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# Predictors and costs of surgical site infections in patients with endometrial cancer☆,☆☆

Jamie N. Bakkum-Gamez [a,*], Sean C. Dowdy [a], Bijan J. Borah [b], Lindsey R. Haas [b], Andrea Mariani [a], Janice R. Martin [a], Amy L. Weaver [c], Michaela E. McGree [c], William A. Cliby [a], Karl C. Podratz [a]

[a] Division of Gynecologic Surgery, Mayo Clinic, 200 First St SW, Rochester, MN 55905, USA
[b] Division of Health Care Policy and Research, Mayo Clinic, Rochester, MN, USA
[c] Division of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, MN, USA

## HIGHLIGHTS

- MIS approaches decrease the risk of superficial incisional SSI following EC staging.
- Hyperglycemia and smoking are modifiable risk factors that increase organ/space SSI.
- The 30-day costs of SSI are substantial and vary according to SSI type.

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## ABSTRACT

*Objective.* Technological advances in surgical management of endometrial cancer (EC) may allow for novel risk modification in surgical site infection (SSI).

*Methods.* Perioperative variables were abstracted from EC cases surgically staged between January 1, 1999, and December 31, 2008. Primary outcome was SSI, as defined by American College of Surgeons National Surgical Quality Improvement Program. Counseling and global models were built to assess perioperative predictors of superficial incisional SSI and organ/space SSI. Thirty-day cost of SSI was calculated.

*Results.* Among 1369 EC patients, 136 (9.9%) had SSI. In the counseling model, significant predictors of superficial incisional SSI were obesity, American Society of Anesthesiologists (ASA) score >2, preoperative anemia (hematocrit <36%), and laparotomy. In the global model, significant predictors of superficial incisional SSI were obesity, ASA score >2, smoking, laparotomy, and intraoperative transfusion. Counseling model predictors of organ/space SSI were older age, smoking, preoperative glucose >110 mg/dL, and prior methicillin-resistant *Staphylococcus aureus* (MRSA) infection. Global predictors of organ/space SSI were older age, smoking, vascular disease, prior MRSA infection, greater estimated blood loss, and lymphadenectomy or bowel resection. SSI resulted in a $5447 median increase in 30-day cost.

*Conclusions.* Our findings are useful to individualize preoperative risk counseling. Hyperglycemia and smoking are modifiable, and minimally invasive surgical approaches should be the preferred surgical route because they decrease SSI events. Judicious use of lymphadenectomy may decrease SSI. Thirty-day postoperative costs are considerably increased when SSI occurs.



## Introduction

Standard therapy for endometrial cancer (EC) begins with surgery which is essential for treatment, staging, prognostication, and determination of adjuvant treatments [1–3]. Surgical intervention carries with it inherent risks, including surgical site infection (SSI). The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) was developed to harness risk-adjusted perioperative data directly from patient medical charts to determine postoperative complications that are preventable with the goal of improving the quality of surgical care. NSQIP has defined 3 categories of SSI: superficial incisional, deep incisional, and organ/space [4–8] (Box 1). SSI is a

*Abbreviations:* ASA, American Society of Anesthesiologists; BMI, body mass index; EBL, estimated blood loss; EC, endometrial cancer; MIS, minimally invasive surgery; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; PRBCT, packed red blood cell transfusion; SSI, surgical site infection.

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* Corresponding author at: Fax: +1 507 266 9300.
*E-mail address:* bakkum.jamie@mayo.edu (J.N. Bakkum-Gamez).

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**Box 1**
American College of Surgeons National Surgical Quality Improvement Program (NSQIP) surgical site infection (SSI) definitions

Superficial incisional SSI[a]

1) Purulent incisional drainage from above the fascia
2) Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision
3) Pain/tenderness, wound swelling, redness, or heat, and the superficial incision is deliberately opened by the surgeon (unless its culture is negative for organisms)

Deep incisional SSI[b]

1) Purulent drainage from the deep incision
2) Spontaneous dehiscence or deliberate opening of the fascia in the setting of fever or localized pain/tenderness (unless it is culture negative)
3) An abscess is found involving the deep incision through physical examination, reoperation, or radiologic examination

Organ/space SSI

1) Purulent drainage from an intraperitoneal drain
2) Presence of organisms in culture of fluid obtained aseptically from an organ or space
3) Abscess or other infection involving an organ or space on physical examination, reoperation, or histopathologic or radiologic examination

[a]Surgeon diagnosis of any of the 3 types of SSI also meets NSQIP criteria.
[b]Involves deep soft tissues, such as the fascia or muscle layers of the incision.

major contributor to postoperative morbidity and death [9–11]. In fact, more than one-third of postoperative deaths are related, in part, to SSIs [9] and SSIs increase the cost of care. Among colorectal patients, SSI increases the cost of care more than $6000 per patient [12].

