | 108 (21.9%) | 18 (20.0%) | 147 (30.1%) | 266 (37.7%) | 240 (40.9%) | 1065 (34.3%) | |
| Hispanic | 291 (39.3%) | 170 (34.4%) | 32 (35.6%) | 190 (38.9%) | 225 (31.9%) | 278 (47.4%) | 1186 (38.2%) | |
| Black | 106 (14.3%) | 175 (35.4%) | 25 (27.8%) | 90 (18.4%) | 144 (20.4%) | 39 (6.6%) | 579 (18.6%) | |
| Asian/Pacific Islander | 49 (6.6%) | 35 (7.1%) | 11 (12.2%) | 55 (11.2%) | 59 (8.4%) | 25 (4.3%) | 234 (7.5%) | |
| Other/unknown | 8 (1.1%) | 6 (1.2%) | 4 (4.4%) | 7 (1.4%) | 12 (1.7%) | 5 (0.9%) | 42 (1.4%) | |
| BMI | | | | | | | | <.001 |
| Mean (SD) | 30.4 (6.5) | 30.3 (6.8) | 32.8 (8.6) | 30.7 (7.3) | 30.0 (6.8) | 28.8 (5.7) | 30.1 (6.7) | |
| BMI | | | | | | | | <.001 |
| <18.5 (under) | 6 (0.8%) | 3 (0.6%) | 1 (1.1%) | 2 (0.4%) | 1 (0.1%) | 6 (1.0%) | 19 (0.6%) | |
| 18.5–24.9 (normal) | 144 (19.5%) | 109 (22.1%) | 18 (20.0%) | 104 (21.3%) | 166 (23.5%) | 144 (24.5%) | 685 (22.1%) | |
| 25.0–29.9 (overweight) | 245 (33.1%) | 155 (31.4%) | 20 (22.2%) | 158 (32.3%) | 225 (31.9%) | 226 (38.5%) | 1029 (33.1%) | |
| 30.0–34.9 (obese class 1) | 179 (24.2%) | 120 (24.3%) | 18 (20.0%) | 107 (21.9%) | 175 (24.8%) | 139 (23.7%) | 738 (23.8%) | |
| 35.0–39.9 (class 2) | 110 (14.9%) | 63 (12.8%) | 16 (17.8%) | 67 (13.7%) | 76 (10.8%) | 48 (8.2%) | 380 (12.2%) | |
| 40+ (class 3) | 56 (7.6%) | 44 (8.9%) | 17 (18.9%) | 51 (10.4%) | 63 (8.9%) | 24 (4.1%) | 255 (8.2%) | |
| Pelvic specimen (g) | | | | | | | | <.001 |
| Mean (SD) | 214.8 (199.5) | 394.0 (433.9) | 712.7 (962.5) | 529.3 (680.7) | 303.2 (418.4) | 113.6 (85.2) | 298.3 (429.3) | |
| Pelvic specimen (g) | | | | | | | | <.001 |
| Missing | 51 (6.9%) | 75 (15.2%) | 57 (63.3%) | 58 (11.9%) | 63 (8.9%) | 51 (8.7%) | 355 (11.4%) | |
| 0–50 | 334 (45.1%) | 139 (28.1%) | 7 (7.8%) | 137 (28%) | 268 (38%) | 419 (71.4%) | 1304 (42.0%) | |
| 151–300 | 220 (29.7%) | 114 (23.1%) | 9 (10.0%) | 91 (18.6%) | 198 (28%) | 93 (15.8%) | 725 (23.3%) | |
| 301–500 | 87 (11.8%) | 68 (13.8%) | 4 (4.4%) | 57 (11.7%) | 83 (11.8%) | 20 (3.4%) | 319 (10.3%) | |
| 501+ | 48 (6.5%) | 98 (19.8%) | 13 (14.4%) | 146 (29.9%) | 94 (13.3%) | 4 (0.7%) | 403 (13%) | |

