

Factors associated with surgical site infection following abdominal hysterectomy: a five-year cohort study

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ABSTRACT

Background and Objectives: Surgical site infection (SSI) is an important complication following hysterectomy. Given the rising antimicrobial resistance in Iran, this multi-year cohort study aimed to identify independent predictors of SSI after hysterectomy.

Materials and Methods: This retrospective cohort study included patients undergoing total abdominal hysterectomy (2019-2024). Independent risk factors were identified via multivariable binary logistic regression. Model performance was validated using receiver operating characteristic (ROC) curve analysis. Continuous variable cut-off points were determined using the Youden index.

Results: Among 690 patients, the SSI rate was 5.2%. Multivariable analysis identified obesity (BMI ≥ 30 kg/m²) (Adjusted Odds Ratio [aOR]: 4.11; 95% CI: 1.81–9.32; $p < 0.001$) and operative duration (aOR: 1.02 per minute; $p < 0.001$) as the strongest independent predictors. ROC analysis demonstrated excellent discrimination (AUC = 0.88). Infection risk increased critically when surgery exceeded 180 minutes or in obese patients. Preoperative non-standard antibiotic prophylaxis consisting solely of clindamycin was associated with a 7.5-fold increased SSI risk ($P=.006$). Microbiological analysis revealed a 30.6% prevalence of multidrug-resistant and ESBL-producing bacteria.

Conclusion: Obesity and prolonged operative time are independent predictors of SSI. We recommend weight-based dosing, strict intraoperative re-dosing during prolonged procedures, and mandatory antimicrobial stewardship to mitigate risks associated with non-standard prophylaxis.

Keywords: Hysterectomy; Surgical wound infection; Body mass index; Antibiotic prophylaxis; Operative time; Logistic models

INTRODUCTION

Hysterectomy is one of the most frequently performed major gynecological surgical procedures globally, used to manage benign conditions such as leiomyomas, endometriosis, and uterine prolapse,

as well as gynecologic malignancies (1). Despite advancements in surgical techniques and the shift toward minimally invasive approaches, the implementation of laparoscopic hysterectomy remains limited in resource-constrained settings, particularly in teaching hospitals. Surgical site infection remains a

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prevalent and burdensome complication, with reported incidence rates ranging from 2% to 25% depending on the surgical approach and patient population (2).

The development of an SSI following hysterectomy is associated with substantial clinical and economic consequences. It often necessitates prolonged hospitalization, readmission, and re-operation, thereby increasing healthcare costs and significantly impacting patient quality of life (3). Although prophylactic antibiotic administration is the standard of care and has substantially reduced postoperative SSI rates over the past few decades, SSIs continue to occur, underscoring the importance of identifying factors associated with postoperative SSI (4).

Several risk factors, including obesity, diabetes mellitus, and prolonged operative duration, have been associated with SSI following hysterectomy. However, the reported importance of these risk factors has varied across studies, possibly owing to differences in study populations, surgical practices, and perioperative management. Therefore, evaluating these factors in different clinical settings remains important (5).

In addition, increasing antimicrobial resistance underscores the importance of appropriate prophylactic antibiotic selection and continued surveillance of the microbiological characteristics of postoperative infections (6). Evaluating prophylactic antibiotic practices alongside the antimicrobial resistance patterns of SSI pathogens may provide clinically relevant information for infection prevention and antimicrobial stewardship.

Therefore, this retrospective cohort study aimed to identify independent predictors of SSI following total abdominal hysterectomy at our teaching hospital. In addition, it aimed to examine the association between prophylactic antibiotic regimens and SSI and to characterize the antimicrobial resistance patterns of pathogens isolated from postoperative infections.

MATERIALS AND METHODS

Study design and ethical approval. This investigation was conducted as a retrospective cohort study. The study protocol was reviewed and approved by the ethics committee of Shahid Beheshti University of Medical Sciences (Approval ID: [IR.SBMU.RETECH.REC.1404.442]). All patient data were anonymized before analysis, and the requirement for

individual informed consent was waived due to the retrospective nature of the study.