Minimally invasive approaches to abdominal and pelvic cancers have emerged and evolved over the past several decades. Laparoscopic colorectal, gastric, prostate, and hepatobiliary surgery have been shown to have lower rates of SSI and other postoperative complications, as well as shorter hospital stays, than open surgery [8,10,13–15]. Among women undergoing hysterectomy for benign indications, minimally invasive approaches decrease the risk of procedure-related complications without increasing the cost of care [16,17]. Laparoscopic staging for EC results in similar intraoperative complication rates and lower rates of overall postoperative complications compared to open staging [18–20]. Length of hospital stay is substantially shorter with laparoscopic staging; the ability to identify metastatic disease appears similar with laparoscopy [11,21], and quality of life is improved among women who undergo minimally invasive EC staging [19,21]. In addition, laparoscopic staging does not appear to adversely affect survival [22].

Our primary objective was to determine perioperative variables associated with the risk of SSI in EC patients, to identify modifiable variables. A counseling model (preoperative variables only) and a global model (preoperative, intraoperative, and postoperative variables) for SSI development were constructed. We also determined the additional 30-day cost to the surgical episode of EC care associated with any SSI and each subtype of SSI that our patients had. Identification of fixed and modifiable variables in the surgical process of care is essential for preoperative patient counseling, risk management, development of preventive strategies, and risk-adjusted reimbursement.

## Methods

### *Patient population and data collection*

All women who underwent surgical staging for EC between January 1, 1999, and December 31, 2008, at Mayo Clinic in Rochester, Minnesota, were eligible for inclusion. In accordance with the Minnesota Statute for Use of Medical Information in Research, women were excluded who did not consent to the use of their medical records for study purposes. To assess the factors influencing the development of SSI within 30 days after surgery, we used the ACS NSQIP platform [23,24] to systematically annotate patient risk factors, process of care variables, and disease-specific parameters. These data were abstracted from the patient records by a dedicated registered nurse (J.R.M.). Each SSI diagnosis was reviewed, confirmed, and classified by a sole surgeon (J.N.B.). NSQIP definitions of superficial incisional SSI, deep incisional SSI, and organ/space SSI were used [6,25]. Mayo Clinic Institutional Review Board approval was secured for this study.

### *Surgical approaches*

Minimally invasive surgery (MIS) was defined as hysterectomy and staging performed through any mode other than laparotomy. Thus, vaginal, laparoscopic, and robotic approaches were all considered MIS. If an MIS case was converted to laparotomy, it was considered staging through laparotomy. Laparoscopic pelvic and para-aortic lymphadenectomy was introduced at Mayo Clinic in Minnesota in April 2005 and robotic staging was initiated in December 2006. Throughout the study period, Mayo Clinic gynecologic oncologists performed vaginal hysterectomy for patients with low-risk EC [1–3] amenable to this approach.

### *Statistical analyses*

All data analyses were performed with SAS version 9.2 (SAS Institute Inc.). Patient- and disease-specific characteristics and process of care variables were summarized using standard descriptive statistics. Comparisons between patients with and without SSI were evaluated with $\chi^2$ or Fisher exact test for categorical variables and with Wilcoxon rank sum test for continuous variables. Counseling models were defined as the multivariate preoperative predictive models for the risk of superficial incisional SSI; the risk of organ/space SSI was developed through inherent patient factors and planned approach to surgical staging. Global predictive models for the risk of superficial incisional SSI and organ/space SSI were also developed including factors considered in the preoperative risk model (except preoperative laboratory values), as well as additional intraoperative factors. Stepwise and backward variable selection methods were used in both model-building processes, and variables with a $P$ value $<.05$ were retained. Associations were summarized with odds ratio (OR) and corresponding 95% CI. Variables with more than 40% missing data were not considered in the final model. Because of limited numbers of deep incisional SSI and combinations of SSI types, predictive models for these SSIs were not generated. To avoid potential confounding, within the superficial incisional SSI analyses, we excluded those cases with deep incisional SSI or a combination of superficial incisional SSI and organ/space SSI in the model building process. Those with pure organ/space SSI were compared to all others (no SSI, superficial incisional SSI, and combination SSIs) in the analyses.

### *Cost analysis*

Cost data for the study patients were captured from the Olmsted County (Minnesota) Healthcare Expenditure and Utilization Database [26]. These claims-based data contain all acute-care medical costs (regardless of payer or plan) for every service and procedure received by patients seen at Mayo Clinic. The database captures information about the use of medical resources, the associated fees, and the