**Table I.** (Continued)

| Hysterectomy route | LAVH (N=740) | LSH (N=494) | SAH (N=90) | TAH (N=489) | TLH (N=706) | TVH (N=587) | Total (N=3106) | p-value |
|---|---|---|---|---|---|---|---|---|
| Estimated blood loss (mL) | | | | | | | | <.001 |
| Mean (SD) | 184.4 (177.7) | 93.0 (111.3) | 362.1 (315.9) | 333.8 (449.7) | 106.9 (117.4) | 183.0 (149.1) | 180.9 (241.7) | |
| Estimated blood loss (mL) | | | | | | | | <.001 |
| Missing | 27 (3.6%) | 27 (5.5%) | 5 (5.6%) | 30 (6.1%) | 54 (7.6%) | 29 (4.9%) | 172 (5.5%) | |
| 0–50 | 153 (20.7%) | 269 (54.5%) | 6 (6.7%) | 48 (9.8%) | 324 (45.9%) | 73 (12.4%) | 873 (28.1%) | |
| 51–100 | 204 (27.6%) | 115 (23.3%) | 10 (11.1%) | 78 (16%) | 159 (22.5%) | 156 (26.6%) | 722 (23.2%) | |
| 101–200 | 175 (23.6%) | 45 (9.1%) | 25 (27.8%) | 124 (25.4%) | 105 (14.9%) | 199 (33.9%) | 673 (21.7%) | |
| 201–300 | 91 (12.3%) | 17 (3.4%) | 7 (7.8%) | 74 (15.1%) | 41 (5.8%) | 70 (11.9%) | 300 (9.7%) | |
| 301+ | 90 (12.2%) | 21 (4.3%) | 37 (41.1%) | 135 (27.6%) | 23 (3.3%) | 60 (10.2%) | 366 (11.8%) | |
| Total time of surgery (min) | | | | | | | | <0001 |
| Mean (SD) | 142.8 (57.4) | 153.3 (71.3) | 139.4 (54.7) | 134.1 (66.3) | 149.4 (60.4) | 140.1 (72.5) | 144.0 (65.0) | |
| Total time of surgery (h) | | | | | | | | <.001 |
| <1 | 17 (2.3%) | 6 (1.2%) | 2 (2.2%) | 24 (4.9%) | 13 (1.8%) | 59 (10.1%) | 121 (3.9%) | |
| 1–2 | 272 (36.8%) | 179 (36.2%) | 30 (33.3%) | 228 (46.6%) | 225 (31.9%) | 219 (37.3%) | 1153 (37.1%) | |
| 2–3 | 284 (38.4%) | 176 (35.6%) | 41 (45.6%) | 144 (29.4%) | 301 (42.6%) | 157 (26.7%) | 1103 (35.5%) | |
| 3+ | 167 (22.6%) | 133 (26.9%) | 17 (18.9%) | 93 (19%) | 167 (23.7%) | 152 (25.9%) | 729 (23.5%) | |
| Coincident surgery | | | | | | | | <.001 |
| Hysterectomy alone | 310 (41.9%) | 370 (74.9%) | 54 (60.0%) | 176 (36.0%) | 348 (49.3%) | 193 (32.9%) | 1451 (46.7%) | |
| Hysterectomy w/adnexal surgery only | 294 (39.7%) | 92 (18.6%) | 35 (38.9%) | 291 (59.5%) | 315 (44.6%) | 50 (8.5%) | 1077 (34.7%) | |
| Hysterectomy w/combination of adnexal, pelvic, and/or urinary surgeries | 136 (18.4%) | 32 (6.5%) | 1 (1.1%) | 22 (4.5%) | 43 (6.1%) | 344 (58.6%) | 578 (18.6%) | |
| Inpatient length of stay | | | | | | | | <.001 |
| Mean (SD) | 0.9 (1.4) | 0.3 (076) | 3.1 (3.3) | 2.8 (1.5) | 0.4 (0.7) | 1.2 (1.0) | 1.1 (1.5) | |
| Inpatient length of stay | | | | | | | | <.001 |
| 0 | 209 (28.2%) | 362 (73.3%) | 3 (3.3%) | 10 (2.0%) | 494 (70.0%) | 60 (10.2%) | 1138 (36.6%) | |
| 1 | 458 (61.9%) | 111 (22.5%) | 4 (4.4%) | 21 (4.3%) | 167 (23.7%) | 388 (66.1%) | 1149 (37.0%) | |
| 2 | 57 (7.7%) | 17 (3.4%) | 31 (34.4%) | 196 (40.1%) | 33 (4.7%) | 111 (18.9%) | 445 (14.3%) | |
| 3+ | 16 (2.2%) | 4 (0.8%) | 52 (57.8%) | 262 (53.6%) | 12 (1.7%) | 28 (4.8%) | 374 (12.0%) | |

LAVH: laparoscopic-assisted vaginal hysterectomy; LSH: laparoscopic supracervical hysterectomy; SAH: supracervical abdominal hysterectomy; TAH: total abdominal hysterectomy; TLH: total laparoscopic hysterectomy; TVH: total vaginal hysterectomy.