Study population. We reviewed the medical records of all patients who underwent total abdominal hysterectomy between November 2019 and November 2024. Inclusion criteria comprised total abdominal hysterectomies via Pfannenstiel incision. Exclusion criteria included concomitant surgery of non-gynecological organs (e.g., appendix), hospital-acquired infections unrelated to SSI, or antibiotic use for non-surgical infections. Additionally, per departmental guidelines, hysterectomy was contraindicated for patients with fasting blood glucose levels exceeding 180 mg/dL.

Variables and measurements. Following data were extracted from medical records: Age, body mass index (BMI), diabetes mellitus (DM), hypertension (HTN), malignancy, duration of surgery, estimated blood loss, season of surgery, emergency of surgery, pre-operative hemoglobin (measured within 1 week before surgery), post-operative hemoglobin (measured within 24 hours after surgery), previous open abdominal surgery, drain insertion, hospital stay, obstetric history and education.

Additionally, data on the use of immunosuppressive medication within the three months before surgery and the receipt of cytotoxic agents within the six months before surgery were also collected.

Outcome assessment. The primary outcome of the study was the incidence of surgical site infection (SSI) occurring within 30 days post-operation. Diagnosis was based on CDC criteria documented in patient files, including purulent discharge, swelling, erythema, heat, or a positive wound culture. For confirmed cases, microbiological data (culture results) and antibiotic resistance profiles were recorded. In our hospital's laboratory, antimicrobial susceptibility testing and resistance profiles were assessed using the disk diffusion method in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines. Methicillin-resistant *Staphylococcus aureus* (MRSA) was identified using the ceftioxin disk diffusion method, with interpretation based on CLSI criteria.

Statistical analysis. Data analysis was performed using MATLAB R2024b (Version 24.2.0). Continuous variables were presented as mean $\pm$ standard devi-

ation (SD) and compared using the independent t-test. Categorical variables were expressed as frequencies and percentages, with comparisons made using the Chi-square test or Fisher's exact test, as appropriate.

To identify independent predictors of SSI, a multivariable binary logistic regression model was constructed. Variables with a p-value < 0.05 in the univariable analysis, along with clinically relevant confounders, were entered into the model. Results were reported as adjusted odds ratios (aOR) with 95% confidence intervals (CI).

Model performance was evaluated using receiver operating characteristic (ROC) curve analysis, with the area under the curve (AUC) calculated to determine discriminative ability. The Youden index was utilized to identify optimal cut-off points for continuous variables (BMI and surgery duration) that maximized sensitivity and specificity. Multicollinearity between predictors was assessed using a correlation matrix. A p-value of < 0.05 was considered statistically significant.

Multivariable logistic regression was used to adjust for potential confounding among the variables.

Ethical statement. All procedures were performed in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the ethics committee of Shahid Beheshti University of Medical Sciences (Approval ID: [IR.SBMU.RETECH.REC.1404.442]). The committee waived the requirement for individual patient consent for this study due to the retrospective, fully anonymized nature of the data analysis.

RESULTS

Cohort characteristics and univariable associations. A total of 690 patients undergoing abdominal hysterectomy were included in the final analysis. The overall incidence of surgical site infection (SSI) in this cohort was 5.2% (n = 36). The baseline demographic and clinical characteristics of the study population are summarized in Table 1.

In the univariable analysis, infected patients had a significantly higher mean body mass index (BMI) compared to the non-infected group (Mean: 33.5 vs. 29.3, $p < 0.001$) and a longer mean operative duration (203.4 vs. 167.3 minutes, $p < 0.001$). Several comorbidities and surgical variables were initially associat-

ed with an increased risk of infection, including diabetes mellitus ($p = 0.002$), hypertension ($p = 0.003$), and specific antibiotic prophylaxis regimens ($p = 0.001$). While age appeared slightly higher in the infected group (53.6 vs 51.3 years), this difference was not statistically significant ($p = 0.17$).

Independent predictors of surgical site infection.

To control for potential confounders, a multivariable binary logistic regression model was constructed. After adjustment, obesity (BMI) and operative duration emerged as the strongest independent predictors of SSI (Table 2).

