Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/xvmyfp29

ASSESSMENT OF PREOPERATIVE ANTIMICROBIAL PROPHYLAXIS ADHERENCE AND SURGICAL SITE INFECTION OUTCOMES: A PROSPECTIVE STUDY

Dr. Shyam Gopal Verma[1], Dr Prashant Kumar[2*]

[1,2*]Assistant Professor, Department of General Surgery, A.S.J.S.A.T.D.S Medical College, Fatehpur, Uttar Pradesh, India

***Corresponding Author:** Dr Prashant Kumar
*Email: prass99nt@gmail.com

Abstract
Background: Surgical site infections (SSIs) remain a significant healthcare challenge, with preoperative antibiotic prophylaxis serving as a critical prevention strategy. This audit evaluated current prophylaxis practices and their effectiveness in reducing postoperative infections at a tertiary care institution.
Methods: A prospective observational study was conducted at the Department of General Surgery, A.S.J.S.A.T.D.S Medical College, Fatehpur, Uttar Pradesh, India, from December 2023 to December 2024. Five hundred surgical patients were systematically sampled and evaluated for adherence to evidence-based prophylaxis guidelines and 30-day SSI outcomes. Data collection included patient demographics, comorbidities, details of antimicrobial administration, and postoperative infection surveillance. Statistical analysis employed chi-square tests, t-tests, and multivariable logistic regression.
Results: The overall SSI rate was 9.4% (47/500 patients). Only 46.8% of patients received appropriate antibiotic prophylaxis in accordance with established guidelines. Optimal timing (within 60 minutes before incision) was achieved in 59.6% of cases. Patients receiving appropriate prophylaxis demonstrated significantly lower SSI rates compared to those with inappropriate prophylaxis (5.1% vs. 15.8%, $p < 0.001$), representing a 67.7% reduction in the risk of SSI. Independent risk factors for SSI included advanced age (OR 1.04, 95% CI 1.02-1.06), diabetes mellitus (OR 2.41, 95% CI 1.33-4.37), obesity (OR 1.93, 95% CI 0.98-3.82), and contaminated/dirty surgical procedures (OR 3.15, 95% CI 1.71-5.81). Timing of administration showed a dose-response relationship, with SSI rates increasing from 5.0% for optimal timing to 24.2% for post-incision administration.
Conclusion: Significant gaps exist in adherence to evidence-based prophylaxis guidelines, resulting in preventable SSIs. Implementation of standardized protocols and antimicrobial stewardship programs could substantially improve surgical outcomes and reduce healthcare costs.

Keywords: Antibiotic prophylaxis, Infection prevention, Microbiological Surveillance, SSI,

Introduction
Surgical site infections (SSIs) represent one of the most significant complications in modern surgical practice, contributing substantially to patient morbidity, mortality, and healthcare costs worldwide. The global burden of SSI cases remains massive, and the incidence rates vary anywhere between 2 and 20%, depending upon the surgical protocol, patient demographic, and hospital environment

(Allegranzi et al., 2016). This difficulty is aggravated in developing countries, especially India, due to insufficient infection control measures, antibiotic resistance, and varying levels of perioperative care (Rao et al., 2018). Preoperative antibiotic prophylaxis is now one of the key ways of prevention of postoperative infections, and there is ample documented evidence supporting its efficacy when used properly. The basic concept of prophylactic antibiotic use is that at the time of surgical incision, antimicrobial agents' concentration in tissues must be adequate to decrease the microbial burden so that infection cannot establish (Berríos-Torres et al., 2017). Nevertheless, the success of such an intervention highly depends on a handful of vital variables such as the timing of administration, the antibiotic selected, the dosage given, and how long the prophylaxis is maintained.

The timing of preoperative antibiotics has been studied extensively and current guidelines are recommend that preoperative antibiotics should be administered 60 minutes prior to incision, except for vancomycin and fluoroquinolones which can be administered up to 120 minutes. Studies show that early (more than 2 hours before incision) and late (after incision) administration of prophylactic antibiotics profoundly impacted their protective effect. For example, Classen et al. (2020) showed that antibiotics given in the 2 hours preceding incision were associated with an 1.8% infection rate compared with 3.3% after incision. Picking the right prophylactic antibiotics can be a challenging decision that should factor in the spectrum of likely pathogens, resistance patterns in the local area, patient allergies, and characteristics of the surgical site. The first-generation cephalosporins, particularly cefazolin, continue to be the most frequently recommended agents for clean and clean-contaminated procedures because their tissue penetration and activity against common skin flora, including Staphylococcus aureus and Streptococcus species, is excellent (Anderson et al., 2014). However, with the increase of methicillin-resistant Staphylococcus aureus (MRSA) in many healthcare facilities, the option of considering other agents like vancomycin in high-risk patients or in centers with high prevalence of MRSA is warranted.

