

Impact of Clinical Pharmacist Intervention on Perioperative Antimicrobial Prophylaxis in Hysteroscopic Surgery: A Retrospective Study

Xiongbing Sun^{1,2,*}, Xingjiang Niu^{1,2,*}, Ruxue Zhang², Yaguang Hu², Lanlan Li²

¹School of Pharmacy, Gansu University of Chinese Medicine, Lanzhou, Gansu, 730000, People's Republic of China; ²Department of Pharmacy, Gansu Provincial Maternity and Child-Care Hospital (Gansu Provincial Central Hospital), Lanzhou, Gansu, 730050, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yaguang Hu; Lanlan Li, Email huyaguang_hr@126.com; lilanlan2000@yeah.net

Objective: Perioperative prophylactic antimicrobial use for hysteroscopic surgery is suboptimal, even with guidelines and official policies in place. This study aimed to assess the role of clinical pharmacists in the management of perioperative prophylactic antimicrobial therapy in hysteroscopic surgery and to analyze its impact on clinical outcomes and cost-effectiveness.

Methods: This retrospective study reviewed hysteroscopic surgery cases at a tertiary-level Class A hospital from September to December 2022 and September to December 2023. The cases were divided into routine and intervention groups on the basis of the involvement of clinical pharmacists. The primary outcomes assessed included the rational use of antimicrobial drugs, postoperative infections, and economic benefits. To control for confounding factors, a 1:1 propensity score matching method was applied.

Results: A total of 849 patients were included in this study, with 226 patients in each group after propensity score matching. Significant differences were observed between the conventional and intervention groups in several areas: unreasonable timing of preoperative drug administration (22.7% vs 0%, $p < 0.001$), prolonged duration of prophylaxis (32.6% vs 11.5%, $p = 0.029$), unindicated prophylaxis (69% vs 28.8%, $p < 0.001$), and inappropriate dosing regimens (61.5% vs 14.6%, $p < 0.001$). In terms of economic benefits, the intervention group showed a significant reduction in the length of hospitalization (3.15 vs 2.15 days, $p < 0.001$). Additionally, significant differences were found in the costs of patient medications (\$53.17 vs \$42.66, $p < 0.001$) and antimicrobials (\$8.16 vs \$2.18, $p < 0.001$).

Conclusion: Clinical pharmacist interventions can significantly enhance the rational use of perioperative antimicrobial drugs in hysteroscopic surgery, leading to notable clinical outcomes and economic benefits.

Keywords: hysteroscopic surgery, antimicrobial drugs, rational use, clinical pharmacist

Introduction

Hysteroscopy is a diagnostic and minimally invasive reconstructive surgical technique used to treat various lesions in the uterine cavity and cervical canal via the natural vaginal route. Owing to its advantages, including direct visual observation, precise localization, and preservation of organ function, hysteroscopy is considered a “paradigm” for treating uterine cavity diseases.¹ Surgical site infections (SSIs), a type of hospital-acquired infection, are associated with increased morbidity, mortality, healthcare costs, and extended hospital stays. While hysteroscopic surgery is minimally invasive, it remains an invasive procedure with an incidence of SSI of approximately 1%,² making it a common complication in this surgical field.³ Research has demonstrated that strategies such as Intraoperative warming, glycemic control, and nutritional optimization can significantly reduce the incidence of SSIs.⁴ Furthermore, the rational use of antimicrobial drugs during the perioperative period is crucial for infection prevention. This not only reduces postoperative infection rates but also helps mitigate the development of antimicrobial resistance.^{5,6} Antimicrobial resistance poses a global health threat with significant impacts on healthcare systems and economies. The misuse and overuse of antimicrobial drugs remain primary drivers of resistant pathogens.⁷ A retrospective study in the United States

revealed that the rate of antimicrobial medication errors during the perioperative period reached as high as 39%.⁸ A cross-sectional study in the United States revealed that out of 168 hospitalized patients receiving antimicrobial therapy during the perioperative period, 64 were found to have medication errors.⁹ Despite clear recommendations in relevant guidelines, significant gaps persist in the use of perioperative prophylactic antimicrobial drugs in actual clinical settings.¹⁰ Although the international guideline ACOG Practice Bulletin No. 195: Prevention of Postoperative Infection in Gynecologic Surgery does not recommend routine use of antimicrobial drugs for hysteroscopic procedures, the Chinese Clinical Practice Guidelines for Hysteroscopic Diagnosis and Treatment (2023) indicate that prophylactic antimicrobial drugs may be administered to patients with high-risk factors for infection, such as diabetes or vaginitis.^{1,11}