**Table 2.** Mean (SD) predictors by surgery type.

|  | Vaginal (TVH) (N = 587) | Laparoscopic (TLH, LSH, LAVH) (N = 1940) | Abdominal (TAH) (N = 489) | p-value |
|---|---|---|---|---|
| Pelvic specimen weight (g) | 113.6 (85.2) | 290.1 (360.1) | 529.3 (680.7) | <.001 |
| Estimated blood loss (mL) | 183.0 (149.1) | 133.5 (148.3) | 333.8 (449.7) | <.001 |
| Surgery duration (min) | 140.1 (72.5) | 147.9 (62.4) | 134.1 (66.3) | <.001 |
| Length of stay (24-h period) | 1.2 (1.0) | 0.6 (1.1) | 2.8 (1.5) | <.001 |

TVH: total vaginal hysterectomy; TLH: total laparoscopic hysterectomy; LSH: laparoscopic supracervical hysterectomy; LAVH: laparoscopic-assisted vaginal hysterectomy; TAH: total abdominal hysterectomy.

twice the average at 71.4%, while only 7.8% of those with data on pelvic specimen weight in the SAH group had small specimens. Almost no women in the TVH group fell into the largest pelvic specimen weight category (501 g or more), while those undergoing TAH were over-represented (29.9%, compared to 13% for the sample as a whole).

EBL was lowest in the LSH and TLH groups; roughly half of these women lost 50 mL of blood or less (54.5% and 45 .9%, respectively). The SAH and TAH groups had the highest EBL. Respectively, 41.1% and 27.6% of these women lost 301 mL of blood or more. Relatively few of the women in the SAH and TAH groups underwent lengthy procedures; less than one-fifth (18.9% and 19%) of these subjects' surgeries took over 3 h. The mean surgery time for the SAH and TAH groups (139.4 and 134.1 min) was slightly lower than the overall average of 144.0 min.

While almost half of all women (46.7%) underwent some coincident procedure during their hysterectomy surgery, only one-quarter of the women in the LSH group had a coincident surgery. Completion of adnexal surgery only (without any other pelvic or urinary surgeries) in conjunction with hysterectomy was common (34.7% overall), particularly among women undergoing TAH (59.5%); it was uncommon for women in the TVH group (8.5%) and LSH group (18.6%). Women undergoing TVH were more likely to have a combination of adnexal, pelvic, and/or urinary surgeries in conjunction with their hysterectomy; however, 58.6% of these women underwent multiple coincident surgeries, while less than 10% of women in most other groups fell into this category. If pelvic floor pathology or urinary incontinence was coincident, not surprisingly, the vaginal approach was usually preferred historically.[7]

Average inpatient stay varied from 0.3 to 3.1 days, with SAH and TAH having the longest mean stay (3.1 and 2.8 days, respectively); most patients in these groups were inpatients for more than 3 days (57.8% and 53.6%, respectively). Most patients undergoing LSH (73.3%) and TLH (70%) had no inpatient stay.

In an additional analysis, we combined TLH, LSH, and LAVH into a single "laparoscopic" category and compared this category to vaginal and abdominal surgical approaches (see Table 2). Significant differences were found across groups in pelvic specimen weight, EBL, surgery duration, and length of stay. Mean specimen weight among women

undergoing TAH was 1.8 times the mean for women in the laparoscopic group and 4.7 times the mean for women in the vaginal group (529.3 g versus 290.1 and 113.6 g, respectively; p < .001). EBL was also highest in the TAH group (333.8 mL versus 133.5 mL for the laparoscopic group and 183.0 mL for TVH; p < .001), as was length of inpatient stay (2.8 days versus 0.6 and 1.2 days; p < .001). Abdominal surgeries were, on average, the shortest; laparoscopic and vaginal surgeries took roughly 10% and 5.6% longer to complete, respectively (134.1 min versus 147.9 and 140.1 min; p < .001).