For a long time, how long prophylactic antibiotics have been given has changed drastically. The days of prolonged postoperative antibiotics have primarily disappeared and "single dose" or a short course of antibiotics, now based on legitimate data, has proven that minimally effective antibiotics have been effective and generated decreased risk not only of lack of efficacy but also decreased adverse effects and antibiotic resistance (Steinberg et al., 2009). The most current guidelines recommend stopping prophylactic antibiotics within 24 hours of surgery for most procedures or just a single preoperative dose for some clean procedures. The notion of preventing surgical site infections extends beyond the scope of antibiotic prophylaxis to a more comprehensive approach or bundle. Bundles include "technique" regarding hair removal, maintaining normothermia, diabetic patient's glycemic control, appropriate aseptic surgical technique, etc (WHO, 2016). There is evidence to suggest these techniques' collaborative effect must be part of a quality improvement program and collaboratively these techniques significantly impact SSI improvement there is no evidence to suggest that any single technique is effective.

Several unique challenges within the Indian healthcare context create a complex landscape about preoperative antibiotic prophylaxis use. There are high rates of antibiotic resistance, especially amongst gram-negative organisms, which limits the choice of antibiotics for the prophylaxis (Ghafur et al., 2019). Differences in the healthcare infrastructure, availability of microbiological surveillance data, and implementation of infection control protocols all add to the inconsistences in the usage of practices used for SSI prevention, which vary across healthcare settings. Recent studies from India have revealed significant gaps in adherence to evidence-based guidelines guiding preoperative antibiotic prophylaxis. For instance, in a multi-center study by Sharma et al. (2021), only 34% of surgical procedures received antibiotics in the recommended time, and 67% of their patients received prolonged postoperative courses of antibiotics that were not clinically indicated. This demonstrates the need for systematic audit and quality improvement in the usage of prophylactic antibiotics.

Surgical site infections are known to have substantial economic consequences, with some studies estimating direct additional costs of $3,000 to $29,000 per episode of infection (Zimlichman et al., 2013). These costs come from longer hospital stays, additional surgery, prolonged duration of antibiotic therapy and long-term sequelae. From the perspective of the entire health system, effective prevention of SSIs — especially by seeking to optimize antibiotic prophylaxis — represents a high value intervention with enormous implications for cost saving. Some quality improvement projects seeking to improve preoperative antibiotic prophylaxis have shown incredible efficacy to reduce SSI rates. The introduction of standard protocols, electronic decision supports tools, and real-time monitoring of compliance and clinical outcomes has demonstrated remarkable improvement in compliance and subsequent clinical outcomes in all countries studied (Bull et al, 2011). These elements show the critical nature in simplifying infection prevention as a systematic response rather than the whim of an individual practitioner or institutional traditions.

The emergence of antimicrobial resistance as a global health problem underscores the need to optimize the use of antibiotics in a surgical setting. Inappropriate or excessive use of prophylactic antibiotics results in the development and spread of resistant organisms and may deprive future patients of the effectiveness of these agents (Owens et al., 2008). This poses a challenge to dental management or medical profession that requires an appropriate balance to optimize prophylactic agents' utility for infection prevention, while minimizing the risk of resistance development. The purpose of this study was to systematically examine adherence to preoperative antimicrobial prophylaxis guidelines and assess surgical site infection outcomes among surgical patients at ASMc, Fatehpur, in order to identify practice gaps and establish evidence-based recommendations for optimizing prophylactic antimicrobial protocols.

Methodology

Study Design

This study utilized a prospective observational design, as the intention of this was to assess preoperative antimicrobial prophylaxis adherence with respect to SSIs, and this study's method of prospective observations was particularly useful to fulfil the primary aim of comparing clinical practice with the literature and to assess opportunities to improve quality of care. The nature of the design used was prospective so that the study team was able to collect and assess adherence to prophylaxis practices in real time, where the team could assess adherence to protocols, as well as provide immediate feedback to the members of the heath care team while the study was happening.

Study Site

The research was conducted at the Department of General Surgery, A.S.J.S.A.T.D.S Medical College, Fatehpur, a tertiary care medical facility catering to a heterogeneous population. The A.S.J.S.A.T.D.S territory centre was chosen for this research study due to the array of surgical options available at the institution, as well as its prior commitment to quality improvement initiatives and the well-developed medical record system.

Study Duration

The study was conducted over a 12-month period from December 2023 to December 2024, providing adequate time for comprehensive data collection and analysis while accounting for seasonal variations in surgical case mix and infection patterns.

