



Antibiotic Stewardship in the Preoperative Surgical Setting: Optimizing Prophylaxis to Reduce Antibiotic Use and Surgical Site Infections

Yahya Almarhabi^{1*}

¹Department of Surgery, Faculty of Medicine, King Abdulaziz University, Al Ehtifalat St, 21589 Jeddah, Saudi Arabia

Author Designation: 'Associate Professor

*Corresponding author: Yahya Almarhabi (e-mail: yalmarhabi@kau.edu.sa).

©2025 the Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>)

Abstract Background: Surgical Site Infections (SSIs) are significant postoperative complications, increasing morbidity, mortality and healthcare costs. Antibiotic Stewardship Programs (ASPs) ensure appropriate preoperative antibiotic prophylaxis to prevent SSIs, reduce antimicrobial resistance (AMR) and lower costs. This study evaluates an ASP's impact in a single-center study, comparing extended (Group A) versus single-dose (Group B) prophylaxis to assess antibiotic consumption, SSIs and readmissions. **Methods:** A retrospective chart review (January 2022-December 2024) included 458 patients: Group A (extended prophylaxis, n = 306) and Group B (single-dose prophylaxis, n = 152). Data on demographics, comorbidities, antibiotic regimens (type, duration, Defined Daily Dose (DDD)) and outcomes (SSIs, readmissions) were analyzed using SPSS v25. Chi-square, Fisher's exact and t-tests were applied ($p < 0.05$ significant). This study contributes to regional ASP evidence in the Middle East. **Results:** Groups were comparable demographically ($p > 0.05$). Group B had reduced antibiotic duration (2.51 ± 3.00 vs. 3.18 ± 3.11 days, $p = 0.032$) and DDD (5.46 ± 6.92 vs. 6.73 ± 6.63 , $p = 0.048$). SSI rates were low (0.3% vs. 0% , $p = \text{NA}$), with no readmission differences. Antibiotic use varied by surgery type ($p < 0.001$), with extended prophylaxis common in orthopedic/general surgeries. **Conclusion:** Single-dose prophylaxis via ASPs reduces antibiotic use without increasing SSIs, supporting adoption to curb AMR and costs. Multicenter prospective validation is needed.

Key Words Antibiotic Stewardship, Surgical Site Infections, Preoperative Prophylaxis, Antimicrobial Resistance, Surgical Outcomes, Healthcare Costs

INTRODUCTION

Surgical Site Infections (SSIs) are prevalent healthcare-associated infections, affecting 0.3% of surgical patients globally, leading to prolonged hospital stays, increased mortality and economic burdens [1,2]. In resource-limited settings, SSI rates may exceed 10% [3]. Antibiotic Stewardship Programs (ASPs) optimize preoperative antibiotic use to prevent SSIs, minimize antimicrobial resistance (AMR) and reduce costs [4]. Appropriate prophylaxis, administered within 60 minutes before incision, reduces SSI risk by 30-50% in clean and clean-contaminated surgeries [5,6]. However, prolonged postoperative antibiotic use contributes to AMR, complicating treatments and increasing costs [7]. The World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) report that up to 50% of surgical antibiotic prescriptions may be inappropriate [8,9].

Challenges to ASP implementation include guideline variability, non-compliance and cultural barriers in surgical teams [10]. Inconsistent timing or prolonged prophylaxis increases SSI risk and AMR. In the Middle East, limited data exist on single-dose prophylaxis efficacy, highlighting a research gap [12,13]. This study assesses the effect of an ASP in a single-center setting, comparing extended prophylaxis (Group A) with single-dose prophylaxis (Group B) to evaluate antibiotic use, SSI rates and readmissions.

Objectives

- Evaluate the impact of an ASP on optimizing preoperative antibiotic prophylaxis
- Compare extended versus single-dose prophylaxis in reducing antibiotic consumption (duration, DDD)
- Assess SSI and readmission rates under ASP-guided prophylaxis

METHODS

Study Design and Setting

This retrospective cross-sectional chart review (January 2022–December 2024) at a single-center hospital followed Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [14]. Ethical approval (IRB No. 309-25, approved September 28, 2025) was obtained, with consent waived per the Declaration of Helsinki. Data were anonymized.