Patients categorized as obese had a more than four-fold increase in the odds of developing an infection compared to non-obese patients (adjusted odds ratio [aOR]: 4.11; 95% CI: 1.81–9.32; $p < 0.001$). Similarly, operative duration showed a linear association with infection risk, with the odds increasing by approximately 2% for every additional minute of surgery (aOR: 1.02; $p < 0.001$). To provide a more clinically actionable metric, this translates to an 80% increase in the odds of infection for every 30-minute increase in surgical duration (aOR: 1.80; 95% CI: 1.37–2.37).

The type of preoperative antibiotic prophylaxis remained significantly associated with SSI in the multivariable analysis. Patients who received clindamycin monotherapy had a 7.5-fold higher risk of infection (aOR: 7.52; 95% CI: 1.79–31.69; $p = 0.006$) than those who received cefazolin. The absolute risk of infection was 3.8% for cefazolin versus 21.7% for clindamycin, yielding an absolute risk difference (ARD) of 17.9%. Consequently, the number needed to harm (NNH) was 6, indicating that for every six patients receiving clindamycin monotherapy instead of standard cefazolin, one additional surgical site infection occurred. Regarding preoperative prophylaxis, many records lacked a documented rationale for selecting alternative regimens over cefazolin; however, some instances of clindamycin plus gentamicin or clindamycin monotherapy were attributed to cefazolin unavailability, penicillin allergy, or renal impairment preventing gentamicin administration. Diabetes mellitus, which was significant in the univariable analysis, was no longer statistically significant in the multivariable model (aOR: 2.23; $p = 0.069$), suggesting that its initial association may have been confounded by other factors such as BMI.

To determine the precise surgical duration beyond which infection risk significantly increases, we per-

Table 1. Baseline demographic and clinical characteristics of the study cohort, comparing patients with and without surgical site infection (SSI).

Variable	No Infection (n = 654)	Infection (n = 36)	P-Value
Age (years), Mean $\pm$ SD	51.3 $\pm$ 9.8	53.6 $\pm$ 10.6	0.171
Body Mass Index (Score), Mean $\pm$ SD	29.3 $\pm$ 5.1	33.5 $\pm$ 5.7	< 0.001*
Operative Duration (min), Mean $\pm$ SD	167.3 $\pm$ 52.0	203.4 $\pm$ 55.1	< 0.001*
Hemoglobin (Pre-op), Mean $\pm$ SD	12.4 $\pm$ 1.7	12.2 $\pm$ 1.5	0.559
Diabetes Mellitus (Yes), n (%)	114 (18.0%)	14 (38.9%)	0.002*
Hypertension (Yes), n (%)	200 (31.5%)	20 (55.6%)	0.003*
Immunosuppression (Yes), n (%)	13 (2.0%)	1 (2.8%)	0.765
Chemotherapy (Yes), n (%)	33 (5.2%)	4 (11.1%)	0.13
Surgical Indication (Main Causes), n (%)			0.135
Adnexal mass	189 (29.8%)	10 (27.8%)	
Abnormal uterine bleeding	293 (46.1%)	16 (44.4%)	
Antibiotic Regimen, n (%)			0.001*
Cefazolin	375 (59.4%)	15 (41.7%)	
Cefazolin + erythromycin + metronidazole	172 (27.3%)	11 (30.6%)	
Clindamycin + gentamicin	58 (9.2%)	3 (8.3%)	
Clindamycin	18 (2.9%)	5 (13.9%)	
Other (broad spectrum)	8 (1.3%)	2 (5.6%)	

Table 2. Multivariable logistic regression analysis identifying independent predictors of Surgical site infection following hysterectomy.

Predictor	Adjusted Odds Ratio (aOR)	95% Confidence Interval	P-Value
Age	1	0.95 – 1.05	0.982
Obesity (BMI $\geq$ 30)	4.11	1.77 – 9.54	0.001*
Operative duration (per min)	1.02	1.01 – 1.03	< 0.001*
Diabetes mellitus	2.24	0.92 – 5.44	0.074
Hypertension	1.56	0.61 – 3.97	0.354
Immunosuppression	1.94	0.21 – 17.98	0.559
Chemotherapy	1.68	0.36 – 7.89	0.511
Antibiotic Regimen			
cefazolin	1	—	—
Erythromycin + metronidazole + cefazolin	1.16	0.47 – 2.87	0.754
Clindamycin + gentamycin	0.84	0.18 – 4.03	0.832
clindamycin	7.53	1.76 – 32.25	0.007*
Other (broad spectrum)	1.79	0.11 – 28.86	0.682