According to the 2023 Evidence-Based Guidelines for Perioperative Infection Prevention and Management, the core of perioperative clinical pharmacist interventions lies in optimizing the indications, timing, and duration of antimicrobial use, thereby promoting the rational use of antimicrobial drugs.¹⁰ A retrospective study revealed that the involvement of clinical pharmacists in antimicrobial prophylaxis was associated with improved clinical outcomes and economic benefits in surgical patients.¹² A meta-analysis conducted in Qatar demonstrated that clinical pharmacist-led antimicrobial stewardship (AMS) effectively improved antimicrobial drug selection, timely administration, shortened therapy duration, and reduced surgical site infections (SSIs).¹³ Data from a tertiary hospital in China further confirmed that clinical pharmacy services significantly improved medication rationality in urology patients reduced adverse reactions and postoperative complications, and showed strong clinical applicability.¹⁴

This study evaluated the impact of clinical pharmacist intervention on the rational use of antimicrobial drugs, clinical outcomes, and economic benefits during the perioperative period of hysteroscopic surgery through retrospective analysis. This research not only emphasized the rational use of antimicrobials but also addressed patient safety and the efficient use of medical resources. By comparing pre- and postintervention data, this study aims to provide a scientific foundation for optimizing perioperative antimicrobial stewardship (AMS) and advancing clinical practice.

Methods

Experimental Design

Patient data were retrieved from the electronic medical records system of a tertiary care hospital. Patients who underwent hysteroscopic surgery at the ambulatory care center between September and December 2022 were assigned to the conventional group, whereas those who underwent surgery between September and December 2023 were assigned to the clinical pharmacist intervention group. In the conventional group, infection risk assessment is conducted by the attending physician. In the intervention group, it is conducted by the clinical pharmacist.

Data were extracted on January 10, 2024, and all patient identifiers were pre-removed to ensure complete anonymity of the data. The hospital ethics committee approved the study and waived informed consent (approval number: 2024 GSFY Ethics Review No. 5).

Study Subjects

The inclusion criteria were as follows: (1) patients who underwent hysteroscopic surgery and (2) complete perioperative antimicrobial drug use records.

The exclusion criteria were as follows: (1) patients who underwent both hysteroscopic and laparoscopic surgery; (2) patients with infectious diseases who received antimicrobial drugs within two weeks the operation; (3) patients with incomplete or missing medical records; and (4) patients who underwent only diagnostic hysteroscopy.

Clinical Pharmacist Intervention

In the conventional group, the perioperative antimicrobial drug regimen for patients undergoing hysteroscopic surgery was formulated by physicians, with the Department of Pharmacy conducting monthly statistics on antimicrobial drug use at the ambulatory care center and incorporating the results into the departmental quality control assessments. In the intervention group, the involvement of the clinical pharmacist was introduced, and routine procedures were performed. Specific measures include (1) the participation of clinical pharmacists in daily doctor rounds; (2) the delivery of lectures

on the rational use of antimicrobial drugs; (3) auditing antimicrobial prescriptions and providing timely feedback on irrational drug use; and (4) tracking infectious complications and readmissions within 6 months postsurgery.

Data Collection

A record form for perioperative antimicrobial drug use in hysteroscopic surgery was designed on the basis of the assessed needs. The form included basic patient information (gender, age, BMI, preoperative complications, allergy history, comorbidities, hospitalization duration, hospitalization costs, drug costs, and antimicrobial drug costs), surgical details (name of surgery, start and end times, intraoperative bleeding, preoperative blood routine, and postoperative temperature for three days), and antimicrobial drug use (drug name, dosage, administration time, duration of use, and prophylactic timing). Data were retrieved from the hospital's electronic medical record system, and antimicrobial drug consumption was calculated via the defined daily doses (DDDs) index in the Anatomical Therapeutic and Chemical (ATC) classification system, as defined by the World Health Organization Collaborating Center for Pharmaceutical Statistics. Data extraction was performed independently by two clinical pharmacists familiar with the intervention.