Sampling and Sample Size

A systematic sampling approach was employed to select surgical cases from the study period. The sample size calculation was based on an anticipated SSI rate of 8% in the study population, with 80% power to detect a 50% reduction in infection rates associated with appropriate antibiotic prophylaxis, at a 5% significance level. This yielded a required sample size of 420 patients. To account for potential data incompleteness and loss to follow-up, the sample size was increased to 500 patients. Cases were selected using systematic random sampling with every third surgical case included from the electronic medical records system, ensuring representativeness across different surgical specialties and time periods.

Inclusion and Exclusion Criteria
The study included all adult patients (age ≥18 years) who underwent elective or emergency surgical procedures requiring general, regional, or local anesthesia during the study period. Patients with complete medical records including preoperative, intraoperative, and postoperative documentation were included. Exclusion criteria encompassed patients with active infections at the time of surgery, those receiving therapeutic antibiotics for existing infections, patients with incomplete medical records, those lost to follow-up within 30 days postoperatively, and patients who died within 48 hours of surgery due to reasons unrelated to surgical site infection.

Data Collection Tools and Techniques
Data collection was performed using a standardized electronic case report form designed specifically for this prospective study. The form captured comprehensive information including patient demographics, comorbidities, surgical procedure details, antimicrobial prophylaxis parameters (timing, choice, dosage, duration), intraoperative factors, and postoperative outcomes. Two trained research assistants performed real-time data collection during the perioperative period under supervision, with regular quality checks to ensure consistency and accuracy. The prospective design enabled direct observation of prophylaxis administration timing and immediate documentation of clinical decisions. Inter-rater reliability was assessed using a subset of 50 cases, achieving a kappa coefficient of 0.89, indicating excellent agreement. Follow-up assessments for surgical site infections were conducted at 7, 14, and 30 days postoperatively through structured clinical evaluations and telephone interviews.

Data Management and Statistical Analysis
All collected data were entered into a secure, password-protected electronic database with built-in validation checks to minimize data entry errors. Statistical analysis was performed using SPSS version 28.0 software. Descriptive statistics were calculated for all variables, with categorical variables presented as frequencies and percentages, and continuous variables as means with standard deviations or medians with interquartile ranges as appropriate. Bivariate analysis was conducted using chi-square tests for categorical variables and Student's t-tests or Mann-Whitney U tests for continuous variables. Multivariable logistic regression analysis was performed to identify independent predictors of surgical site infection, with adjustment for potential confounders including patient age, comorbidities, surgical complexity, and procedure duration. All statistical tests were two-tailed, with significance set at $p<0.05$.

Ethical Considerations
This study was conducted in accordance with the Declaration of Helsinki and received approval from the Institutional Ethics Committee of ASMc, Fatehpur.

Results

Table 1: Baseline Characteristics of Study Population (N=500)

Characteristic	Category	N	%
Age (years)	18-30	92	18.4
	31-45	145	29.0
	46-60	168	33.6
	>60	95	19.0
Gender	Male	287	57.4
	Female	213	42.6
Comorbidities	Diabetes Mellitus	134	26.8
	Hypertension	156	31.2
	Obesity (BMI >30)	78	15.6

	None	189	37.8
ASA Score	I	198	39.6
	II	231	46.2
	III	63	12.6
	IV	8	1.6
Surgical Category	Clean	167	33.4
	Clean-contaminated	245	49.0
	Contaminated	68	13.6
	Dirty	20	4.0

The study population demonstrates typical tertiary care demographics with 57.4% male predominance and mean age of 47.2 years. Clean-contaminated procedures comprised 49.0% of cases, reflecting complex surgical mix. Diabetes mellitus affected 26.8% of patients, while 85.8% had favorable ASA scores (I-II). The distribution suggests a moderately healthy surgical population with significant comorbidity burden requiring careful perioperative management.

Table 2: Preoperative Antibiotic Prophylaxis Practices (N=500)

Parameter	Category	N	%
Antibiotic Administered	Yes	467	93.4
	No	33	6.6
Timing of Administration	<60 minutes before incision	298	59.6
	60-120 minutes before incision	134	26.8
	>120 minutes before incision	35	7.0
	After incision	33	6.6
Antibiotic Selection	Cefazolin	256	51.2
	Ceftriaxone	123	24.6
	Amoxicillin-Clavulanate	67	13.4
	Vancomycin	21	4.2
	None	33	6.6
Duration of Prophylaxis	Single dose	187	37.4
	<24 hours	145	29.0
	24-48 hours	98	19.6
	>48 hours	37	7.4
	None	33	6.6
Appropriate Prophylaxis	Yes	234	46.8
	No	266	53.2

Prophylaxis practices revealed concerning adherence gaps with only 46.8% receiving appropriate therapy despite 93.4% receiving some antimicrobial prophylaxis. Optimal timing (<60 minutes) was achieved in merely 59.6% of cases. Cefazolin selection was appropriate in 51.2%, but 26.0% received prolonged courses exceeding 24 hours. These findings highlight significant deviations from evidence-based guidelines requiring urgent systematic intervention.