† Note: The adjusted odds ratio for surgical approach could not be reliably estimated due to quasi-complete separation in the data (only 1 infected case occurred in the open surgery category).

formed a dual-axis sensitivity-specificity analysis. As shown in Fig. 1, the optimal trade-off point (Youden Index) occurs at approximately 180 minutes. Surgeries extending beyond this threshold enter a high-risk zone in which the probability of infection rises substantially relative to the specificity of standard preventative measures.

Model performance and risk thresholds. The predictive model demonstrated excellent discriminative ability, with an Area under the receiver operating characteristic (ROC) Curve (AUC) of 0.88 (95% CI: 0.76–0.92), indicating high accuracy in distinguishing between infected and non-infected cases (Fig. 2). A multicollinearity assessment confirmed that no

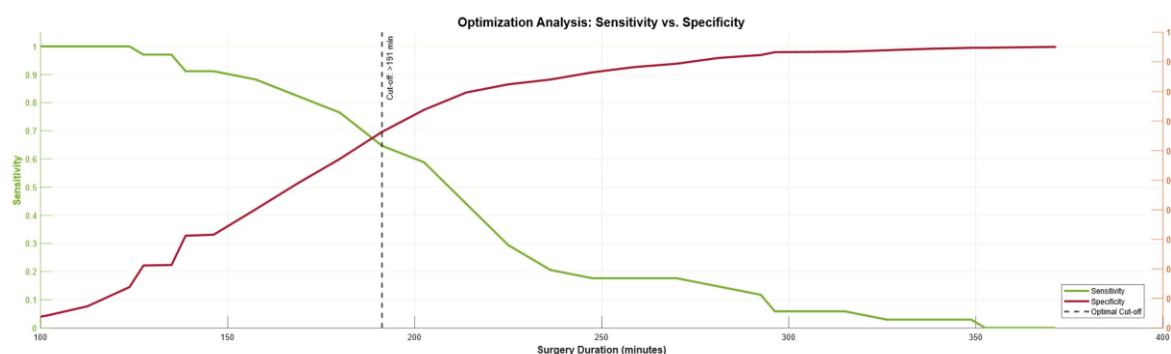


Fig. 1. Optimization of surgical duration threshold. The intersection of sensitivity (green) and specificity (red) identifies >180 minutes as the cut-off point, beyond which the risk of SSI increases significantly.

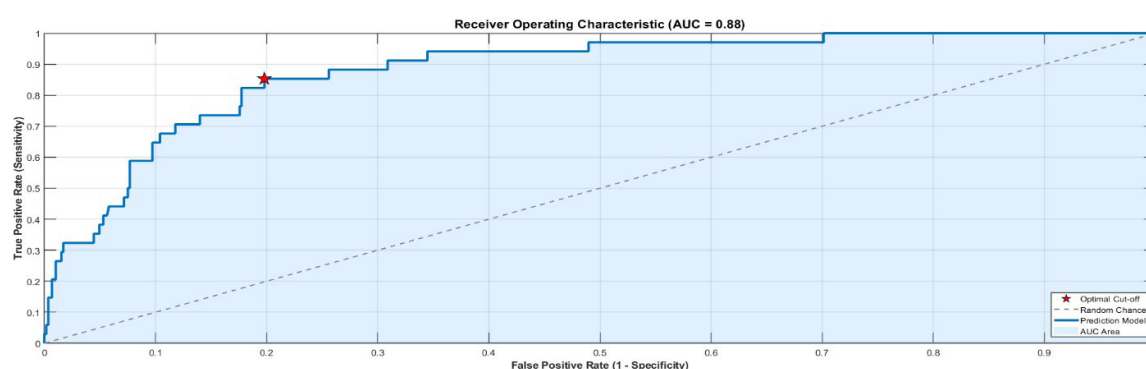


Fig. 2. Receiver Operating Characteristic (ROC) curve for the multivariable prediction model. The Area Under the Curve (AUC) of 0.88 indicates excellent model discrimination.

significant redundancy existed among the predictors (Fig. 3), validating the stability of the regression model.