Participants and Grouping

Inclusion: Adults (≥ 18 years) undergoing elective/emergency surgeries (general, orthopedic, gynecological, gastrointestinal, head and neck). **Exclusion:** Active infections, immunocompromised states, incomplete records. Sample size ($n = 458$) was calculated for 80% power, $\alpha = 0.05$, to detect SSI differences (effect size 0.3). Patients were grouped: Group A (extended prophylaxis >24 hours, $n = 306$, 2022–2023) and Group B (single-dose preoperative, $n = 152$, 2023–2024). All surgical departments were included. Unequal group sizes resulted from longer pre-ASP data collection and gradual ASP adoption.

Data Collection

Data from electronic records included demographics, comorbidities, surgery type, antibiotic details (agent, dose, timing, duration, DDD) and outcomes (CDC-defined SSIs, readmissions). SSI adjudication was performed by two independent reviewers, with inter-rater reliability ensured via kappa statistics ($\kappa = 0.85$).

Statistical Analysis

Using SPSS v25, qualitative data were reported as frequencies/percentages, quantitative as Mean $\pm$ SD (normality confirmed via Shapiro-Wilk test). Chi-square/Fisher's exact tests assessed associations; t-tests compared means. No statistical comparison for SSI was conducted due to zero events in Group B. The $p < 0.05$ was significant 95% Confidence Intervals (CIs) were calculated for mean differences.

RESULTS

Groups were comparable in demographics and clinical characteristics ($p > 0.05$; Table 1). Mean age was

43.90 $\pm$ 14.90 years, with females comprising 68.3% and obesity present in 40.6% of the cohort. Comorbidities, including hypertension (7.6%) and diabetes (7.2%), showed no intergroup differences (Table 2). General surgery comprised 65.7% of procedures, with 92.6% elective. SSI rates were low (0.3% in Group A, $n = 1$; 0% in Group B, $p = \text{NA}$) and readmissions were rare (0.9% overall, $p = 0.157$; Table 2). Common antibiotics included cefuroxime (45%), ceftriaxone (30%) and cefazolin (20%), with no significant differences in agent selection between groups ($p = 0.312$).

Antibiotic use was significantly reduced in Group B (Table 3). Duration was shorter (2.51 $\pm$ 3.00 vs. 3.18 $\pm$ 3.11 days, $p = 0.032$, 95% CI: 0.06–1.28) and DDD was lower (5.46 $\pm$ 6.92 vs. 6.73 $\pm$ 6.63, $p = 0.048$, 95% CI: 0.01–2.53). Antibiotic patterns varied by surgery type ($p < 0.001$; Table 4), with extended prophylaxis (>24 hours) most common in general surgery (53.4%) and orthopedics (22.1%). Orthopedic surgeries in Group A had longer durations (4.2 $\pm$ 2.8 days) than Group B (1.8 $\pm$ 1.5 days, $p = 0.020$). Gynecological surgeries showed moderate extended use (24.5%).

DISCUSSIONS

This study demonstrates that ASP-guided single-dose prophylaxis (Group B) significantly reduces antibiotic duration and DDD while maintaining low SSI rates, aligning with international guidelines from WHO and CDC [8,9]. Single-dose regimens, administered within 60 minutes before incision, are effective for clean and clean-contaminated surgeries, with systematic reviews confirming no additional benefit from extended prophylaxis [15–17]. This supports the adoption of ASPs to standardize preoperative antibiotic use, reducing unnecessary exposure and mitigating AMR risks.

The reduction in antibiotic duration (2.51 vs. 3.18 days) and DDD (5.46 vs. 6.73) in Group B highlights the ASP's impact on optimizing antibiotic consumption. These findings are consistent with studies reporting 20%–36% reductions in antibiotic use through stewardship, particularly in general and orthopedic surgeries where extended prophylaxis was common (53.4% and 22.1%, respectively) [12,18]. Prolonged use in orthopedics may stem from perceived risks associated with implants, yet evidence supports single-dose cefazolin for most procedures [5,19]. Gynecological

Table 1: Demographic Characteristics of Patients ($n = 458$)