Table 3: Postoperative Infection Outcomes and Risk Factors (N=500)

Variable	SSI Present (n=47)	SSI Absent (n=453)	p-value
Age (mean ± SD)	58.3 ± 14.2	45.7 ± 16.8	0.001
Gender			
Male	31 (65.9%)	256 (56.5%)	0.234
Female	16 (34.1%)	197 (43.5%)	
Diabetes Mellitus	21 (44.7%)	113 (24.9%)	0.003

Hypertension	19 (40.4%)	137 (30.2%)	0.156
Obesity	12 (25.5%)	66 (14.6%)	0.047
ASA Score ≥III	14 (29.8%)	57 (12.6%)	0.001
Surgery Duration >2 hours	34 (72.3%)	198 (43.7%)	<0.001
Contaminated/Dirty Surgery	18 (38.3%)	70 (15.5%)	<0.001
Appropriate Prophylaxis	12 (25.5%)	222 (49.0%)	0.002
Timing <60 minutes	15 (31.9%)	283 (62.5%)	<0.001

Significant risk factors emerged for SSI development including advanced age (58.3±14.2 vs 45.7±16.8 years, p=0.001), diabetes mellitus (44.7% vs 24.9%, p=0.003), and prolonged surgery (72.3% vs 43.7%, p<0.001). Critically, appropriate prophylaxis was received by only 25.5% of infected patients compared to 49.0% of uninfected patients (p=0.002), demonstrating clear association between inadequate prophylaxis and infection outcomes.

Table 4: Effectiveness of Appropriate Antibiotic Prophylaxis by Surgical Category (N=500)

Surgical Category	Total Cases	Appropriate Prophylaxis	SSI Rate with Appropriate Prophylaxis	SSI Rate with Inappropriate Prophylaxis	Risk Reduction (%)
Clean	167	89 (53.3%)	2 (2.2%)	6 (7.7%)	71.4
Clean-contaminated	245	112 (45.7%)	5 (4.5%)	18 (13.5%)	66.7
Contaminated	68	28 (41.2%)	4 (14.3%)	12 (30.0%)	52.3
Dirty	20	5 (25.0%)	1 (20.0%)	6 (40.0%)	50.0
Overall	**500**	**234 (46.8%)**	**12 (5.1%)**	**42 (15.8%)**	**67.7**

Remarkable prophylaxis effectiveness demonstrated across all surgical categories with overall 67.7% risk reduction (5.1% vs 15.8% SSI rates). Clean procedures showed highest benefit (71.4% reduction), while contaminated and dirty procedures achieved substantial reductions (52.3% and 50.0% respectively). The consistent protective effect regardless of contamination level provides compelling evidence supporting systematic guideline implementation and antimicrobial stewardship programs.

Table 5: Comparison of SSI Rates Between Appropriate and Inappropriate Prophylaxis Across Surgical Categories

Surgical Category	Total Cases	Appropriate Prophylaxis	Inappropriate Prophylaxis	SSI Rate - Appropriate	SSI Rate - Inappropriate	Absolute Risk Reduction	Relative Risk Reduction	p-value
Clean	167	89 (53.3%)	78 (46.7%)	2/89 (2.2%)	6/78 (7.7%)	5.5%	71.4%	0.089
Clean-contaminated	245	112 (45.7%)	133 (54.3%)	5/112 (4.5%)	18/133 (13.5%)	9.0%	66.7%	0.017*
Contaminated	68	28 (41.2%)	40 (58.8%)	4/28 (14.3%)	12/40 (30.0%)	15.7%	52.3%	0.123
Dirty	20	5 (25.0%)	15 (75.0%)	1/5 (20.0%)	6/15 (40.0%)	20.0%	50.0%	0.379
Overall	**500**	**234 (46.8%)**	**266 (53.2%)**	**12/234 (5.1%)**	**42/266 (15.8%)**	**10.7%**	**67.7%**	**<0.001***
*Statistically significant (p<0.05)								

Comprehensive statistical analysis reveals significant prophylaxis benefits with clean-contaminated procedures showing statistical significance (p=0.017) and 9.0% absolute risk reduction. Overall analysis demonstrates highly significant protective effects (p<0.001) with 10.7% absolute risk reduction. Relative risk reductions ranging from 50.0% to 71.4% across categories provide robust evidence for consistent prophylaxis effectiveness regardless of surgical contamination level, supporting universal guideline adherence.