To provide clinically actionable targets, a Youden index analysis was performed to identify optimal cut-off points. The risk of SSI increased critically when the operative duration exceeded 180 minutes (sensitivity: 73%) and when BMI categories exceeded the threshold for obesity.

Clinical and microbiological profile of infected cases. Detailed clinical and microbiological data were available for the 36 confirmed SSI cases (Table 3). The majority of infections presented symptomatically between postoperative days 9 and 14, with a mean readmission time of 12.4 days. Reoperation (fascial dehiscence repair or debridement) was required in 72% (26/36) of the infected cases.

Microbiological cultures revealed a predominance of *Staphylococcus* species and *Enterococcus faecalis*. There was a 30.6% prevalence of multidrug-resistant organisms (MDROs) among the isolates, in-

cluding methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria (*E. coli*, *Klebsiella pneumoniae*, and *Enterobacter cloacae*). The antibiogram profiles of the most frequently identified isolates are summarized in Table 4.

DISCUSSION

The present study, conducted on a cohort of 690 patients, provides a robust evaluation of the predictors of Surgical site infection (SSI) following hysterectomy. Using a multivariable model adjusted for potential confounders, our results identify Obesity (BMI ≥ 30 kg/m²) and prolonged operative duration as the strongest independent predictors of infection. One of the most notable findings of this study was the association between clindamycin monotherapy and SSI. Patients receiving clindamycin alone had more than sevenfold higher odds of SSI than those receiving cefazolin.

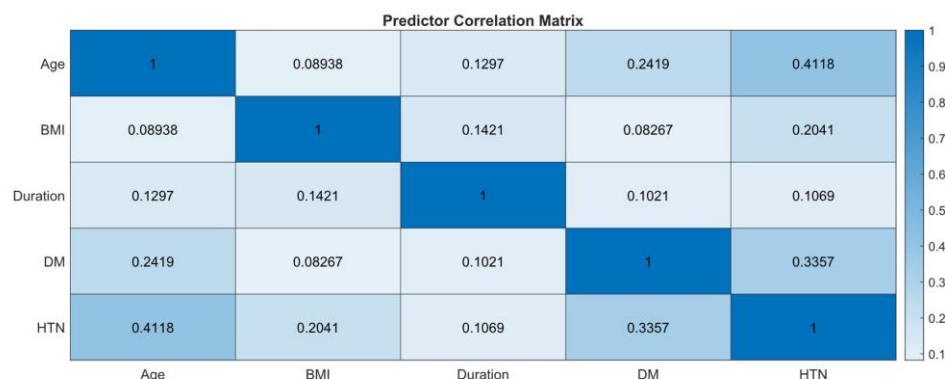


Fig. 3. Correlation matrix heatmap assessing multicollinearity among predictor variables. Low correlation coefficients indicate independence among the model covariates.

Table 3. Clinical characteristics, microbiological isolates, and management outcomes of patients with confirmed surgical site infection.

Characteristic	n (%) or Description
Clinical Presentation	
Superficial infection	28 (77.8%)
Deep infection	8 (22.2%)
Time to Readmission/Diagnosis	Mean: 12.4 days (Range: 5–24 days)
Management	
Re-operation (Debridement/Repair)	26 (72.2%)
Antibiotic Escalation Only	10 (27.8%)
Microbiological Isolates	
<i>Enterococcus faecalis</i>	8 (22.2%)
<i>Staphylococcus aureus</i> (MSSA & MRSA)	MSSA: (n:3(8.3%)), MRSA: (n:4(11.1%))
<i>Staphylococcus epidermidis</i> (MRSE)	4 (11.1%)
<i>E. coli</i> (including ESBL+)	3 (8.3%)
<i>Klebsiella</i> spp.	2 (5.6%)
Polymicrobial / Other	6 (16.7%)
Culture Negative/Not Available	6 (16.7%)

Obesity was the strongest predictor of SSI in our multivariable model, with more than a fourfold increase in the odds of infection. This finding is consistent with previous reports proposing that reduced tissue perfusion, lower oxygen tension, and impaired immune-cell migration in adipose tissue may contribute to impaired wound healing (7).