Table 1: Demographic Characteristics of Patients (n = 458)				
Variables	Total (n = 458)	Group A (n = 306)	Group B (n = 152)	p-value
Age (Years)	43.90±14.90	44.33±14.68	45.06±15.03	0.242
Weight (kg)	75.77±17.56	76.19±17.70	74.93±17.30	0.468
Height (cm)	161.37±10.25	161.39±10.19	161.32±10.40	0.942
Gender				
Male	145 (31.7%)	100 (32.7%)	45 (29.6%)	0.505
Female	313 (68.3%)	206 (67.3%)	107 (70.4%)	
BMI				
Underweight	16 (3.5%)	10 (3.3%)	6 (3.9%)	0.799
Normal	128 (27.9%)	82 (26.8%)	46 (30.3%)	
Overweight	128 (27.9%)	89 (29.1%)	39 (25.7%)	
Obese	186 (40.6%)	125 (40.8%)	61 (40.1%)	

Chi-square test for categorical variables; t-test for continuous variables. BMI: Body Mass Index

Table 2: Clinical Features of Patients (n = 458)

Variables	Total (n = 458)	Group A (n = 306)	Group B (n = 152)	p-value
Comorbidities				
None	345 (75.3%)	235 (76.8%)	110 (72.4%)	0.448
Hypertension	35 (7.6%)	24 (7.8%)	11 (7.2%)	
Diabetes Mellitus	33 (7.2%)	17 (5.6%)	16 (10.5%)	
Hypertension, Diabetes & Dyslipidemia	25 (5.5%)	18 (5.9%)	7 (4.6%)	
Hypertension & Diabetes	16 (3.5%)	10 (3.3%)	6 (3.9%)	
Dyslipidemia	4 (0.9%)	2 (0.7%)	2 (1.3%)	
Type of Surgery				
General Surgery	301 (65.7%)	202 (66.0%)	99 (65.1%)	0.198
Gastrointestinal Surgery	4 (0.9%)	4 (1.3%)	0 (0.0%)	
Orthopedic Surgery	56 (12.2%)	41 (13.4%)	15 (9.9%)	
Gynecological Surgery	95 (20.7%)	57 (18.6%)	38 (25.0%)	
Head and Neck Surgery	2 (0.4%)	2 (0.7%)	0 (0.0%)	
Surgical Procedure				
Elective	424 (92.6%)	281 (91.8%)	143 (94.1%)	0.387
Emergency	34 (7.4%)	25 (8.2%)	9 (5.9%)	
Readmission				
Yes	4 (0.9%)	4 (1.3%)	0 (0.0%)	0.157
No	454 (99.1%)	302 (98.7%)	152 (100.0%)	
Infection				
No	454 (99.1%)	302 (98.7%)	152 (100.0%)	0.307
Yes	4 (0.9%)	4 (1.3%)	0 (0.0%)	
Surgical Site Infection				
Non-SSI	3 (0.7%)	3 (1.0%)	0 (0.0%)	NA
SSI	1 (0.2%)	1 (0.3%)	0 (0.0%)	

Chi-square/Fisher's exact test for categorical variables. SSI: Surgical Site Infection

Table 3: Comparison of Antibiotic Use Among Groups (n = 458)

Variables	Group A (n = 306)	Group B (n = 152)	p-value
Duration of Antibiotic (Days)	3.18±3.11	2.51±3.00	0.032
Defined Daily Dose (DDD)	6.73±6.63	5.46±6.92	0.048

T-test for continuous variables. DDD: Defined Daily Dose

Table 4: Association of Antibiotic Use Patterns with Surgery Types (n = 458)

Type of Surgery	Single Dose Before Surgery	Prolonged Within 24 hr Postoperative	>24 hrs Postoperative	Total	p-value
General Surgery	194 (77.0%)	20 (48.8%)	87 (53.4%)	301 (65.7%)	<0.001
Gastrointestinal Surgery	3 (1.2%)	1 (2.4%)	0 (0.0%)	4 (0.9%)	
Orthopedic Surgery	17 (6.7%)	3 (7.3%)	36 (22.1%)	56 (12.2%)	
Gynecological Surgery	39 (15.4%)	16 (39.0%)	40 (24.5%)	95 (20.7%)	
Head and Neck Surgery	0 (0.0%)	1 (2.4%)	1 (0.6%)	2 (0.4%)	
Total	253	41	164	458	

Chi-square test for associations

surgeries showed moderate extended use (24.5%), aligning with recommendations for single-dose ceftriaxone in cesarean sections [20]. The ASP's success in reducing antibiotic use without increasing SSIs (0.3% in Group A, 0% in Group B) underscores its efficacy in high-risk populations, such as patients with diabetes (7.2%) or obesity (40.6%), where tailored dosing and glycemic control were sufficient [11,21,22].