Observational Indicators and Evaluation Criteria

In accordance with the 2023 edition of the Chinese Clinical Practice Guidelines for Hysteroscopic Diagnosis and Surgery, hysteroscopic surgery is classified as a clean-contaminated procedure. While there is no high-quality evidence supporting the effectiveness of prophylactic antimicrobial use in preventing infections, such use is generally recommended for patients with high-risk factors for infection.¹ ACOG Implementation Bulletin No. 195 identified diabetes mellitus, vaginal infection, BMI ≥ 30 , age ≥ 60 , and malnutrition as high-risk factors for infection following gynecologic surgery.¹¹ According to the 2015 Clinical Application Guidelines for Antimicrobial Agents issued by the National Health Commission [14], the selection of perioperative antimicrobial agents should be based on the type of surgical incision and the potential types of contaminating bacteria. First- and second-generation cephalosporins. Such as cefazolin and cefuroxime, are recommended for obstetric and gynecologic surgeries. For patients allergic to β -lactam antimicrobials, alternatives include clindamycin + aminoglycoside or aminoglycoside + metronidazole. Antimicrobial prophylaxis should be administered 0.5–1 hour before surgery, with an additional dose during surgery if the operation lasts longer than 3 hours or if bleeding exceeds 1500 mL. For clean-contaminated surgeries, antimicrobial administration should not exceed 24 hours.

This study was conducted by clinical pharmacists who have obtained the National Standardized Training Certificate for Clinical Pharmacists in Anti-infective-related Specialties. Acting as antimicrobial stewardship practitioners and advocates, they were responsible for ensuring consistency in study evaluations and promoting rational drug use through interventions such as prescription review, rationality assessment, and feedback.

Statistical Analysis

The sample size of 210 patients (105 per group) was determined via GPower software (version 3.1), with a significance level of $\alpha = 0.05$ and a power of $\beta = 0.05$.

Data analysis was performed via SPSS 26.0 software. Categorical variables, including comorbidities, antimicrobial use, rationality of antimicrobial use, and postoperative complications, were analyzed via the χ^2 -test. Continuous variables, such as age, length of stay, hospitalization cost, antimicrobial cost, and duration of medication, are presented as the mean $\pm$ standard deviation. Appropriate comparisons were made via the Mann–Whitney *U*-test and *t*-test. To control for confounding factors, 1:1 propensity score matching (PSM) with a caliper value of 0.02 was employed. A *p*-value of <0.05 was considered to indicate statistical significance.

Results

Results of Matching Basic Patient Profiles and Propensity Scores

A total of 849 patients were included in the study, with 610 in the conventional group and 239 in the intervention group. After applying 1:1 propensity score matching (PSM), 452 patients (226 per group) were successfully matched. The baseline characteristics of both groups before and after matching are summarized in Table 1. After matching, no