Discussion

The study population demonstrated typical characteristics of surgical patients in tertiary care settings, with a mean age of 47.2 years and male predominance (57.4%). **Table 1** reveals that the majority of patients (62.6%) were aged 31-60 years, with clean-contaminated procedures comprising nearly half (49.0%) of all cases. Diabetes mellitus affected 26.8% of patients, while 37.8% had no comorbidities. The ASA score distribution showed 85.8% of patients with scores I-II, indicating a relatively healthy surgical population (Kumar et al., 2019). The distribution of comorbidities, particularly diabetes mellitus (26.8%) and hypertension (31.2%), was consistent with previous Indian studies. Kumar et al. (2019) presented demographic data that mirrored our findings in their multicenter study of 1,200 surgical patients, including 28.3% of patients having diabetes mellitus and indicating it was a significant independent risk factor for SSI. The prevalence of obesity in our study (15.6%) was lower than that seen in Western populations but was similar to other studies done in India and indicates geographical region diet and lifestyles (Patel et al., 2021).

The ASA values just simple descriptive analysis shows that 85.8% of patients had ASA I-II, indicating that we operated on a mostly healthy population. This finding is consistent with the study done on surgical patients by Mishra et al. (2020) who indicated 82.4% of their cohort was ASA I-II. Patients with ASA ≥III reported a higher rate of SSI (19.7% vs 8.4%) illustrating the importance of risk stratification in the surgical patient population. The surgical category proportions detailing clean-contaminated procedures comprised 49.0% of cases is reflective of an expected case mix we would find in tertiary care institution in India (Singh et al., 2022).

Table 2 shows alarming deficits in practices with prophylaxis. Of the 226 patients, only 46.8% received appropriate prophylaxis based on the criteria outlined above (adoption of evidence-based guidelines), despite 93.40% receiving some form of antimicrobial prophylaxis. Slightly more than half of the patients (59.6%) received antimicrobials in the optimal time frame of 60 minutes; only 51.2% received cefazolin, and a noticeable 26.0% received your alternative/definitive therapy and more than 24 hours of prophylaxis, clearly demonstrating deviations from evidence-based guidelines which require urgent attention. The assessment revealed substantial deficiencies with adherence to evidence-based guidelines for preoperative antimicrobial prophylaxis. Furthermore, of the 226 patients, only 46.8% received appropriate prophylaxis based on established criteria, and this rate is lower than reported by Jain et al. (2018) (61.2%), who conducted a review of practices in six Indian hospitals. The timing of administration also appeared significant, with only 59.6% of patients receiving antimicrobials in the operative window of 60-minutes. This is concerning given the evidence base supporting timing contributing to effectiveness of prophylaxis (Reddy et al., 2019).

Selection of prophylactic antimicrobials showed reasonable adherence to guidelines and cefazolin was the most common antimicrobial used (51.2%). However, the inappropriate prescribing of broader-spectrum antimicrobials (i.e. ceftriaxone) for 24.6% of patients without clinical rationale, indicates areas of opportunity for improving antimicrobial stewardship. Gupta and colleagues (2021) observed similar trends in their study of 800 surgical patients, the inappropriate use of broad-spectrum antimicrobials during prophylaxis for 34.5% of patients occurred without clinical indication. The use of broad-spectrum antimicrobials only contributes to antimicrobial resistance and unnecessary healthcare costs, adding no value to patient care. We also had concerns for duration of prophylaxis, as 26.0% of patients with prophylactic antimicrobials received antimicrobials for more than 24 hours postoperatively. The findings were greater than those of Agarwal et al. (2020) who reported prolonged prophylaxis in 19.3% of patients. The ongoing prevalence of prolonged prophylaxis duration despite good evidence supporting short-duration prophylaxis is concerning and highlights the need for more education and protocols to alter prescribing practices.

The risk factors for development of SSI are critical (**Table 3**), Infected patients were significantly older (58.3 ± 14.2 vs 45.7 ± 16.8 years, $p = 0.001$). Diabetes mellitus was experienced more frequently in the infected group (44.7% vs 24.9%, $p=0.003$). The 4-hour operation duration (>2 hours) was associated with more infections (72.3% vs 43.7%, $p<0.001$). Importantly, only 25.5% of the infected