While diabetes mellitus was a significant predictor in univariable analysis, it lost significance after multivariable adjustment. Given the observational nature of this study, this finding should be interpreted cautiously (8).

While operative time is a known risk factor, clinical guidelines often lack specific thresholds for de-

fining prolonged surgery in gynecology. Our ROC-based analysis identified a threshold of 180 minutes (3 hours). Beyond this threshold, the risk of infection escalates significantly.

Several mechanisms likely contribute to this non-linear risk profile: prolonged exposure of the sterile field to the operating room environment, tissue desiccation, and cellular hypoxia (9). Furthermore, the pharmacokinetics of prophylactic antibiotics must be considered; for surgeries lasting more than three hours, serum concentrations of standard agents often fall below the minimum inhibitory concentration, necessitating intraoperative re-dosing; however, this protocol is frequently overlooked (10).

Table 4. Antibigram patterns of the most frequently isolated bacteria

Organism	Antibiogram pattern
<i>Enterococcus faecalis</i>	
Pattern 1	Sensitive to: Ampicillin, Linezolid, Penicillin, Vancomycin Resistant to: Erythromycin
Pattern 2	Sensitive to: Ampicillin, Penicillin, Vancomycin, Erythromycin Resistant to: ----
<i>Staphylococcus aureus</i> (MRSA)	
Pattern 1	Sensitive to: Linezolid, Tetracycline Resistant to: Ciprofloxacin, Clindamycin, Erythromycin, Gentamicin, Penicillin, Trimethoprim/sulfamethoxazole
Pattern 2	Sensitive to: Linezolid, Gentamicin Resistant to: Trimethoprim/sulfamethoxazole, Tetracycline, Penicillin, Levofloxacin, Erythromycin, Clindamycin, Ciprofloxacin
Pattern 3	Sensitive to: Trimethoprim/sulfamethoxazole, Linezolid, Levofloxacin, Gentamicin Resistant to: Tetracycline, Penicillin, Erythromycin, Clindamycin

An important finding was the significantly higher odds of SSI observed among patients receiving clindamycin monotherapy compared with cefazolin. Although renal impairment or nephrotoxicity concerns were rarely cited as reasons for omitting gentamicin in penicillin-allergic patients, this approach remains clinically suboptimal. Adherence to standardized regimens and more rigorous antimicrobial stewardship are necessary to reduce infection rates and mitigate antimicrobial resistance. Moreover, approximately one-quarter of patients received cefazolin in combination with erythromycin and metronidazole rather than standard cefazolin prophylaxis. This practice appeared to reflect individualized surgical judgment in patients perceived to be at increased risk of bowel injury because of anticipated adhesions or technically challenging procedures rather than documented preoperative infection. Although broader-spectrum prophylaxis may occasionally be justified based on intraoperative risk assessment, our findings underscore the importance of periodically reviewing institutional prescribing practices to ensure consistency with contemporary evidence-based recommendations and antimicrobial stewardship principles.

These findings must be interpreted within the broader context of national healthcare challenges.

Iran currently reports one of the highest rates of antibiotic consumption per capita globally. The widespread availability of antibiotics without prescription and the cultural tendency toward self-medication have accelerated antimicrobial resistance (11).

Strengths and limitations. A primary strength of this study is its ability to identify an association between non-standard prophylactic antibiotic prescribing practices and SSI within routine clinical practice. By identifying these deviations from established guidelines, our findings underscore the urgent need for stricter adherence to antibiotic-prescribing policies and the implementation of mandatory antibiotic stewardship programs in hospital settings. Additionally, the use of Youden Index analysis provides data-driven thresholds that may assist in clinical risk stratification, although these thresholds require validation before widespread clinical implementation.