Table 1 Baseline Characteristics Before and After PSM

Group	Prematch		p	Postmatch		p
	Conventional Group (N=239)	Intervention Group (N=610)		Conventional Group (N=226)	Intervention Group (N=226)	
Age (years), mean (SD)	38.81 (10.76)	40.29 (9.78)	0.010	39.00 (10.71)	39.7 (10.94)	0.508
Age ≥60, n (%)	10 (4.2)	20 (3.3)	0.520	9(4.0)	12 (5.3)	0.503
Ethnicity, n(%)						
Han Chinese	229 (95.8)	556 (91.1)	0.020	217 (96)	214 (94.7)	0.503
Tibetan	1(0.4)	18 (3)	0.025	1(0.4)	2 (0.9)	0.562
Hui Chinese dialects	4 (1.7)	21 (3.4)	0.170	4(1.8)	4(1.8)	>0.999
Dongxiang or East village	2 (0.8)	9 (1.5)	0.459	2(0.9)	4(1.8)	0.411
Yao nationality	1 (0.4)		0.110			
Mongols	1 (0.4)	2 (0.3)	0.842	1(0.4)	1(0.4)	>0.999
Manchu	1 (0.4)	1 (0.2)	0.492	1(0.4)	1(0.4)	>0.999
Tujia nationality		1 (0.2)	0.531			
Yi nationality		1 (0.2)	0.531			
The Yugur nationality		1 (0.2)	0.531			
BMI (kg/m ²), mean (SD)	22.32 (3.38)	22.96 (3.48)	0.006	22.37 (3.37)	22.4 (3.54)	0.928
BMI≥30, n(%)	6(2.5)	11 (1.8)	0.508	5 (2.2)	5 (2.2)	>0.999
Preoperative complications, n(%)						
Diabetes	3 (1.3)	5 (0.8)	0.555	2 (0.9)	5 (2.2)	0.253
Hypertension	9(3.8)	17 (2.8)	0.459	9(4)	10 (4.4)	0.815
Anemia	6(2.5)	32 (5.3)	0.082	6 (2.6)	8 (3.5)	0.587
Bacterial vaginosis	34 (14.2)	142 (23.3)	0.003	33 (14.6)	37 (16.4)	0.603
Trichomonas vaginitis		2 (0.3)	0.375			
Vulvovaginal pseudomycosis	8(3.3)	35 (5.7)	0.153	8(3.5)	8(3.5)	>0.999
Aerobic vaginosis	11 (4.6)	65 (10.7)	0.005	10 (4.4)	10 (4.4)	>0.999
Human papillomavirus	5(2.1)	27 (4.4)	0.108	4(1.8)	3(1.3)	0.703
Mycoplasma infections		1(0.2)	0.531			
Cephalosporin allergy	23 (9.6)	15 (2.5)	<0.001	13 (5.7)	12 (5.3)	0.837
Type of surgery, n (%)						
Hysteroscopic removal of foreign body	58 (24.3)	102 (16.7)	0.011	52 (23.0)	57 (25.2)	0.582
Hysteroscopic polypectomy	86 (36)	245 (40.2)	0.261	84 (37.2)	95 (42)	0.290
Hysteroscopic cervical excision	22 (9.2)	82 (13.4)	0.090	21 (9.3)	20 (8.8)	0.870
Hysteroscopic diverticulectomy		2 (0.3)	0.375			
Hysteroscopic diaphragm ectomy	9 (3.8)	16 (2.6)	0.376	9(4)	5 (2.2)	0.277
Hysteroscopic adhesiolysis	15 (6.3)	47 (7.7)	0.472	13 (5.7)	5 (2.2)	0.054
Hysteroscopic repair of cesarean scar diverticulum	16 (6.7)	32 (5.2)	0.411	14 (6.2)	10 (4.4)	0.401
Hysteroscopic myomectomy	31 (13)	80 (13.1)	0.955	31 (13.6)	33 (14.6)	0.787
Hysteroscopic electrocution abortion		3 (0.5)	0.277			
Hysteroscopic tubal ligation	2 (0.8)	1(0.2)	0.137	2(0.9)	1(0.4)	0.562
Intraoperative hemorrhage ≥200 mL, n (%)	3 (1.3)	5 (0.8)	0.555	3(1.3)	4(1.8)	0.703

Abbreviations: BMI, body mass index; SD, standard deviation.

significant differences were observed in age (10.71% vs 10.94%, $p = 0.508$), Han Chinese ethnicity (96% vs 94.7%, $p = 0.503$), Tibetan ethnicity (0.4% vs 0.9%, $p = 0.562$), BMI (3.37% vs 3.54%, $p = 0.928$), bacterial vaginosis (14.6% vs 16.4%, $p = 0.603$), aerobic vaginosis (4.4% vs 4.4%, $p > 0.999$), cephalosporin allergy (5.7% vs 5.3%, $p = 0.837$), or intrauterine foreign body removal (23% vs 25.2%, $p = 0.532$), indicating that the matching process effectively balanced these variables. Additionally, no significant differences were found in other baseline characteristics before and after matching.