Economically, reduced antibiotic use likely lowers costs, with studies estimating savings of \$732-€247,000 per high-volume procedure [23]. In the Middle East, ASPs align with regional healthcare policies to curb AMR and optimize resources [12]. This study contributes to regional evidence by demonstrating practical ASP implementation in a single-center setting, overcoming barriers like surgeon resistance through education and multidisciplinary collaboration [18]. However, the retrospective design, unequal group sizes (306 vs. 152), lack of direct cost data, missing wound-

classification data and potential under-reporting of minor SSIs limit generalizability. Future multicenter prospective trials, incorporating microbiome and cost-effectiveness analyses, are needed to validate these findings and enhance ASP integration into surgical quality metrics [16,24,25].

Strengths

- Large sample (n = 458)
- Contemporary data (2022-2024)
- Clear pre/post-ASP comparison

CONCLUSIONS

Single-dose prophylaxis via ASPs optimizes antibiotic use, reduces costs and sustains low SSI rates. This single-center retrospective study requires prospective multicenter validation. Surgical departments should integrate ASPs into quality metrics to enhance outcomes and counter AMR.

Limitations

- Single-center retrospective design
- Unequal group sizes (306 vs. 152)
- No direct cost data
- Missing wound-classification data
- Potential under-reporting of minor SSIs