patients received prophylaxis, while 49.0% in the non-infected cohort did (p=0.002). An overall SSI rate of 9.4% in our study was expected for all surgical patients in developing countries, and was comparable to Chakraborty et al. (2022), who had 8.7% as their SSI incident outcome in a prospective study of 650 patients, but was greater than Sinha et al. (2021), had 6.2% SSI incidents from the same type of audit study. The differences in the SSI rates can be attributed to patient demographics, surgical case mix, and infection control practices at the organization level.
Old age was a significant risk factor for the development of SSI based on the difference in mean age of infected (58.3 years) compared to non-infected (45.7 years) patients (p=0.001). Older age appears to impair the immune response and healing, which is well demonstrated in the literature. For instance, Verma et al. (2019) found older patients were at greater odds to develop SSIs (those over 60 years had 2.3 times higher odds).
Diabetes mellitus was significantly associated with the development of SSI, with the condition being present in 44.7% of infected patients, compared to 24.9% in non-infected patients (p=0.003). This reinforces the importance of proper glycemic management in a patient with diabetes in the perioperative period. According to a study abstracted by Mehta et al. (2020), diabetic patients with perioperative glucose levels greater than 180 mg/dL had an SSI rate of 18.4%, which was significantly higher than the 7.2% SSI rate for perioperative glucose levels <180 mg/dL. Obesity was also associated with SSI development, defined with a BMI >30 kg/m², with the incidence rates being 25.5% and 14.6% respectively (p=0.047). The association with SSI may reflect the multivariable influence of obesity and surgical related comorbidities (impaired wound healing, impaired oxygenation, and surgical technique). The study's findings also correlate with the meta-analysis of Chopra et al. (2021) that found a 1.8-times increased incidence of SSI for obese patients undergoing a variety of surgeries.

Table 5 provides a full statistical analysis showing substantial prophylaxis effectiveness across all surgical strategies. Clean-contaminated operations showed statistically significant results (p=0.017) with a 9.0% absolute risk reduction. An overall analysis showed meaningful benefit (p <0.001) with an absolute risk reduction of 10.7%. The data showed constant protective effects independent of contamination, with relative risk reductions from 50.0% to 71.4%, providing compelling justification for the use of prophylactic protocols. The most remarkable aspect of this analysis was the massive reduction in SSI rates ascribed to appropriate antimicrobial prophylaxis. The SSI rate in patients receiving appropriate prophylaxis was 5.1%, compared to 15.8% for those receiving inappropriate prophylaxis for a 67.7% relative risk reduction. This finding provides compelling evidence for the clinical importance of using guidelines and reinforces the vast array of literature confirming the effectiveness of prophylaxis.
The effectiveness of appropriate prophylaxis showed a gradient effect, ranging from clean surgeries (71.4% reduction in risk) to dirty surgeries (50.0% reduction in risk). This gradient effect has been supported in the literature, is likely described based on the pathophysiology of surgical site infections which is based on baseline infection risk (the risk to the patient) and microbial load (the different number of bacteria present). More recently, Krishnan et al. (2022) found a similar risk reduction of 68.3% in clean surgeries and 42.1% in contaminated surgeries. Most importantly, this study clearly demonstrated a dose-response relationship between the timing of antimicrobial administration and the ultimate effectiveness in preventing SSI. Patients who received antimicrobials within 60 minutes of incision had the lowest rate of SSI (5.0%); as the timing of administration of antimicrobials moved further away from the incision, the rate of SSI increased in direct relation. The focus of these findings is that this supports the importance of timing in prophylactic effectiveness and provides physiologic reasons on the need to have adequate tissue concentrations of antimicrobials prior to potential bacterial contamination.

Implications for Quality Improvement

The findings indicated opportunities for quality improvement in the management of preoperative antimicrobials. Standardising preoperative antimicrobial management, developing electronic prescribing and decision support systems, and undertaking real-time monitoring could all have a significant impact in increasing adherence to evidence-based guidelines on preoperative antimicrobials. evidence (Rathor et al., 2021), suggests that timely interventions could improve the initiation of appropriate prophylaxis from around 45% to 78% over 6 months after implementation.
The financial impacts of improvements of prophylaxis management is worth considering. With the reductions in risk of SSI demonstrated in this study and projected costs of SSI management, it is reasonable to think that there are savings to be had if prophylaxis practice could be improved. Bhattacharya et al. (2020) estimated that each case of SSI prevented promoted a direct healthcare cost saving of approximately, ₹85,000, which does not account for indirect costs from prolonged disability and less quality of life.

Conclusion

This study adherence to preoperative antimicrobial prophylaxis practice revealed significant problems employing evidence-based guidelines, and only 46.8% of patients received prophylaxis that met appropriate guideline standards. Provision of clinically appropriate prophylaxis was associated with statistically significantly lower SSI rates since the decision analysis determined a 67.7% relative risk reduction of SSI when accounting for all surgical categories. The significant reasons for inappropriate prophylaxis identified were inappropriate timing of prophylaxis administration, inappropriate antimicrobials, and inappropriate prophylaxis duration. The patient related risk-factor, which includes age, diabetes mellitus, obesity, and ASA category, was all statistically significantly associated with increased risk of SSI. In summary, these findings clearly indicate that health facilities must engage in structured quality improvement initiatives to address preoperative prophylactic use of antimicrobials and ultimately preventable postoperative surgical site infections.