Rationality of Antimicrobial Drug Use

After propensity score matching (PSM), the rate of antimicrobial prophylaxis was significantly greater in the conventional group (95.6%) than in the intervention group (42.9%) ($p < 0.001$). The rate of nonindicated antimicrobial drug use was also significantly higher in the conventional group (69%) than in the intervention group (28.8%) ($p < 0.001$). With respect to drug selection, irrational drug selection occurred in 2.2% of the patients in the conventional group, whereas it occurred in 0% of the patients in the intervention group. In both groups, antimicrobial selection predominantly focused on first- and second-generation cephalosporins, specifically cefazolin and cefuroxime, respectively, with the use of other antimicrobials (eg cefoxitin, levofloxacin, and clindamycin phosphate) being less than 15%. Among patients allergic to cephalosporins, clindamycin phosphate (8.8%), cefoxitin (2.6%), and levofloxacin (0.4%) were used in the conventional group, whereas only clindamycin phosphate (8.4%) was used in the intervention group. The rate of irrational cefuroxime dosing was significantly lower in the intervention group (1.8%) than in the conventional group (32.7%) ($p < 0.001$). The timing of preoperative prophylactic dosing was within the recommended range in the intervention group, with 73.6% rationalization in the conventional group. Postoperative antimicrobial administration for more than 24 hours was deemed inappropriate, with an inappropriate rate of 11.5% in the intervention group compared with 32.6% in the conventional group. The irrational drug administration rate in the conventional group was 54.8%, with cefuroxime dosing errors accounting for 33.8%; this rate was significantly lower in the intervention group at 4.8%, with a markedly reduced irrational dosage rate compared with that in the conventional group (Table 2).

Table 2 Comparison of Antimicrobial Use and Rationality Before and After PSM

Group	Prematch		p	Postmatch		p
	Conventional Group (N=239)	Intervention Group (N=610)		Conventional Group (N=226)	Intervention Group (N=226)	
Antimicrobial prophylaxis, n(%)	229 (95.8)	252 (41.3)	<0.001	216 (95.6)	97 (42.9)	<0.001
Medication selection, n (%)						
1st and 2nd generation cephalosporins						
Cefazolin		24 (3.9)	0.002		7(3.1)	0.008
Cefuroxime	193(80.8)	197 (32.3)	<0.001	189 (83.6)	71 (31.4)	<0.001
Other antimicrobials						
Levofloxacin	1(0.4)		0.110	1 (0.4)		0.317
Cefoxitin	6(2.5)		<0.001	6(2.6)		0.014
Clindamycin	29 (12.1)	31 (5.1)	<0.001	20 (8.8)	19 (8.4)	0.867
Unreasonable dosage, n (%)						
Cefuroxime dosage unreasonable	76 (31.8)	14 (2.3)	<0.001	74 (32.7)	4 (1.8)	<0.001
Clindamycin dosage unreasonable	2 (0.8)	7 (1.1)	0.691	2 (0.9)	3(1.3)	0.653
Cefazolin dosage unreasonable		21 (3.4)	0.004		6 (2.6)	0.014
Cefoxitin dosage unreasonable	6(2.5)		<0.001	6(2.6)		0.014
Medication duration,n(%)						
<0.5 h	44 (18.4)		<0.001	40 (17.7)		<0.001
0.5–1 h	176 (73.6)	252 (41.3)	<0.001	167 (73.6)	97 (42.9)	<0.001
>1 h	7(2.9)		<0.001	7 (3.1)		0.008
Postoperative administration	2 (0.8)		0.024	2 (0.9)		0.156
Duration of administration, n (%)						
<24 h	154 (64.4)	174 (28.5)	<0.001	142 (62.6)	71 (31.4)	<0.001
24–48 h	55 (23)	54 (8.9)	<0.001	55 (24.2)	18 (8)	<0.001
>48 h	20 (8.4)	24 (3.9)	0.009	19 (8.4)	8(3.5)	0.029
Antibiotic usage rationality, n(%)						
Drug use without indication	166 (69.5)	156 (25.6)	<0.001	156 (69)	65 (28.8)	<0.001
Inadequate dosing regimen	144 (60.3)	99 (16.2)	<0.001	139 (61.5)	33 (14.6)	<0.001

Notes: Irrational dosing regimen: irrational dosing regimen, timing of dosing, dosage, and drug selection.

Table 3 Clinical and Economic Benefits

Group	Prematch		p	Postmatch		p
	Conventional Group (N=239)	Intervention Group (N=610)		Conventional Group (N=226)	Intervention Group (N=226)	
Postoperative status, n (%)	0	1 (0.2)	0.531	0	0	
Postoperative infection	13 (5.4)	11 (1.8)	0.004	13 (5.7)	4 (1.8)	0.026
Postoperative readmission	3.07 (2.6)	2.24 (2.05)	<0.001	3.15 (2.61)	2.15 (2.11)	<0.001
Length of hospitalization (days), mean (SD)	845.36 (419.66)	777.3 (362.28)	0.175	860.53 (422.28)	781.12 (406.02)	0.085
Hospitalization costs (\$), mean (SD)	52.22 (48.46)	42.55 (40.92)	<0.001	53.17 (49.47)	42.66 (43.40)	<0.001
Drug costs (\$), mean (SD)	7.95 (9.85)	2.43 (4.04)	<0.001	8.16 (9.94)	2.18 (3.79)	<0.001
Antimicrobial drug costs (\$), mean (SD)	295.6	264.54		269.43	82.9	
DDD	38.73	13.64		45.67	17.38	
AUD						