Table 3 lists the hysterectomy-related post-operative complications leading to hospital readmission within 90 days by type and inclusion criteria, including 43 complications unrelated to hysterectomy. There were 109 patients (3.5%) who experienced hysterectomy-related post-operative complications leading to hospital readmission. Some patients had more than one complication, yielding an observed number of 168 respective complications. Of the 168 complications, the most common were pelvic abscesses (n = 61, 30.74%), bowel obstruction or severe ileus (n = 29, 17.3%), and vaginal cuff complications (n = 20, 11.9%). Pelvic abscesses were significantly more frequent among TLH and TAH cases (p = .002), and vaginal cuff complications were most frequent among TLH cases (p = .015). These p-value data are not shown in tables. The range from day of surgery to day of hospital readmission is 0–84 days (mean = 18.1 days and median = 10.5 days).

In our sub-analysis of 1294 patients that examined for complications recognized and managed intra-operatively or during the hospital stay, we identified 74 complications among 59 hysterectomy cases (4.6%; 9 cases with more than one complication, data not shown in tables). In all, 20 complications were medical or unrelated to surgery and 54 were directly resulting from the hysterectomy surgery. The most common complication noted intra-operatively or during the hospital stay was excessive bleeding associated with surgery (14 cases) or injury to nearby structures (such as perforated viscus, 13 cases). Among the sub-sample of 1294 patients, those with hospital operative complications were more likely to experience post-operative complications that consequently lead to hospital readmission (odds ratio (OR) = 3.82, confidence interval (CI) = 1.55–9.43, p = .004).

**Table 3.** Readmitted post-operative complications within 90 days of hysterectomy.

| Code | Type | Definition/complications included | Hysterectomy Related | Frequency |
|---|---|---|---|---|
| W | Wound | Seroma, disruption, hematoma, infection | Yes | 14 |
| I | Infection | Other infections related to pelvis or progress to sepsis | Yes | 61 |
| B | Bowel complication | Obstruction, ileus | Yes | 29 |
| PV | Perforated viscus | Bowel, bladder | Yes | 5 |
| BL | Bleeding | Hospitalization or transfusion | Yes | 9 |
| H | Hematoma | Anybody surface or cavity | Yes | 9 |
| C | Cuff/vaginal | Abscess, cellulitis, or dehiscence | Yes | 20 |
| P | Pain management | | Yes | 12 |
| U | Ureteral injury/obstruction | Surgical injury | Yes | 6 |
| V | Vesicovaginal fistula | Pneumonia, deep vein thrombosis | Yes | 3 |
| M | Medical complication | Other surgical episode | No | 32 |
| O | Other | | No | 11 |
| | | | Total | 168 |

Additionally, among the 1294 sub-sample, we observed that there were statistically significant differences ($p < .05$) in route selection by all examined pre-operative indications for surgery or post-operative diagnoses, except for uterine bleeding and borderline ovarian neoplasm; but no statistically significant differences in complication rates by the same variables.

Table 4 presents crude and adjusted ORs for readmission due to post-operative complications. SAH cases were excluded due to small case volume, leaving a sample of 3016 patients with 105 complications. In the full model including all covariates, procedure type was an independent predictor of complications leading to readmission: those who underwent TVH (OR=2.13, CI=1.15–3.92), LSH (OR=3.11, CI=1.13–8.57), and TLH (OR=5.60, CI=2.90–10.79) experienced increased occurrence of post-operative complications, relative to LAVH. Surprisingly, there was no association of performing TAH and complications that lead to subsequent readmission, even when sub-analyzed by medical center area or surgeon case volume. Other variables associated with an increased readmission risk included high EBL (201–300 and 301+ mL, relative to 0–50 mL; OR=2.28, CI=1.24–4.18 and OR=2.63, CI=1.67–4.14) and long length of stay of 3 days or more (relative to 0 days; OR=2.93, CI=1.28–6.69). Pelvic specimen weight in the 151–300 g and 501+ ranges appeared protective (OR=0.40, CI=0.25–0.64 and OR=0.54, CI=0.33–0.90). In an additional model categorizing procedure types as vaginal hysterectomy (TVH and LAVH) or other (TAH and TLH), women undergoing TAH and TLH were almost three times as likely to experience a post-operative complication resulting in readmission (OR=2.66, CI=1.46–4.85; data not shown).