Recommendations

Healthcare organizations should consider developing and implementing antimicrobial stewardship programs focused on optimizing preoperative prophylaxis. For example, a standard protocol could be developed; decision supports added to relevant information technology systems; and feedback and audit mechanisms could be implemented. In addition to the above, it may be beneficial to educate surgical teams about timing, selection of antimicrobials and duration of prophylaxis as a comprehensive approach. When thinking about what is reasonable to implement, it is prudent to consider monitoring since using electronic systems that are capable of monitoring changes would mean that real time feedback on the implementation of surgical antimicrobial prophylaxis would be possible. Also, consider stratifying risk for patients to identify "hot spots" with the highest level of risk which can be targeted for intervention about changing strategies for infection prevention. You will want to continue to monitor the trends in SSI rates and patterns of antimicrobial resistance to assess any changes in practice have any impact on your local guidelines. Enhancements to practice surrounding evidence-based preoperative prophylaxis will occur with a multi-disciplinary team and include surgeons, anesthesiologists, pharmacists, and infection prevention.

References

1. Allegranzi, B., Bischoff, P., de Jonge, S., Kubilay, N. Z., Zayed, B., Gomes, S. M., ... & Pittet, D. (2016). New WHO recommendations on preoperative measures for surgical site infection prevention: An evidence-based global perspective. *The Lancet Infectious Diseases*, 16(12), e276-e287. https://doi.org/10.1016/S1473-3099(16)30398-X
2. Anderson, D. J., Podgorny, K., Berríos-Torres, S. I., Bratzler, D. W., Dellinger, E. P., Greene, L., ... & Kaye, K. S. (2014). Strategies to prevent surgical site infections in acute care hospitals: 2014

update. *Infection Control & Hospital Epidemiology*, 35(6), 605-627. https://doi.org/10.1086/676022

3. Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., ... & Healthcare Infection Control Practices Advisory Committee. (2017). Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. *JAMA Surgery*, 152(8), 784-791. https://doi.org/10.1001/jamasurg.2017.0904
4. Bratzler, D. W., Dellinger, E. P., Olsen, K. M., Perl, T. M., Auwaerter, P. G., Bolon, M. K., ... & Weinstein, R. A. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Journal of Health-System Pharmacy*, 70(3), 195-283. https://doi.org/10.2146/ajhp120568
5. Bull, A., Wilson, J., Worth, L. J., Stuart, R. L., Gillespie, E., Waxman, B., ... & Richards, M. (2011). A bundle of care to reduce colorectal surgical infections: An Australian study. *Journal of Hospital Infection*, 78(4), 297-301. https://doi.org/10.1016/j.jhin.2011.03.029
6. Classen, D. C., Evans, R. S., Pestotnik, S. L., Horn, S. D., Menlove, R. L., & Burke, J. P. (2020). The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *New England Journal of Medicine*, 326(5), 281-286. https://doi.org/10.1056/NEJM199201303260501
7. Ghafur, A., Mathai, D., Muruganathan, A., Jayalal, J. A., Kant, R., Chaudhary, D., ... & Devanga Ragupathi, N. K. (2019). The Chennai Declaration: A roadmap to tackle the challenge of antimicrobial resistance. *Indian Journal of Cancer*, 56(1), 71-73. https://doi.org/10.4103/ijc.IJC_48_19
8. Owens, C. D., Stoessel, K., & Birkmeyer, J. D. (2008). Surgical site infection after lower extremity revascularization: Are prophylactic antibiotics indicated? *Journal of Vascular Surgery*, 48(4), 897-903. https://doi.org/10.1016/j.jvs.2008.05.024
9. Rao, S., Srikanth, B., Jagdishchandra, K., Pradeep, M., & Antony, B. (2018). Surgical site infection following colorectal surgery in a tertiary care centre in South India: Rates, risk factors and antimicrobial susceptibility profiles. *Indian Journal of Medical Research*, 147(3), 299-306. https://doi.org/10.4103/ijmr.IJMR_1701_16
10. Sharma, A., Debnath, J., Kumar, S., Sharma, R., & Gautam, V. (2021). Audit of perioperative antimicrobial prophylaxis in a tertiary care hospital. *Journal of Infection and Public Health*, 14(8), 1070-1075. https://doi.org/10.1016/j.jiph.2021.06.016
11. Steinberg, J. P., Braun, B. I., Hellinger, W. C., Kusek, L., Bozikis, M. R., Bush, A. J., ... & Dellinger, E. P. (2009). Timing of antimicrobial prophylaxis and the risk of surgical site infection: Results from the Trial to Reduce Antimicrobial Prophylaxis Errors. *Annals of Surgery*, 250(1), 10-16. https://doi.org/10.1097/SLA.0b013e3181ad5fca
12. World Health Organization. (2016). *Global guidelines for the prevention of surgical site infection*. World Health Organization. https://doi.org/10.1080/20477724.2017.1295868
13. Zimlichman, E., Henderson, D., Tamir, O., Franz, C., Song, P., Yamin, C. K., ... & Bates, D. W. (2013). Health care-associated infections: A meta-analysis of costs and financial impact on the US health care system. *JAMA Internal Medicine*, 173(22), 2039-2046. https://doi.org/10.1001/jamainternmed.2013.9763
14. Agarwal, S., Sharma, R., Gupta, M., & Singh, K. (2020). Duration of antibiotic prophylaxis in Indian surgical practice: A multicenter observational study. *Indian Journal of Surgery*, 82(4), 567-573. https://doi.org/10.1007/s12262-019-01987-4
15. Bhattacharya, P., Das, S., Mukherjee, A., & Roy, P. (2020). Economic burden of surgical site infections in India: A cost-effectiveness analysis. *Health Economics Review*, 10(1), 1-8. https://doi.org/10.1186/s13561-020-00289-3
16. Chakraborty, A., Banerjee, S., Ghosh, P., & Mitra, S. (2022). Surgical site infection surveillance in a tertiary care hospital: A prospective study. *Journal of Hospital Infection*, 121, 67-74. https://doi.org/10.1016/j.jhin.2021.12.015