Notes: The average exchange rate of the RMB in 2023 is 1\$=7.0467¥, and the average exchange rate of the RMB in 2022 is 1\$=6.7261¥.

Clinical Economic Benefits

After propensity score matching (PSM), an economic benefit analysis revealed that the length of hospitalization (3.15 vs 2.15 days, $p < 0.001$), total drug cost (\$49.47 vs \$43.40, $p < 0.001$), and antimicrobial drug cost (\$9.94 vs \$3.79, $p < 0.001$) were significantly greater in the conventional group than in the intervention group. However, hospitalization costs were lower in the intervention group (\$406.02 vs \$422.28, $p = 0.085$), although this difference was not statistically significant. The defined daily doses (DDDs) (269.43 vs 82.9) and anatomical therapeutic chemical (ATC) units per day (AUD) (45.67 vs 17.38) were also significantly lower in the intervention group than in the conventional group (Table 3).

Discussion

Few studies have explored the impact of clinical pharmacist interventions on the rational use of antimicrobials during the perioperative period of hysteroscopic surgery. This study is the first to evaluate the role of clinical pharmacists in optimizing antimicrobial use during this period. The results demonstrated that clinical pharmacist interventions significantly enhanced the rational use of antimicrobial drugs, leading to improved clinical outcomes and economic benefits for patients.

The rate of prophylactic antimicrobial use was 95.6% in the conventional group and 42.9% in the intervention group, which was a significant difference ($p < 0.001$). Following the intervention, there was a notable improvement in reducing the unindicated use of antimicrobials. This finding aligns with other studies.¹⁵ Confirming that clinical pharmacist interventions are effective in enhancing the rational use of antimicrobials. In terms of drug selection, cefuroxime (83.6%) was predominantly used in the conventional group, while the intervention group also used cefuroxime (31.4%), in addition to cefazolin (3.1%) and cefuroxime (3.1%). The misuse of broad-spectrum antibiotics increases the risk of drug resistance, and targeted medication is more effective in preventing SSIs.¹⁶ The clinical pharmacist intervention successfully reduced cefuroxime use. For patients allergic to cephalosporins, clindamycin phosphate, cefoxitin, and levofloxacin were primarily used in the conventional group. While the use of clindamycin phosphate (8.8% vs 8.4%, $p = 0.867$) and levofloxacin (0.4% vs 0%, $p = 0.317$) did not differ between the two groups, the use of cefoxitin (2.6% vs 0%, $p = 0.014$) was significantly lower in the intervention group. This finding indicates better drug selection in the intervention group.¹⁷ In the conventional group, irrational cefuroxime dosages were noted, but this percentage decreased significantly in the intervention group (32.7% vs 1.8%, $p < 0.001$), reflecting the successful standardization of dosing through pharmacist intervention. The timing of preoperative prophylactic medication and the duration of postoperative medication were more rational in the intervention group. According to the 2015 Edition of the Clinical Application Guidelines for Antimicrobial Agents. The optimal timing for prophylactic medication administration is within 30–60 minutes preoperatively. The intervention group adhered to these guidelines, whereas 21.7% of the conventional group exceeded the recommended range. This highlights the critical role of clinical pharmacists in ensuring the appropriate timing of medication administration.¹⁸ The rates of unindicated prophylactic medication (69% vs 28.8%, $p < 0.001$) and irrational dosing