## Comments

In this large, diverse sample, pelvic infections, bowel complications, and vaginal cuff complications were the most common hysterectomy-related complications leading to hospital readmission. These results are consistent with the findings in a recent review of hysterectomy complications.[8] Compared to LAVH, women undergoing LSH had 2.8 times the risk of complications resulting in readmission, while women undergoing TLH were at almost 5 times the risk. The odds of complications leading to readmission among women undergoing TVH and TAH were not significantly different from LAVH. This does not correlate to the conclusions of a 2009 Cochrane review which stated that vaginal hysterectomy should be performed in preference to abdominal procedures, and that laparoscopic procedures should be considered when the vaginal approach is not possible.[5] It is possible that the higher incidence of complications related to TLH was an artifact related to the timing of the study and the fact that some surgeons were only recently trained in performing TLH and LSH procedures.[9] We are conducting an ongoing evaluation to see if this trend continues. Surprisingly, we did not find a higher complication rate leading to readmission among TAH cases even when sub-analyzed by case volume (5, 10, or 15 cases versus lesser number cases per surgeon) or by medical center cohort. This may be due to the relatively small sample size involved, and we are continuing to evaluate this, as the hysterectomy registry data collection has recently become standard practice in our group. Going forward, the distribution of hysterectomy approaches may be skewed by the recent guidance on case employing morcellation during LSH, reducing the number of these procedures for comparison.[7] Regarding the higher prevalence of pelvic infection, bowel complications, and vaginal cuff complications in readmissions associated with hysterectomy type (especially TLH and TAH), further research is needed regarding the etiology of these complications and their association with the surgery approach.

We noted that an EBL of 300 mL or more was associated with increased risk for post-operative complications

**Table 4.** Patients with complications that lead to readmission within 90 days of hysterectomy surgery, by independent variables.