REFERENCES

- [1] Seidelman, J.L. *et al.* "Surgical Site Infection Prevention: A Review." *JAMA*, vol. 329, no. 3, 2023, pp. 244-252. <https://doi.org/10.1001/jama.2022.24075>.
- [2] Negri, G.A. *et al.* "Preoperative Antibiotic Prophylaxis and the Incidence of Surgical Site Infections in Elective Clean Soft Tissue Surgery of the Hand and Upper Limb: A Systematic Review and Meta-Analysis." *Journal of Orthopaedics and Traumatology*, vol. 25, no. 1, 2024, p. 4. <https://doi.org/10.1186/s10195-024-00748-4>.
- [3] Tarchini, G. *et al.* "Antimicrobial Stewardship in Surgery: Challenges and Opportunities." *Clinical Infectious Diseases*, vol. 64, suppl. 2, 2017, pp. S112-S114. <https://doi.org/10.1093/cid/cix087>.
- [4] Bratzler, D.W. *et al.* "Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery." *American Journal of Health-System Pharmacy*, vol. 70, no. 3, 2013, pp. 195-283. <https://doi.org/10.2146/ajhp120568>.
- [5] McGowan, J.E. Jr. "Antibiotic Stewardship: The Role of the Surgeon." *Surgical Infections (Larchmont)*, vol. 20, no. 2, 2019, pp. 89-95. <https://doi.org/10.1089/sur.2018.252>.
- [6] Sarang, B. *et al.* "Implementing Antimicrobial Stewardship to Reduce Surgical Site Infections: Experience and Challenges from Two Tertiary-Care Hospitals in Mumbai, India." *Journal of Global Antimicrobial Resistance*, vol. 20, 2020, pp. 105-109. <https://doi.org/10.1016/j.jgar.2019.08.001>.
- [7] de Jonge, S.W. *et al.* "Timing of Preoperative Antibiotic Prophylaxis in 54,552 Patients and the Risk of Surgical Site Infection: A Systematic Review and Meta-Analysis." *Medicine (Baltimore)*, vol. 96, no. 29, 2017, e6903. <https://doi.org/10.1097/MD.0000000000006903>.
- [8] Centers for Disease Control and Prevention. *Surgical Site Infection Event (SSI)*. 2025. <https://www.cdc.gov/nhsn/pdfs/pscremanual/9pscscscurrent.pdf>.
- [9] Berrios-Torres, S.I. *et al.* "Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017." *JAMA Surgery*, vol. 152, no. 8, 2017, pp. 784-791. <https://doi.org/10.1001/jamasurg.2017.0905>.
- [10] Holmes, A.H. *et al.* "Antimicrobial Stewardship in Surgery." *Antimicrobial Stewardship*, Springer, 2024, pp. 123-140. https://doi.org/10.1007/978-3-031-60462-1_7.
- [11] Turrentine, F.E. *et al.* "Factors Associated with Surgical Site Infection Risk among Patients Undergoing General Surgery." *American Surgeon*, vol. 85, no. 8, 2019, pp. 832-838. <https://doi.org/10.1177/000313481908500824>.
- [12] Alghamdi, S. *et al.* "Synthesizing Evidence to Guide the Design and Implementation of Antimicrobial Stewardship." *Systematic Reviews*, vol. 13, no. 1, 2024, p. 45. <https://doi.org/10.1186/s13643-024-02456-7>.
- [13] Alshammari, E. *et al.* "Surgical Site Infection and Antimicrobial Prophylaxis Prescribing Regimen." *Scientific Reports*, vol. 13, 2023, p. 14709.
- [14] von Elm, E. *et al.* "The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for Reporting Observational Studies." *The Lancet*, vol. 370, no. 9596, 2007, pp. 1453-1457. [https://doi.org/10.1016/S0140-6736\(07\)61602-X](https://doi.org/10.1016/S0140-6736(07)61602-X).
- [15] Calderwood, M.S. *et al.* "Strategies to Prevent Surgical Site Infections in Acute-Care Hospitals: 2022 Update." *Infection Control & Hospital Epidemiology*, vol. 44, no. 5, 2023, pp. 695-720. <https://doi.org/10.1017/ice.2022.304>.
- [16] Nathwani, D. *et al.* "Assessing Antibiotic Stewardship Using the Surgical Site Infection Prevention Bundle." *British Journal of Hospital Medicine (London)*, vol. 79, no. 11, 2018, pp. 643-647. <https://doi.org/10.12968/hmed.2018.79.11.643>.
- [17] Purba, A.K.R. *et al.* "Prevention of Surgical Site Infections: A Systematic Review of Cost Analyses." *Frontiers in Pharmacology*, vol. 9, 2018, p. 776. <https://doi.org/10.3389/fphar.2018.00776>.
- [18] Calderwood, M.S. *et al.* "Antibiotics Should Be Halted upon Closure of Incisions." *Infection Control & Hospital Epidemiology*, vol. 44, no. 5, 2023, pp. 753-757. <https://doi.org/10.1017/ice.2022.312>.
- [19] Li, G. *et al.* "Important Issues on the Prevention of Surgical Site Infections and the Role of Prophylactic Antibiotics." *World Journal of Gastrointestinal Surgery*, vol. 17, no. 4, 2025, p. 102144. <https://doi.org/10.4240/wjgs.v17.i4.102144>.
- [20] Teoh, L. *et al.* "Impact of Antimicrobial Stewardship Interventions on Post-Elective Lower Segment Caesarean Section Antibiotic Prophylaxis Use." *Proceedings of Singapore Healthcare*, vol. 34, 2025, p. 1318754. <https://doi.org/10.1177/20101058241287540>.
- [21] Dhole, S. *et al.* "Antibiotic Prophylaxis in Surgery: Current Insights and Future Directions for Surgical Site Infection Prevention." *Cureus*, vol. 15, no. 10, 2023, e47858. <https://doi.org/10.7759/cureus.47858>.
- [22] Steinberg, J.P. *et al.* "Timing of Preoperative Surgical Antibiotic Prophylaxis after Primary One- to Three-Level Lumbar Fusion." *World Neurosurgery*, vol. 152, 2021, pp. e661-e676. <https://doi.org/10.1016/j.wneu.2021.06.012>.
- [23] Long, D.R. *et al.* "Contribution of the Patient Microbiome to Surgical Site Infection and Antibiotic Prophylaxis Failure in Spine Surgery." *Science Translational Medicine*, vol. 16, no. 742, 2024, eadk8222. <https://doi.org/10.1126/scitranslmed.adk8222>.
- [24] Tiri, B. *et al.* "Antibiotic Stewardship in Surgical Departments." *Antibiotics (Basel)*, vol. 13, no. 4, 2024, p. 329. <https://doi.org/10.3390/antibiotics13040329>.
- [25] Rezaei, A.R. *et al.* "Surgical Site Infections: A Comprehensive Review." *Journal of Trauma and Injury*, vol. 37, no. 2, 2024, pp. 85-95. <https://doi.org/10.20408/jti.2023.0072>.