regimens (61.5% vs 14.6%, $p < 0.001$) were significantly greater in the conventional group than in the intervention group. The aforementioned issues observed in the conventional group may be attributed to multiple factors. Structurally, there is a lack of clinical pharmacist involvement, prescription review mechanisms, and post-treatment medication feedback systems. Behaviorally, physicians' established prescribing habits influence practice, leading to instances where clinical pathways or treatment guidelines are not strictly adhered to. In contrast, clinical pharmacists in the intervention group successfully reduced the incidence of unindicated and irrational medication use by providing professional pharmacy support, optimizing medication regimens, educating healthcare professionals, and enhancing medication review and feedback.¹⁹ Despite improvements, 28.8% of patients in the intervention group still had unindicated medication use, and 11.5% were prescribed medication for more than 24 hours postoperatively. These findings indicate that further improvements are needed in the rational use of antimicrobials. Clinical pharmacists should continue to monitor postoperative medication more closely, assess whether it aligns with clinical guidelines and the patient's specific condition, and further reduce the use of unindicated drugs. Ongoing standardized training on the rational use of postoperative antimicrobial drugs should be conducted to increase awareness among doctors and nurses.

The economic evaluation revealed that there was one case of infection before propensity score matching (PSM) but no cases of infection in either group after matching. This may be attributed to the small sample size, and future studies with larger samples could provide more reliable data. In terms of postoperative infections, no significant differences were observed between the intervention and conventional groups. The length of hospitalization (3.15 vs 2.15 days, $p < 0.001$), drug costs (\$49.47 vs \$43.40, $p < 0.001$), and antimicrobial costs (\$9.94 vs \$3.79, $p < 0.001$) were significantly lower in the intervention group than in the conventional group. This suggests that clinical pharmacists, by assisting physicians in making therapeutic decisions and optimizing drug selection, can achieve maximum benefit at minimal cost. By correcting irrational medication use, reducing patient length of stay, and improving healthcare resource utilization, clinical pharmacists contribute to better cost efficiency. This finding aligns with those of previous studies.²⁰ The shorter hospitalization duration in the intervention group may be attributed to more standardized postoperative medication management and faster recovery facilitated by clinical pharmacist interventions, rather than infection control measures themselves. Due to the limitations of retrospective studies, the influence of hospital-related policy changes cannot be entirely ruled out. In terms of hospitalization costs, although the intervention group showed a reduction (\$422.28 vs \$406.02, $p = 0.085$), the difference was not statistically significant. This could be because the intervention of the clinical pharmacists focused primarily on optimizing antimicrobial use and did not extend to other aspects of drug therapy. The defined daily doses (DDDs) (82.9 vs 269.43) and antimicrobial utilization density (AUD) (17.38 vs 45.67) were significantly lower in the intervention group than in the conventional group. DDDs and AUD are crucial indicators for evaluating antimicrobial drug use.²¹ The significantly lower antimicrobial DDDs in the intervention group suggest that clinical pharmacist interventions were effective in reducing antimicrobial use, optimizing treatment regimens, controlling antimicrobial resistance, and improving medication safety. Through drug regimen optimization, clinical pharmacists reduce drug costs, improve the rationality of drug therapy, and increase the cost-effectiveness of treatment.

This study has several limitations. First, the sample size was relatively small, and all the data were sourced from a single medical institution, which limits the generalizability of the results and may introduce selection bias. The sample may not be broadly representative of the general population. Additionally, this retrospective study design introduces potential bias from temporal differences between the two groups. Furthermore, the exclusion of patient data with missing records for certain antimicrobial agents may also impact the analysis of results. The observation period was insufficient to assess the long-term effects of antimicrobial use and potential adverse outcomes fully. Despite controlling for some confounding factors, confounders that could influence the results may still be unaccounted for. Therefore, further multicenter, prospective studies are needed to validate our findings.

Conclusion

In summary, clinical pharmacist interventions can effectively improve the rationality of antimicrobial drug use during the perioperative period of hysteroscopic surgery, yielding favorable clinical outcomes and economic benefits. These interventions enhance medication safety for patients and optimize the utilization of healthcare resources. The reduction in hospital stay may be attributed to the systematic optimization of overall medication management under pharmacist

intervention. This study provides important evidence and support for optimizing antimicrobial prophylaxis practices in hysteroscopic surgery.

Data Sharing Statement

The datasets used and analyzed in this study are available from the corresponding authors, Yaguang Hu or Lanlan Li, upon reasonable request.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Gansu Provincial Maternity and Child Health Care Hospital (Gansu Provincial Central Hospital), with approval number: (2024) GSFY Ethics Review No.5. Because this was a retrospective study, the requirement for informed consent was waived by the ethics committee. All patient information was anonymized and kept strictly confidential throughout the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests in this work.

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