| | Total[a] (N = 3016) | Readmitted patients (N = 105) | Non-readmitted patients (N = 2911) | Crude OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|---|---|---|
| **Age (years)** | | | | | |
| 25–39 | 412 | 20 (4.9%) | 392 (95.1%) | 1.33 (0.93–1.89) | 1.52 (0.91–2.52) |
| 40–49 | 1484 | 55 (3.7%) | 1429 (96.3%) | 1.00 | 1.00 |
| 50–59 | 690 | 19 (2.8%) | 671 (97.2%) | 0.73 (0.51–1.04) | 0.69 (0.39–1.24) |
| 60–69 | 292 | 8 (2.7%) | 284 (97.3%) | 0.73 (0.38–1.43) | 0.82 (0.36–1.89) |
| 70+ | 138 | 3 (2.2%) | 135 (97.8%) | 0.56 (0.24–1.26) | 0.52 (0.14–2.00) |
| **Race/ethnicity** | | | | | |
| Non-Hispanic White | 1047 | 31 (3.0%) | 1016 (97.0%) | 1.00 | 1.00 |
| Hispanic | 1154 | 35 (3.0%) | 1119 (97.0%) | 1.07 (0.77–1.50) | 0.89 (0.65–1.23) |
| Black | 554 | 30 (5.4%) | 524 (94.6%) | 2.06 (1.39–3.04) | 1.76 (0.88–3.51) |
| Asian/Pacific Islander | 223 | 8 (3.6%) | 215 (96.4%) | 1.17 (0.69–1.99) | 0.65 (0.31–1.35) |
| Other/unknown | 38 | 1 (2.6%) | 37 (97.4%) | 0.88 (0.17–4.57) | 1.00 (0.18–5.58) |
| **BMI** | | | | | |
| <25.0 | 685 | 19 (2.8%) | 666 (97.2%) | 1.00 | 1.00 |
| 25.0–29.9 | 1009 | 35 (3.5%) | 974 (96.5%) | 1.28 (0.89–1.86) | 1.09 (0.68–1.74) |
| 30.0–34.9 | 720 | 26 (3.6%) | 964 (96.4%) | 1.34 (0.83–2.15) | 1.03 (0.60–1.77) |
| 35.0–39.9 | 364 | 16 (4.4%) | 348 (95.6%) | 1.65 (1.02–2.68) | 1.27 (0.69–2.34) |
| 40+ | 238 | 9 (3.8%) | 229 (96.2%) | 1.43 (0.78–2.61) | 0.59 (0.20–1.73) |
| **Pelvic specimen weight (g)** | | | | | |
| 0–150 | 1297 | 46 (3.5%) | 1251 (96.5%) | 1.00 | 1.00 |
| 151–300 | 716 | 16 (2.2%) | 700 (97.8%) | 0.62 (0.42–0.91) | 0.40 (0.25–0.64) |
| 301–500 | 315 | 14 (4.4%) | 301 (95.6%) | 1.25 (0.62–2.52) | 0.76 (0.34–1.72) |
| 501+ | 390 | 16 (4.1%) | 374 (95.9%) | 1.15 (0.74–1.79) | 0.54 (0.33–0.90) |
| **Estimated blood loss (mL)** | | | | | |
| 0–50 | 867 | 20 (2.3%) | 847 (97.7%) | 1.00 | 1.00 |
| 51–100 | 712 | 24 (3.4%) | 688 (96.6%) | 1.64 (1.16–2.31) | 1.72 (1.16–2.54) |
| 101–200 | 648 | 23 (3.5%) | 625 (96.5%) | 1.73 (0.93–3.23) | 1.59 (0.88–2.86) |
| 201–300 | 293 | 13 (4.4%) | 280 (95.6%) | 2.24 (1.36–3.69) | 2.28 (1.24–4.18) |
| 301+ | 329 | 18 (5.5%) | 311 (94.5%) | 2.81 (1.84–4.31) | 2.63 (1.67–4.14) |
| **Surgery duration (h)** | | | | | |
| <2 | 1242 | 36 (2.9%) | 1206 (97.1%) | 1.00 | 1.00 |
| 2–3 | 1062 | 35 (3.3%) | 1027 (96.7%) | 1.12 (0.79–1.59) | 1.16 (0.74–1.83) |
| 3+ | 712 | 34 (4.8%) | 678 (95.2%) | 1.63 (0.98–2.73) | 1.64 (0.81–3.34) |
| **Coincident surgery** | | | | | |
| Hysterectomy alone | 1397 | 49 (3.5%) | 1348 (96.5%) | 1.00 | 1.00 |
| Hysterectomy w/adnexal surgery only | 1042 | 43 (4.1%) | 999 (95.9%) | 1.17 (0.74–1.85) | 1.17 (0.51–2.69) |
| Hysterectomy w/combination of adnexal, pelvic, and or urinary surgeries | 577 | 13 (2.3%) | 564 (97.7%) | 0.64 (0.39–1.04) | 0.62 (0.30–1.32) |
| **Length of stay (days)** | | | | | |
| 0 | 1135 | 37 (3.3%) | 1098 (96.7%) | 1.00 | 1.00 |
| 1 | 1145 | 35 (3.1%) | 1110 (96.9%) | 1.03 (0.67–1.60) | 1.53 (0.81–2.89) |
| 2 | 414 | 12 (2.9%) | 402 (97.1%) | 0.94 (0.70–1.27) | 1.51 (0.85–2.69) |
| 3+ | 322 | 21 (6.5%) | 301 (93.5%) | 2.16 (1.35–3.43) | 2.93 (1.28–6.69) |
| **Hysterectomy procedure[a]** | | | | | |
| LAVH | 740 | 11 (1.5%) | 729 (98.5%) | 1.00 | 1.00 |
| LSH | 494 | 16 (3.2%) | 478 (96.8%) | 2.20 (1.40–3.45) | 3.11 (1.13–8.57) |
| TLH | 706 | 38 (5.4%) | 668 (94.6%) | 3.88 (2.57–5.86) | 5.60 (2.90–10.79) |
| TVH | 587 | 16 (2.7%) | 571 (97.3%) | 1.90 (1.18–3.06) | 2.13 (1.15–3.92) |
| TAH | 489 | 24 (4.9%) | 465 (95.1%) | 3.49 (2.60–4.67) | 2.05 (0.88–4.76) |

LAVH: laparoscopic-assisted vaginal hysterectomy; LSH: laparoscopic supracervical hysterectomy; TLH: total laparoscopic hysterectomy; TVH: total vaginal hysterectomy; TAH: total abdominal hysterectomy.
[a]Supracervical abdominal hysterectomy (SAH) cases excluded due to small sample size.

resulting in readmission. Traditionally, blood loss exceeding 1000 mL defines hemorrhage,[10] but our study indicates that smaller losses of 300 mL or greater may be associated with a clinical risk leading to readmission after hysterectomy. Patient conditions or the clinical scenarios which influence the ability to control bleeding (e.g. planned versus emergent surgery) will be studied in another evaluation of the series of cases affected.