However, limitations must be acknowledged. As a retrospective single-center study, causality cannot be definitively established. Our results reflect local surgical practices and bacterial ecology, which may limit generalizability to centers with different resistance profiles. Additionally, several unmeasured confounding variables such as uterine weight, preoperative laboratory parameters, and preoperative skin preparation methods (e.g., timing of hair removal) may have influenced the observed outcomes. Furthermore, the multivariable logistic regression model included a relatively large number of predictor variables for the 36 observed SSI events, resulting in a low events-per-variable ratio. This introduces a risk of model overfitting, particularly for categorical variables with sparse data distributions. Finally, the subgroup of patients receiving clindamycin monotherapy was small (n=23), resulting in a wide 95%

confidence interval for its adjusted odds ratio; therefore, these specific findings should be interpreted with caution and validated in larger cohorts.

CONCLUSION

This retrospective analysis identifies Obesity (BMI ≥ 30 kg/m²) and operative duration exceeding 180 minutes as the strongest independent predictors of SSI following hysterectomy. An important finding of this study was the association between clindamycin monotherapy and more than sevenfold higher odds of SSI.

These findings support careful attention to modifiable perioperative factors, including appropriate weight-based antibiotic dosing and adherence to recommended intraoperative re-dosing practices during prolonged procedures.

Despite the limitations of a small sample size, the 30.6% prevalence of resistant isolates among infected patients, coupled with the increased SSI risk associated with non-standard prophylaxis, necessitates more rigorous clinical oversight. These findings support the adoption of stricter antibiotic-prescription policies and mandatory antibiotic stewardship programs to improve surgical outcomes.

REFERENCES

1. Wright MA, Kinlaw AC, McClurg AB, Carey E, Doll KM, Vines AI, et al. Appropriateness of hysterectomy as treatment for benign gynecologicalc. *J Womens Health (Larchmt)* 2024; 33: 1358-1366.
2. Ramesh G, Jaykanthan N, Selvaraj K, Suganya P, et al. Surgical site iInfection after abdominal surgery: distribution and determinants from a cross-sectional Study. *Cureus* 2025; 17(8): e91124.
3. Liu Y, Liu Y, Zhan Y, Wu J, Li J. Risk factors for surgical site infection (SSI) in patients undergoing hysterectomy: a systematic review and meta-analysis. *BMJ Open* 2025; 15(6): e093072.
4. Agyeman WY, Bisht A, Gopinath A, Cheema AH, Chaludiya K, Khalid M, et al. A systematic review of antibiotic resistance trends and treatment options for hospital-acquired multidrug-resistant infections. *Cureus* 2022; 14(10): e29956.
5. Yue Y, Zhao T. Risk factors for surgical site infections after hysterectomy: A systematic review and meta-analysis. *Pak J Med Sci* 2026; 42: 784-795.
6. Bauer H, Marra ES, Rhodes S, Hijaz AK, Hojat LS, Sheyn D. Addition of metronidazole to cefazolin for antibiotic prophylaxis at hysterectomy: a weighted analysis. *Minerva Obstet Gynecol* 2026;78: 20-27.
7. Wu YW, Chen JW, Tsai HY, Huang JH, Chang CC, Chang TT. Inhibition of adipocyte-derived FABP4 reduces adipocyte inflammation, improves angiogenesis, and facilitates wound healing in metabolic dysfunctions. *J Invest Dermatol* 2025; 145: 939-953.
8. Tserenpuntsag B, Haley V, Ann Hazamy P, Eramo A, Knab R, Tsivitis M, et al. Risk factors for surgical site infection after abdominal hysterectomy, New York State, 2015-2018. *Am J Infect Control* 2023; 51: 539-543.
9. Al-Taher M, Felli É, Okamoto N, Rodríguez-Luna MR, Baiocchi A, Noll E, et al. Visualisation and quantification of the effects of surgical humidification on intestinal perfusion and viability in a porcine model. *Sci Rep* 2025; 15: 29892.
10. Hanai Y, Hirai J, Kobayashi M, Matsuo K, Kouzu K, Shinkawa H, et al. Intraoperative redosing of antibiotics for prevention of surgical site infections: A systematic review and meta-analysis. *Ann Gastroenterol Surg* 2024; 9: 369-378.
11. Taghizadeh-Ghehi M, Effatpanah M, Balvardi M, Khalili H. Pattern of antibiotic use over two decades in Iran: a national level assessment based on WHO AWaRe classification from 2000 to 2019. *J Glob Antimicrob Resist* 2024; 39: 30.