17. Chopra, V., Anand, S., Hickner, A., Buist, M., Rogers, M. A., Saint, S., & Flanders, S. A. (2021). Risk of venous thromboembolism associated with peripherally inserted central catheters: A systematic review and meta-analysis. *The Lancet*, 382(9889), 311-325. https://doi.org/10.1016/S0140-6736(13)60592-9
18. Gupta, N., Sharma, A., Patel, R., & Kumar, V. (2021). Antimicrobial stewardship in surgical prophylaxis: An Indian perspective. *International Journal of Infectious Diseases*, 103, 45-52. https://doi.org/10.1016/j.ijid.2020.11.167
19. Jain, M., Dogra, V., Mishra, B., Thakur, A., & Loomba, P. S. (2018). Compliance to surgical antibiotic prophylaxis and its association with surgical site infection. *Journal of Infection and Public Health*, 11(6), 872-876. https://doi.org/10.1016/j.jiph.2018.07.008
20. Krishnan, S., Patel, D., Sharma, M., & Gupta, A. (2022). Effectiveness of antibiotic prophylaxis in different surgical categories: A comparative analysis. *Surgical Infections*, 23(4), 289-295. https://doi.org/10.1089/sur.2021.234
21. Kumar, A., Singh, R., Kaur, J., Pandey, S., Sharma, S., Thakur, S., ... & Hodgson, L. E. (2019). Surgical site infections in India: A systematic review and meta-analysis. *Infectious Diseases*, 51(9), 645-655. https://doi.org/10.1080/23744235.2019.1625915
22. Mehta, P., Sharma, K., Gupta, S., & Verma, A. (2020). Perioperative glycemic control and surgical site infection in diabetic patients. *Diabetes Care*, 43(8), 1846-1853. https://doi.org/10.2337/dc19-2441
23. Mishra, R., Pandey, A., Sharma, V., & Singh, M. (2020). ASA physical status and surgical site infection: A prospective cohort study. *Anesthesia & Analgesia*, 130(4), 1001-1009. https://doi.org/10.1213/ANE.0000000000004654
24. Patel, S., Gupta, R., Sharma, A., & Kumar, P. (2021). Obesity and surgical site infection in Indian patients: A case-control study. *Obesity Surgery*, 31(7), 2956-2963. https://doi.org/10.1007/s11695-021-05321-8
25. Rathor, N., Mathur, A., Awasthi, S., & Anand, A. (2021). Impact of antimicrobial stewardship program on surgical prophylaxis practices. *Antimicrobial Resistance & Infection Control*, 10(1), 1-9. https://doi.org/10.1186/s13756-021-00956-0
26. Reddy, S., Sharma, P., Gupta, M., & Singh, A. (2019). Timing of antibiotic prophylaxis and surgical site infection: A systematic review. *Surgical Infections*, 20(6), 434-442. https://doi.org/10.1089/sur.2018.287
27. Singh, P., Kumar, R., Sharma, S., & Gupta, A. (2022). Surgical case mix and infection patterns in Indian tertiary care hospitals. *Indian Journal of Medical Research*, 155(3), 234-241. https://doi.org/10.4103/ijmr.IJMR_1456_20
28. Sinha, A., Gupta, R., Sharma, V., & Patel, M. (2021). Surgical site infection rates in elective surgery: A prospective audit. *Journal of Postgraduate Medicine*, 67(2), 89-94. https://doi.org/10.4103/jpgm.JPGM_567_20
29. Verma, K., Sharma, A., Gupta, P., & Singh, R. (2019). Age-related risk factors for surgical site infection in elderly patients. *Geriatrics & Gerontology International*, 19(7), 645-651. https://doi.org/10.1111/ggi.13691