We documented that vaginal hysterectomy was chosen to remove the smaller uteri and was associated with longer surgical durations, which may be influenced by the higher likelihood that pelvic floor and incontinence surgeries are performed concomitantly. Although associated with the shortest surgical duration, the abdominal hysterectomy is necessary for larger pelvic masses where laparoscopic visualization or visualization of pedicles during the laparotomy approach remains a challenge; this can lead to a greater risk of blood loss and longer post-operative recovery time, which was evidenced in this study. The performance of adnexal, pelvic floor, or urologic procedures concomitant with hysterectomy was not associated with a higher incidence of readmission due to complications. The lack of association of risk of complications was surprising, given the longer length and expanded operative dissection required to perform additional procedures. Pelvic specimen weight outside of the 151–300 and 501+ g ranges may be associated with problematic dissection due to compromised visualization of structures undergoing dissection due to obstruction in large cases and atrophic changes in cases with smaller uteri.[11,12]

Patients who identified as Black had a significantly greater risk for the occurrence of complication-related readmission. This finding is supported by previous work indicating that Black women have an increased risk for hysterectomy complications.[13] While further research is needed to better define racial and ethnic disparities in hysterectomy outcomes, current data indicate that large and numerous fibroid tumors are more prevalent among Black women, an indication that was associated with an increased risk for hysterectomy complications in a study by Jacoby et al.[14]

This comparative effectiveness analysis of usual-care approaches to a sequelae from hysterectomy for benign cases in a large patient sample performed by a large diverse surgeon base may be generalizable to other similar managed care settings. The majority (62%) of the hysterectomy cases examined were performed via a laparoscopic approach, while the remaining 38% were equally distributed among either a vaginal approach or an abdominal approach. The proportions of hysterectomy surgical approaches found in this study are highly comparable to that of another study with similar timing and setting.[4]

The method for identifying and categorizing post-operative complications allowed for a thorough review of patients' health records, but also poses potential limitations. Patient complication data relied on ICD-9 codes followed by chart abstraction in identified cases rather than chart abstraction in every case, and therefore, it is possible that we did not capture all post-operative complications leading to readmission. Patients with complications managed in the outpatient setting and not readmitted may have still been impactful to ultimate recovery, but were not captured because of chart abstraction limitations. Similarly, we could not examine factors such as adhesions or adhesiolysis, conversion, and previous surgeries because to do so would have required more resources than allotted for manual chart abstraction. We also must note the observational nature of this study as a limitation; patients were not systematically assigned to any particular procedure type, but rather the case was treated according to the clinical acumen and decision-making of individual providers. This comparative effectiveness methodology could have introduced bias into the results, but is tempered by our large surgeon and patient sample size.

We focused on post-hysterectomy readmissions related to complications because they are often more serious, costly, clinically impactful, and often offer opportunities for quality improvement regarding pre-discharge recognition or immediate post-discharge surveillance. Furthermore, approximately one-third of all hysterectomy cases were performed in the outpatient setting, reducing the opportunity for in-hospital management of near-term complications. It is noteworthy that those with hospital operative complications or immediate post-operative in-hospital complications had a higher likelihood of a later readmission for a myriad of complications, something we hope to prevent and plan to focus on in future analyses. Some post-discharge complications are difficult to capture because they may not require hospitalization or occur past the expected time period. Our study addressed the latter concern by more broadly and robustly employing a template registry tool (similar to that employed for the 1294 case subset). We plan to further expand our analysis of hysterectomy case records to study the impact of urgent and emergency care (outpatient setting) on later readmission up to 90 days following surgery, rather than the usual 30 days.

## Declaration of conflicting interests

## Ethical approval

## Funding

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